AMi2030

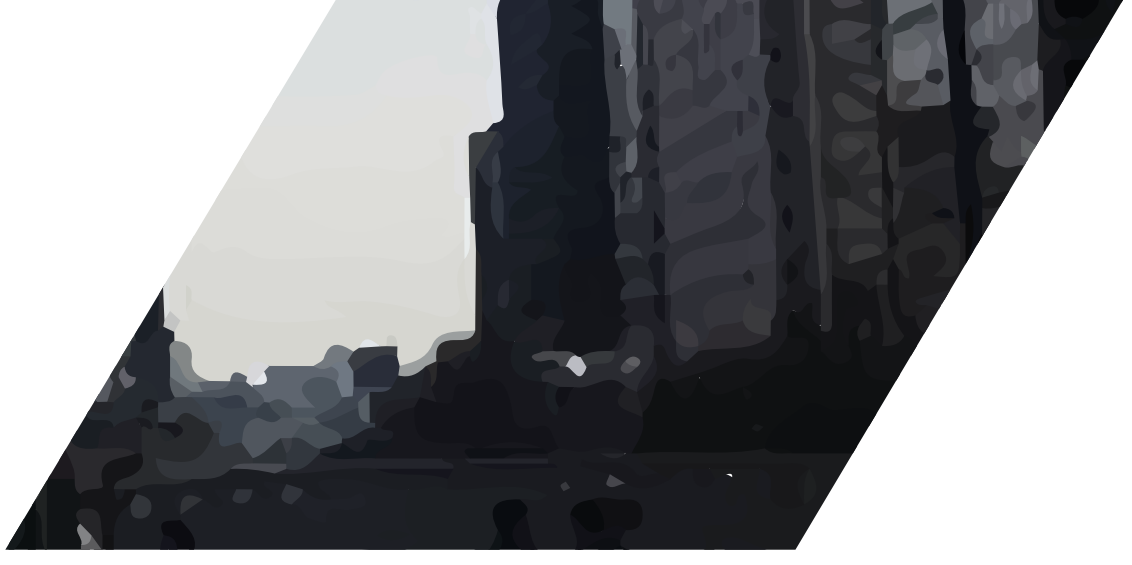
ADVANCED MATERIALS INITIATIVE

STRATEGIC MATERIALS **AGENDA**

APRIL
2023

www.ami2030.eu

Content



Executive Summary

The ambition

As underlined in the Materials 2030 Manifesto published in February 2022, to remain competitive and meet customers' and citizens' needs for high-performance, sustainable products and services, Europe needs **a systemic approach to develop innovative advanced materials to offer faster, scalable, and efficient responses to the challenges and opportunities for Europe's society, economy, and environment.**

The Communication "A secure and sustainable supply of critical raw materials in support of the twin transition" (COM(2023) 165 final) published by the European Commission on March 16, 2023 recognises an important role in the development of advanced materials for substituting CRMs and expressively announces that "the Commission will present a Coordinated Plan of Action with Member States on advanced materials, including substitution of critical raw materials, in order to secure R&I investment levels commensurate with the challenge".

Driven by Europe's green and digital transitions, the Advanced Materials 2030 Initiative aims to set up a **pan-European multi-sectoral accelerator for the design, development and uptake of sustainable advanced materials towards a circular economy.** This will be achieved through an ambitious Research and Innovation Agenda, feeding a pipeline of industrial projects and mobilising all stakeholders of the advanced materials ecosystems in Europe.

The Advanced Materials 2030 Initiative is an open and inclusive forum, seeking to transform the European advanced materials sector sustainably. To do so, a common and shared framework for all advanced materials stakeholders is proposed. By integrating all strands of stakeholders, from upstream developers, manufacturers, downstream users, citizens and all stakeholders in between, the initiative covers the full range of the advanced materials value chain and considers the different needs and challenges along the materials innovation cycle.

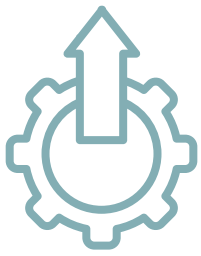
This strategic agenda is intended to feed into the discussions between the European Commission and Member States on the development of the Coordinated Plan of Action on advanced materials.

Thanks to their specifically engineered properties designed to exhibit novel and outstanding functional or structural properties, **Advanced Materials play an important - often critical - role in the green and digital transition while simultaneously reinforcing Europe's strategic sovereignty.**

Consolidating Europe's historical leadership on Advanced Materials can be a source of prosperity for the European industrial society. However, with Europe lagging behind in various key industries, **our strategic and global position on Advanced Materials is currently at risk. New Advanced Materials solutions are needed to reinforce Europe's resilience and sustainability.** Not the least, to meet unprecedented market needs driven by a profound aspiration for a safe and sustainable society, **increasingly complex Advanced Materials are required at an ever faster pace.** Major challenges in the design, development and scale up of advanced materials - and in associated production and processing technologies - have to be tackled to achieve this goal, **with cross-cutting needs in the different strategic Materials Innovation Markets to be addressed in priority.**

This will only be possible by joining all needed resources and skills. A major change is needed, as Europe is faced with a fragmented landscape of actors, skills, resources and initiatives, both at European and national level.

To address these main challenges, general objectives have been set in AMI2030. They encompass the four pillars originally set by the AMI2030 manifesto:



Boost industrial competitiveness through interdisciplinary technology innovations.

Reinforce EU Sovereignty through global leadership and strategic autonomy in key areas, ensuring compatibility with EU values.

Establish and strengthen safe and sustainable, resilient, and circular advanced materials value chains, supporting the Green Deal

Contribute to the Digital Age, through smarter advanced materials and a data economy.

Specific actions

These general objectives will be sustained through a set of specific actions . From different perspectives along the Advanced Materials value chain, a complementary approach will be adopted with the shared ambition to contribute qualitatively and significantly to the general objectives set out in AMI2030.
These **specific actions** are to:

- Leverage game-changing technologies for the fast development of scalable advanced materials solutions.
- Develop safe and sustainable advanced materials and related technologies with low environmental footprint and circular business models.
- Support innovation uptake and access to infrastructures and services.
- Promote outreach, dissemination, and further exploitation
- Support regulatory preparedness and contribute to an efficient implementation of key regulations, codes and standards supporting the design, development and uptake of Advanced Materials.
- Support education and Skills (Knowledge management)
- Build a European Advanced Materials ecosystem
- Engage in International cooperation

Each specific action is introduced in terms of *challenge, scope, output* and *impact.* The **challenge**, which can be multi-faceted, is a variation (by specific action) of the main challenges on Advanced Materials. The **scope** lays out the area of intervention according to AMI2030's ambition. The **output** defines the direct results to be delivered by AMI2030, while the **impact** highlights the consolidated indirect results generated by all future beneficiaries of AMI2030.

The specific actions will be implemented within the upcoming SRIA, in a coordinated way, taking account of the other programmes and initiatives that are in place on advanced materials and other relevant areas.

The way forward

In order to implement AMI2030 specific actions, a new approach is required in terms of funding instruments that will build upon and complement the existing landscape of initiatives and instruments.

As materials are developed and produced by industry, processed, incorporated into products and placed on the market by industry, and recovered at the end of product life by industry, the industry must be directly involved in the development of the R&I strategy for Europe and its implementation. A co-programmed partnership seems to be the most appropriate instrument to anchor industry support. **The AMI2030 partnership will be the new and complementary funding instrument between the European Commission and all stakeholders gathered in the AMI2030 initiative (including industry and research stakeholders/universities). It will bring together matching funds from the European Commission and industry.** However, the ambition of AMI2030 is not to limit itself to such a single instrument.

A major objective of AMI203 is to ensure that the X-cutting challenges of Advanced Materials across strategic European MIMs are appropriately addressed.
To tackle the fragmentation of the materials sector, AMI2030 will leverage the creation of the European Ecosystem for Advanced Material, providing a platform for all stakeholders along the entire Advanced Material value chains and the innovation cycle.

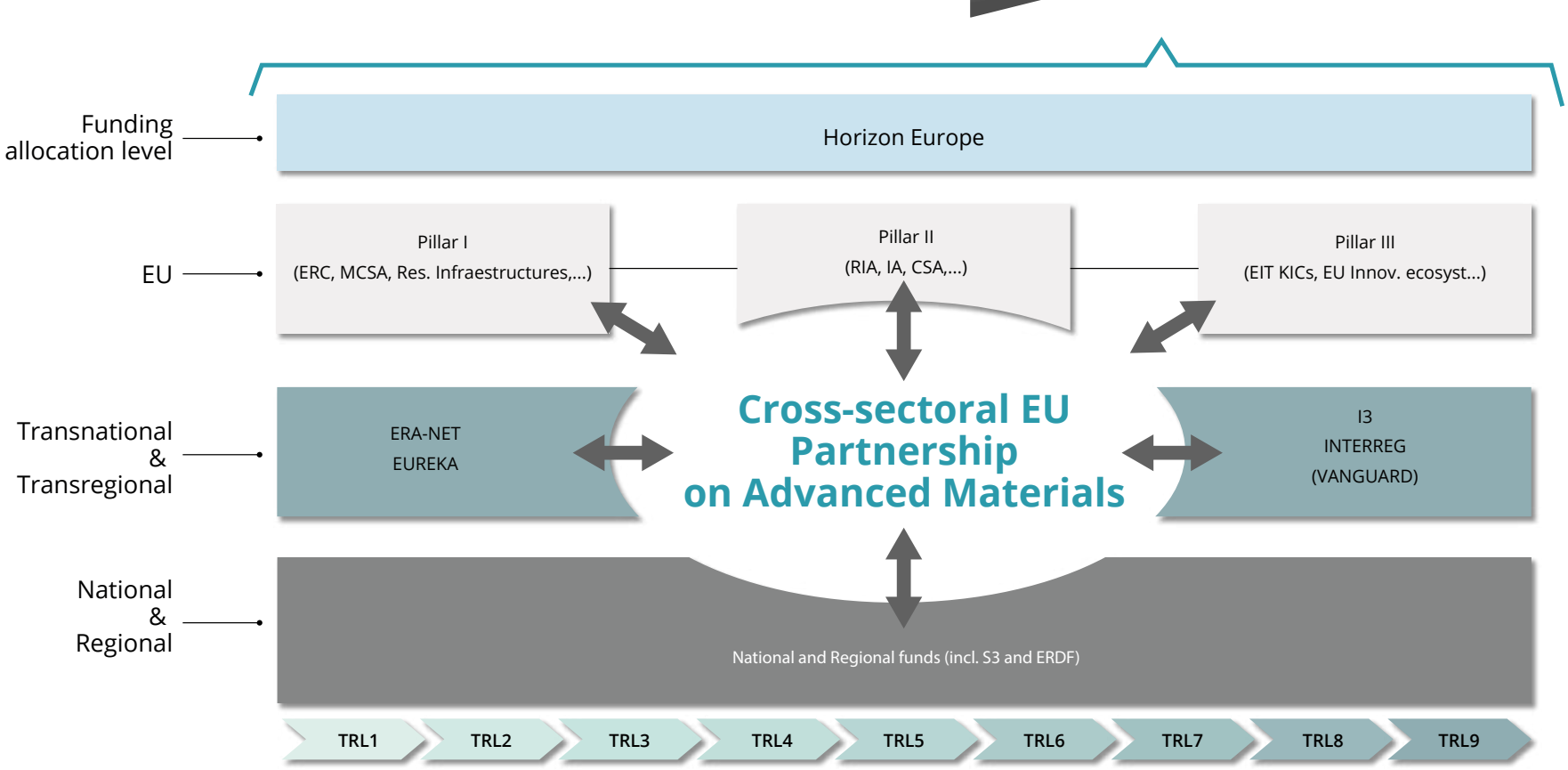
The new platform will be an open and transparent forum to connect and exchange, particularly for the leaders of regional, national & European funding programmes and initiatives.

In conclusion, to implement AMI2030's full ambition, a two-step model is proposed, including the AMI2030 partnership, for funding transformational activities at TRL 3 – 8, to fill the gap between lower (1-3) and higher bands (7-9), and the AMI2030 platform, to foster collaboration and coordinate with existing funding initiatives (upstream and downstream).

A well-structured and lean governance will allow the involvement of the different stakeholders in the future AMI2030 Partnership. It will include a **Steering Board**, a **Management Team**, several **Working Groups**, an **Advisory Board** closely connected to the **Multi-stakeholder platform**.

Transparency and openness will be key aspects which will ensure credibility and will significantly influence the efficiency of processes in all stages of the implementation of AMI2030.

AMI2030
ADVANCED MATERIALS INITIATIVE



1. AMI2030

1.1. Advanced materials, the root and source of prosperity for society in the European Union

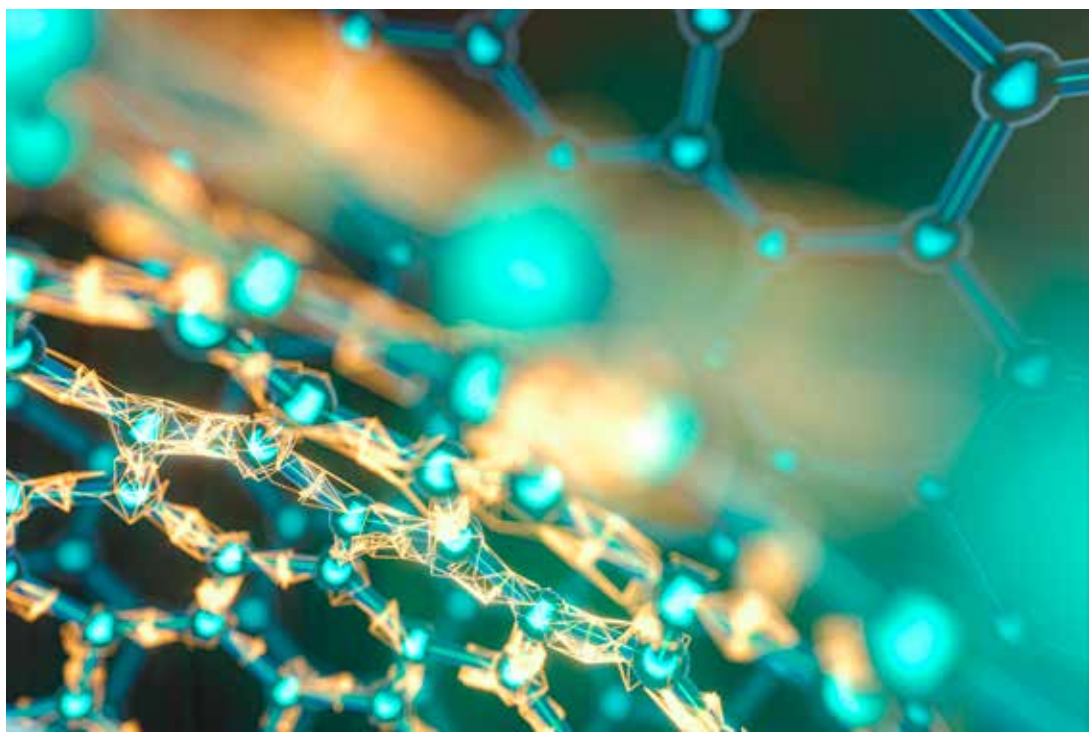
Major scientific advances of the last 5-6 decades have introduced the ability to manipulate substances (inorganic and organic) at an atomic level, making it possible to realize new, purpose-built materials with enhanced properties that considerably outperform naturally occurring materials. These new materials, intentionally designed for superior performance, are generally categorised as **Advanced Materials.**[1]

Advanced Materials revolutionise every aspect of life, from health and food to housing, energy, mobility, communication, consumer goods and beyond. The overall performance of commonly used devices and products is continuously improved by new Advanced Materials. For example, increasingly functional, durable, lighter, safer, cheaper and eco-friendly materials are being utilised in transport applications. In the ICT sector, advanced materials innovation has been a driver of Moore's law which in turn has enabled the evolution of mobile computing and smartphones, with ever increasing device performance. These life-changing innovations depend on many different Advanced Materials technologies, which are reflected within the **AMI2030 roadmap** across **Materials Innovation Markets (MIMs)**. To date, nine strategic materials innovation markets have been selected - Healthcare and medicine, construction, new energy, mobility, home and personal care, packaging, agriculture, textiles and electronics appliances. These are the **markets of prime interest for Europe in terms of consolidated impacts,** in which advanced materials play a key enabling role, for which the dual transition is both a necessity and a future source of prosperity. Any other potentially high value markets sharing the same rationale are encompassed by this definition and will be covered by the AMI2030 initiative.

The benefits of Advanced Materials are clear: they have the potential to bring us more sophisticated, higher performing, safer, more sustainable and more user-friendly products. Our improved capacity to create Advanced Materials from scratch is transformative and extends design potential, enabling, at a truly innovative level, the invention of entirely new components, products and systems. Also, new technologies for the harvesting and analysis of data, and the application of artificial intelligence (AI) to design, monitor, and problem-solving are revolutionising all segments of the materials value chain. In real terms, we are still on the threshold of a new technical revolution. It is likely that the next twenty years will see a leap forward that surpasses the progress of approximately a century of the industrial revolution.

The only real limitations are the laws of physics and human imagination - ethics remaining intangible limitations. In theory, if anybody identifies a radical solution to an existing need, or defines a new concept, scientists will be able to invent novel, bespoke Advanced Materials to translate that idea into reality by using appropriate discovery, design, production and processing technologies.

Overall and thanks to their specifically and targeted engineered properties designed to exhibit novel and outstanding functional or structural properties, **Advanced Materials play an important - often critical - role in the green and digital transition while simultaneously reinforcing Europe's strategic sovereignty.**



1 Also referred to as "Processed materials", "Engineered materials" or "Performance materials".

1.2. Main Challenges in Advanced Materials

1.2.1. Accelerating the green and digital twin transition

The **2020 Industrial Strategy[2] included a list of actions to support and accelerate the green and digital twin transition of the EU industry, to which Advanced Materials bring a central contribution.** The recent crises, of the COVID 19 pandemic followed by the war in Ukraine, have drastically affected the speed and scale of the required transformation. For most industrial sectors, the question is not only about HOW they produce, but WHAT they produce, WHICH resources they use and WHEN their transition will become effective.

Advanced Materials, especially in combination with fast development cycles, are essential for quickly providing the required game-changing solutions. For this reason, **consolidating Europe's historical leadership on Advanced Materials can be a source of prosperity for the European industry and society.** Major challenges have however to be tackled to achieve this goal; these are introduced below as the main challenges for AMI2030 to consider.

The **green and digital twin transition brings up significant challenges** in the entire lifecycle of Advanced Materials, with **cross-cutting needs across the different MIMs to be addressed as a priority,** as presented below.

1.2.2. Increasingly complex Advanced Materials are required at an ever faster pace

Main Challenge 1 *- Increasingly complex Advanced Materials are required at an ever faster pace to meet unprecedented market needs driven by a profound aspiration for a safe and sustainable society.*

The **development of appropriate technologies including their eventual launch to the market is increasingly complex and slow,** frequently requiring 10 to 20 years for the overall process.

With the urgency of finding solutions associated, in particular, with the challenge of global warming, without compromising sustainability and health, we can no longer accommodate this slow timeframe, nor the associated risks and costs. A radical paradigm shift in materials innovation is needed to **drastically accelerate the development and adoption of Advanced Materials.** This is now conceivable, supported by appropriate R&I infrastructures, data science and accelerated methodologies that integrate the knowledge of key experts, skills and data from across the Advanced Materials value chain. An emerging technology which will enable this is the Self-driving Lab; an intelligent experimental platform equipped with different hardware modules that iteratively operate a series of syntheses or physical processes selected and planned by ML algorithms in a closed-loop format to achieve a predefined objective[3].

Despite successful proof-of-concept examples of Self-Driving Labs in the accelerated synthesis of advanced (nano-)materials, many limitations still need to be addressed. Similarly, virtual (digital twins) or physical pilot lines, enabled by progress in digitalization, allow the simultaneous development, testing and validation of Advanced Materials and related production and processing technologies. These add to the new possibilities and may become increasingly relevant.

Providing appropriate Advanced Materials solutions which achieve climate neutrality, reduce pollution and meet resource scarcity and needs, reinforce European resilience, and restore biodiversity, will require a thorough assessment of each of these factors at the different stages of the materials lifecycle.

2 https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-industrial-strategy_en

3 Abolhasani, M., Kumacheva, E. The rise of self-driving labs in chemical and materials sciences. Nature Synthesis (2023). https://doi.org/10.1038/s44160-022-00231-0

Digital technologies that support all segments of the materials lifecycle can also play a key role in accelerating appropriate decision-making, notably by developing and implementing:

- Blockchain-based data management across the lifecycle of materials and products through the different value chains, which will facilitate and thus accelerate verification between different business partners.

- Digital product passports to enable enhanced material, production, component and end-to-end traceability and make data more accessible, which is essential for viable circular business models by avoiding time-consuming information retrieval.

- Digital twins that will facilitate innovation and the design of more sustainable materials, processes and products, and will also accelerate the development e.g., by reducing time-consuming queries.

- Data spaces providing extensive, cross-sectorial information to guide development and monitor progress towards sustainability.

To make full use of these digital technologies, important coordinated efforts are required, notably regarding acquisition, management and exploitation of relevant process, safety and sustainability data at every step of the materials lifecycle.

Data based on FAIR principles[4] will significantly accelerate the development of Advanced Materials and processing solutions relevant for Europe's innovation markets, and may enable public participation in steering the transition and co-creation.

4 Findability, Accessibility, Interoperability, and Reusability of data

1.2.3. EU's technology leadership and manufacturing competitiveness

Main Challenge 2 *– Safeguarding Europe's technology leadership and reinforcing the manufacturing competitiveness of the European Union in strategic global markets.*

A recent assessment[5] of the EU's performance in key technologies and R&I shows that **while the EU has certain strengths** (e.g. in the areas of advanced materials and manufacturing), **it is also at risk of falling behind in other areas** (e.g., in AI, Big Data, cloud, industrial biotech, robotics and micro-electronics) **that will drive future competitiveness.** While the EU still has a sufficient technological base, it is exposed to strong global competition. The increased technological capacities of the EU's competitors highlight the risk of the **EU not being able to create and grow enough companies** in certain key technology sectors, such as ICT, Biotechnology, Energy, Aerospace and Defence[6]. Furthermore, the **EU's R&I efforts in the digital ecosystem fall significantly behind those of the US and have also been overtaken by China**, raising the possibility of future dependencies on those technologies.

Europe is historically a global leader on Advanced Materials and manufacturing technologies. However, **with Europe now lagging behind in various key industries** (Figure 1)**, defending and further building our strategic and global position on Advanced Materials is essential** when combined with our leadership in manufacturing industry capacity and competency (Automobile, Aeronautics…).

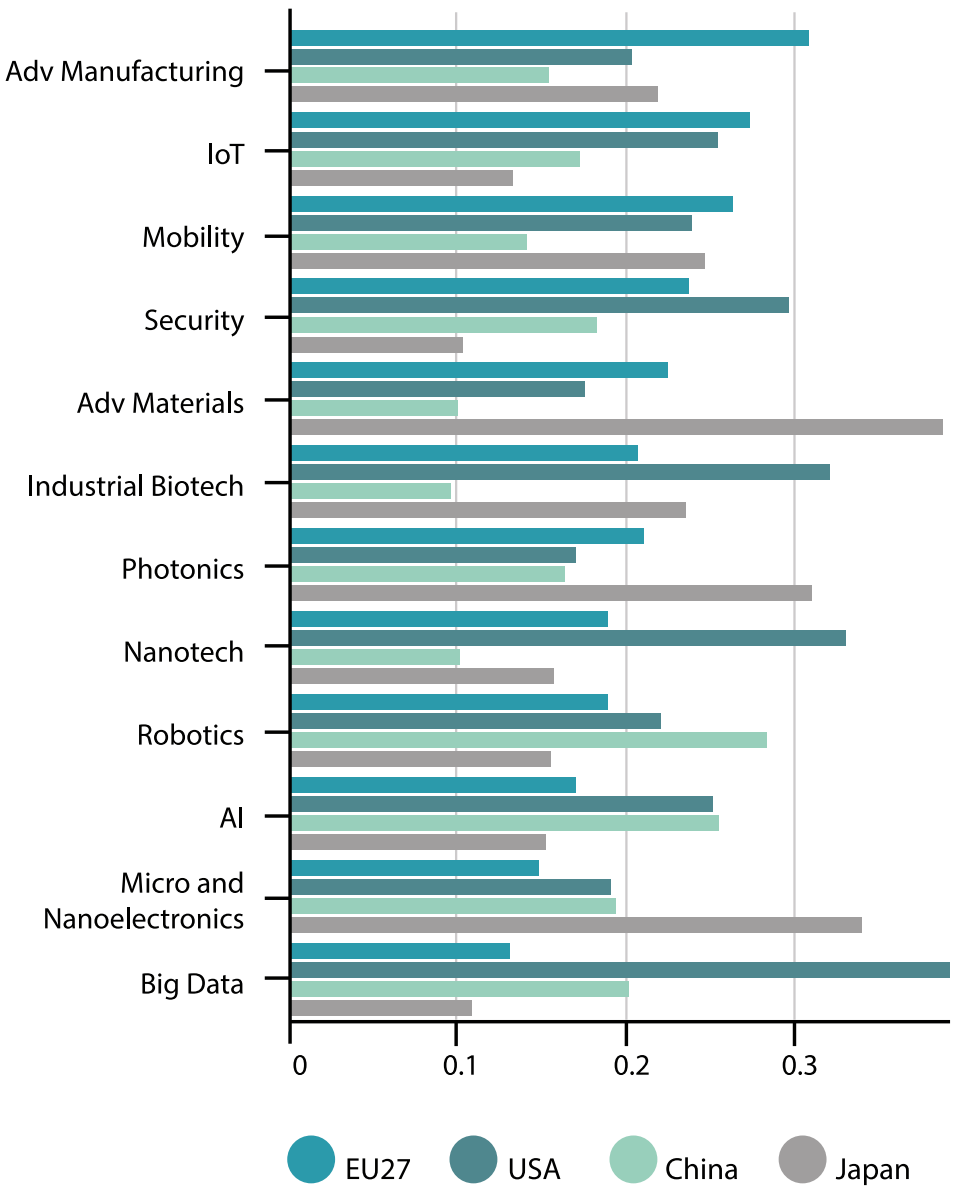


Figure 1: Indicator of overall EU performance in key technologies. (Source: Advanced Technologies for Industry)

1.2.4. EU's resilience and sustainability

Main Challenge 3 *- New Advanced Materials solutions are needed to reinforce Europe's resilience and sustainability.*

Access to resources is fundamental for the entire EU industry and central to Europe's ambition to deliver the Green Deal and ensure the digital transformation of the EU economy.

This needs to be anchored in **diversified and undistorted access to global markets for strategic raw materials,** including **access to a secure and sustainable supply of critical raw materials,** enabling Europe to meet its 2030

5 EC SWD (2021) 352 COMMISSION STAFF WORKING DOCUMENT - Strategic dependencies and capacities accompanying the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery.

6 Moncada-Paternò-Castello P. and H. Hernandez (JRC Policy Insights, European Commission): Ten-year evolution of EU industrial R&I in the global context, 2018

climate and digital objectives (Critical Raw Materials Act - CRM Act).

As the EU does not produce sufficient raw materials that can meet our demand, EU industry faces **global competition for access to raw materials.** The OECD estimates[7] that material extraction doubled since 1990 and that the global consumption of resources will grow up to 40% by 2040 and close to 90% by 2060 (as compared to 2017). This puts significant pressure on our planetary finite resources and on the resilience of raw materials' supply chains globally. With the transition of Europe's industry to climate-neutrality, the reliance on fossil fuels will also progressively be replaced by reliance on critical raw materials.

This drives the need to **build resilient and sustainable value chains in the EU.** Advanced Materials technologies will help by developing substitute solutions, improving resource and materials efficiency, and designing durable products that can be recycled, remanufactured, and reused, thereby extending their lifespan and reducing waste.

1.2.5. Fragmented EU/National landscape of actors, skills, resources and initiatives

Main Challenge 4 - *Europe is faced with a fragmented landscape of actors, skills, resources and initiatives, both at European and national level, leading in particular to a growing gap between SMEs and large companies in terms of innovation capacity and access to digital technologies and skills.*

To achieve the industrial and economic goals of all Materials Innovation Markets serving the twin green and digital transitions, the rapid delivery of Advanced Materials solutions requires **strong coordination between all stakeholders.**

- **Through the full Advanced Materials innovation cycle and across all MIMs**, from materials design (low TRL) to market uptake (high TRL), with continued exchange between fundamental research and consumers/end-users/citizens.

- **Among all industrial sectors and along the multi-disciplinary materials value chains**, from primary to secondary raw materials, including Advanced Materials production and integration of these Advanced Materials into finished components and products.

- **Between industry, research and public authorities, at EU and MS levels**, to maximize impacts across European and national R&I as well as educational programmes and initiatives.

A strong European Materials ecosystem is needed to enable the green and digital transition as well as a sustainable inclusive European society, through a systemic collaboration of upstream developers, downstream users and citizens and all relevant stakeholders. This challenge is promoted and sustained by the AMI2030 Initiative itself, whose overarching objective is to build a sustainable and enduring partnership.

7 https://www.oecd.org/environment/waste/highlights-global-material-resources-outlook-to-2060.pdf

1.3. AMI2030's Ambition

AMI2030's Ambition, A multi-sectoral accelerator for the design, development, and uptake of safe and sustainable Advanced Materials for the circular economy.

Europe needs a **systemic approach for innovation in Advanced Materials** which offers faster, scalable, and efficient responses to the societal, economic, and environmental challenges Europe is facing today. A "systemic approach" means interconnecting the different components and actors of complex ecosystems: Education, Research, Industry, Policy-makers and Society. To this end, AMI2030 provides an open and inclusive forum to coordinate and maximise the impact of joint actions and projects by engaging all stakeholders of the Advanced Materials ecosystems in Europe.

1.3.1. Vision for 2030

By 2030, a **strong and inclusive European materials ecosystem** will have enabled the **twin green and digital transitions** and will have contributed to a **circular** and more **resilient economy and a safe and sustainable European society** for the benefit of European citizens. This will be achieved through **systemic and inclussive collaboration** between upstream developers, downstream users and all intermediate stakeholders. This is the central vision originally set in the **AMI2030 manifesto and pursued in the AMI2030 roadmap.**

European industries will reinforce their global position in terms of **competitiveness, productivity, and technological leadership,** along their complete Advanced Materials value chains. The goal is to increase the number and attractiveness of **jobs**, while at the same time securing the **safety and environmental, economic and societal sustainability** for future generations in Europe. While global competition is increasingly challenging, Europe will reinforce its position because of its **technological leadership** on Advanced Materials, systemic approach and capacity to handle complexity and to fully embrace **digital technologies.** This, in return, provides the basis to increasing services and transparency, from advanced materials design to advanced materials production, transformation and integration into products along the whole product lifecycle.

Europe's experience, expertise and creativity will support the consolidation of European industry. By 2030, European industry will be delivering excellent Advanced Materials solutions (incl. disruptive innovation), ensuring individual user-satisfaction (including customised products and services), high quality, and environmental and social sustainability. Europe will be in the vanguard in Advanced Materials for **net-zero products and services** in a broad range of innovation markets, including new energies, transport, construction, healthcare, textiles, electronics and customer goods.

By 2030, Europe will be at the forefront of **resource efficiency and circular economy** implementation through highly interconnected value chains, which will contribute to its competitiveness at the global level and support environmental sustainability from all perspectives. Manufacturing systems in Europe will be flexible, adapted to the integration of innovative Advanced Materials into sustainable products. And the transformation to a circular economy will need innovative business models, which will furthermore rely on the data economy.

This vision focuses on ensuring **competitiveness, safety and sustainability,** and supporting adaptive Advanced Materials design, production and processing ecosystems which are resilient to external disturbances and rising environmental and social requirements.

1.3.2. General objectives

General objectives have been set in AMI2030 to address the main challenges Europe is facing in the acceleration and development of safe and sustainable Advanced Materials and their integration into products that respond to unmet needs (Part 1.2). Through the specific actions (Chapter 2) that will sustain them, these general objectives will contribute individually and complementarily to the main challenges. They encompass the four pillars originally set by the AMI2030 manifesto and are the following:

1. **Boost industrial competitiveness through interdisciplinary technology innovations.** Innovative sustainable materials technologies are essential to sustain the competitiveness of European strategic industrial value chains in their transition towards circularity and fully sustainable business models. Cohesive cross-sectorial and inter-disciplinary innovation coordination between the industry sectors along the advanced materials value chain will maximise the impact of allocated efforts and support cross-fertilization between projects to better address challenges common to different strategic markets. In that context, research competitiveness is essential to underpin industrial competitiveness. Research has to be fully integrated into the process through close connection with the academic sector.

2. **Reinforce EU Sovereignty through global leadership and strategic autonomy in key areas, ensuring compatibility with EU values.**
Strengthening EU leadership on Advanced Materials production and processing will benefit all industrial sectors and ensure that the future of industry is made in Europe.

3. **Establish and strengthen safe and sustainable, resilient, and circular advanced materials value chains, supporting the Green Deal.**
By reducing the need for or substituting critical raw materials, safer and better sustainable/recyclable advanced materials will contribute to strengthening Europe's autonomy on critical and emerging technologies relevant to the green and digital transition, from computing-related technologies to bio-based circular technologies and net-zero technologies.

4. **Contribute to the Digital Age, through smarter advanced materials and a data economy.**
The digital transformation of the advanced materials sector along entire value chains will enable disruptive solutions, from an accelerated discovery and development of safe and sustainable materials to product passports allowing consumers to make their choices based on transparent and reliable information on the sustainability, durability and carbon footprint of the products.

1.3.3. European policy and regulatory framework

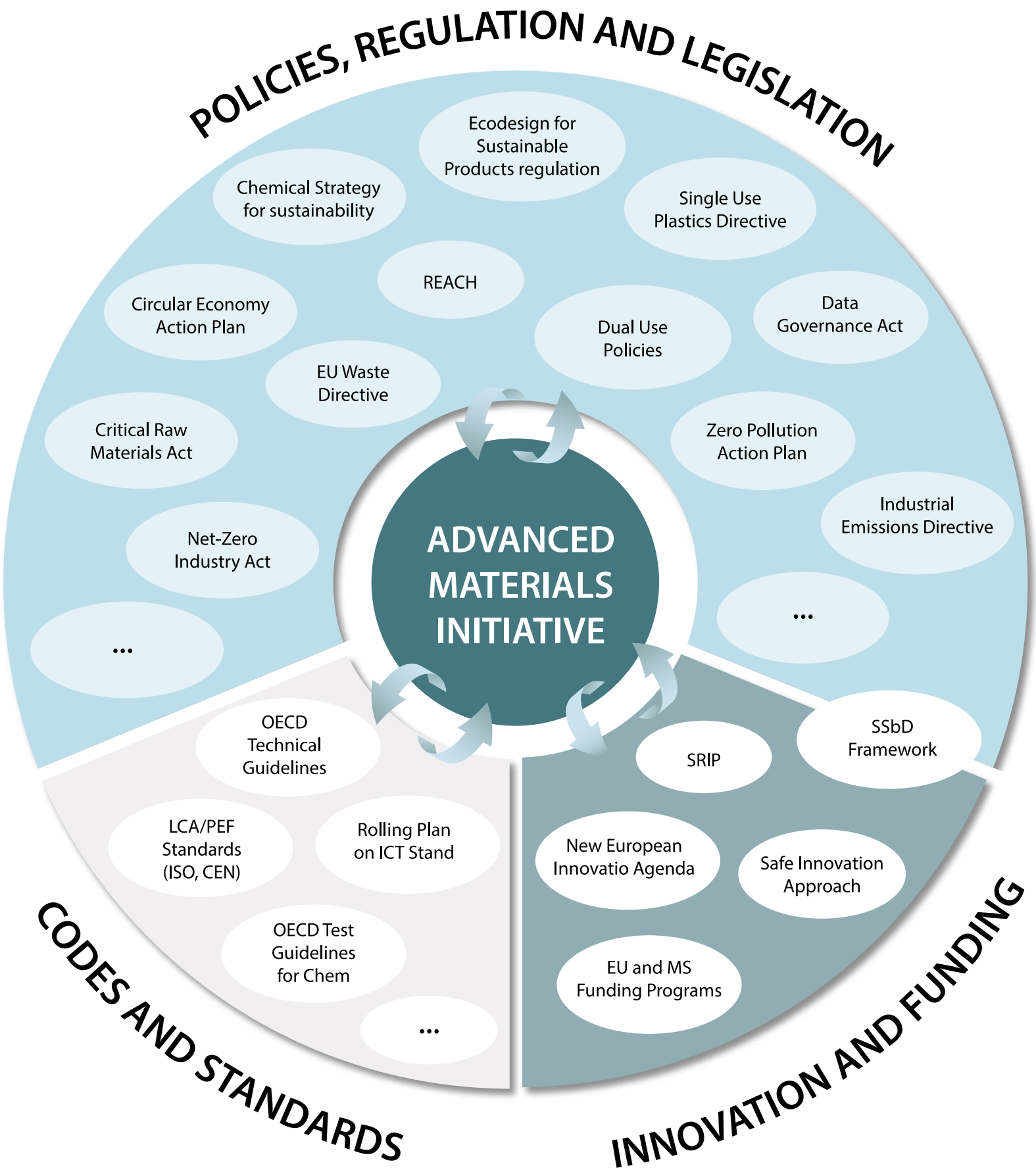
The four (policy) objectives outlined above are aligned with the EU's broader strategies, including the "New Industrial Strategy for Europe", the "European Green Deal", and "A Europe Fit for the Digital Age". The policy ambitions focus on **three key areas**, namely regulations and legislation, codes and standards, and innovation and funding (for a detailed description of most relevant regulation and legislation see Annex 1).

In the area of **regulation and legislation**, the focus is on identifying specific aspects of advanced materials and translating them into market and legislative needs. The policy support also involves an advisory role for emerging policies to support regulatory preparedness.

Concerning **codes and standards**, the goal is to accelerate the development and market uptake of new materials by contributing to the development of new standards and assessment methods and to harmonize those frameworks.

Finally, the policy support in **innovation and funding** aims to identify funding topics derived from market and legal needs, as well as game-changing technologies, while finding synergies among EU-wide and national funding programs to avoid duplication of work and ensure better alignment. In particular, priorities and opportunities of the **New European Innovation Agenda** will be addressed.

Figure 2: AMI2030's policy ambitions focus on three key areas (details in Annex 5.1).



1.3.4. Scope and Areas of Intervention

Core to the general objectives of AMI2030 is the necessity to maximise medium and long-term societal benefit for Europe through improved and extended research activities and better sharing of the respective knowledge flows.

Activities will consider all segments of the **Advanced Materials innovation cycle,** dovetailing upstream research with downstream applications while addressing all segments of th**e Advanced Materials (circular) value chain**, from the design phase to recovery as secondary raw materials.

To achieve the **comprehensive coverage of the Advanced Materials innovation cycle,** the initiative will focus its R&I agenda primarily on TRL 3-7 and establish a close link both with fundamental research upstream and with strategic MIMs downstream, combining technology push and market pull approaches.

To achieve the **comprehensive coverage of the Advanced Materials (safe, sustainable and circular) value chain,** the initiative will unfold its Research and Innovation agenda across four main segments, which are the following:

- Advanced Materials design, development & production
- Advanced Materials transformation and integration into components, products & systems
- Advanced Materials behaviour during the use phase; and
- End-of-use phase.

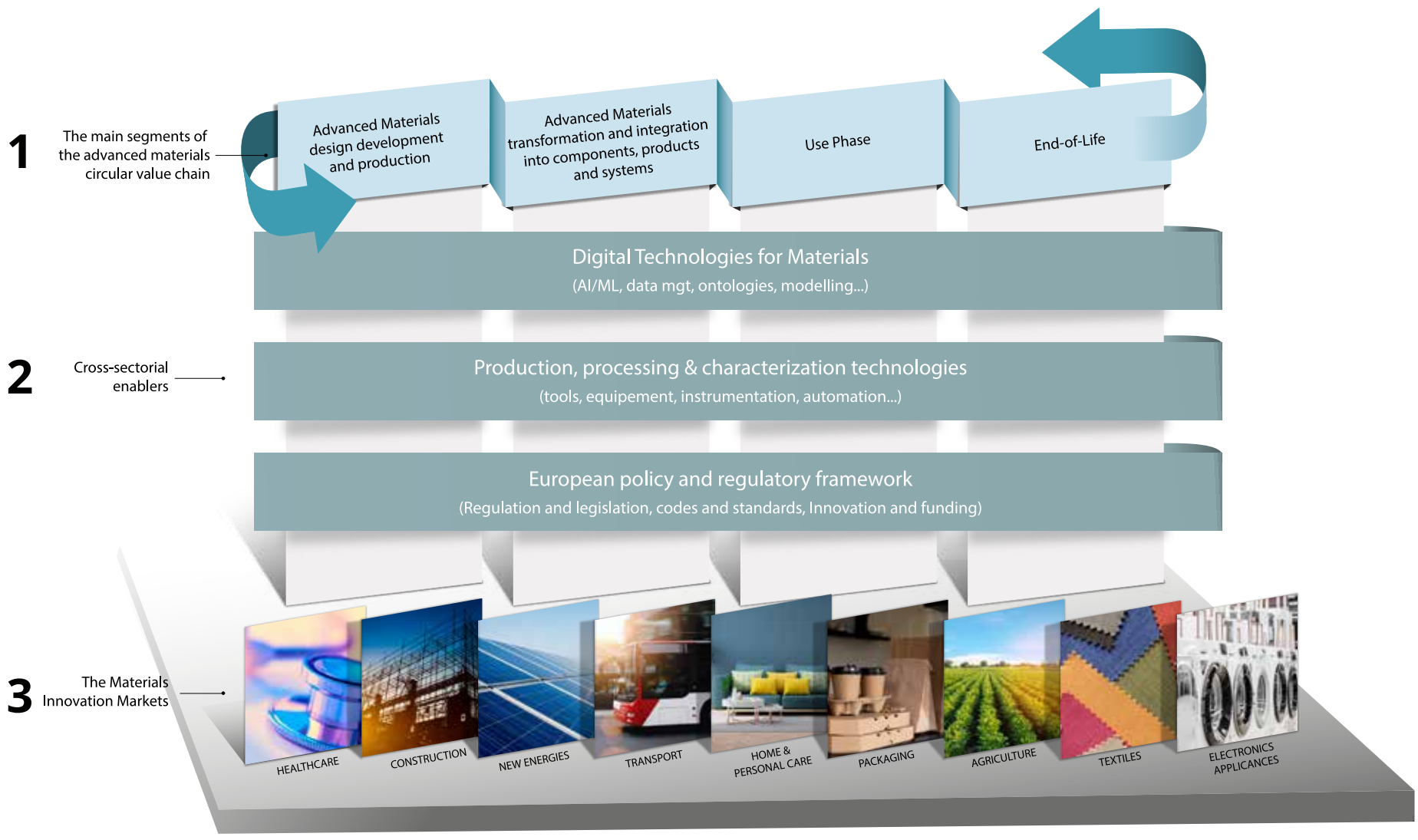
In this two-dimensional space (innovation cycle and value chain), a variety of R&I activities will be organized across different **Areas of Interventions** (AoIs), defined at the crossroads of (Figure 3).

1. Advanced Materials (circular) value chain segments.

2. Cross-enablers:
   - Digital technologies for Advanced Materials.
   - Production, processing & characterization technologies.
   - Regulations, Codes and Standards frameworks.

3. Materials Innovation Markets.

Figure 3: AMI2030 Areas of Intervention.
These will be complemented by activities dedicated to education and training of future skilled workforce, entrepreneurship, public awareness and citizen involvement and participation.



1.3.5. Priorities

AMI2030 covers any Advanced Material, regardless of its type (metals, polymers, ceramics, composites, biomaterials…), role or properties (functional materials, structural materials, smart materials, metamaterials…) or size or structure (nanomaterials, micro-, meso-, macro-porous materials, gels …).

All activities will aim to promote safe and sustainable by design (SSbD) materials contributing to a circular economy that is regenerative by design and progressively decouples growth from the consumption of finite resources, as opposed to the linear 'take-make-waste' model. As highlighted by the Ellen MacArthur Foundation[8], in such a circular economy, economic activity builds and rebuilds the overall system resilience. The concept recognises the importance of the economy needing to work effectively at all scales – for big and small businesses, for organisations and individuals, globally and locally, and is based on principles which resonate well with those of AMI2030.

AMI2030 Principles	Ellen MacArthur Foundation Principles
Advanced materials used in economic activities that do not cause damage to human health and natural systems	Design out waste and pollution
Advanced materials enable safe and sustainable, reusable, remanufactured and recycled products to be designed so that they and their products and components continue to circulate in the economy	Keep products and materials in use
Advanced materials avoid the use of non-renewable resources and preserve or enhance renewable resources, for example by returning valuable nutrients to the soil to promote regeneration	Regenerate natural systems

Accordingly, activities will focus on **Advanced Materials needs** shared across the MIMs and associated **Production and Processing needs** along the materials life cycle (Figure 4, details in Annex 5.2). These (MIMs) **cross-cutting needs** are represented in the table below, formerly introduced as commonalities in the AMI 2030 roadmap and re-formulated here in a Green Deal mind-set, predominantly.

8 https://ellenmacarthurfoundation.org/

Figure 4: Cross-cutting needs

Production & processing X-cutting needs	Resilient materials (low/no CRM containing)	Renewable materials (non-fossil sourced / bio-Sourced)	Circular materials (bio-degradable / recyclable)	Resource efficient materials (low embodied resource / low resource use in operation)	Frontier materials (novel functionality / customized materials / future applications / ...)
	Advanced Materials X-cutting needs				
Resources usage optimization and decarbonization					
Integrated Product Design and Engineering (materials, products and processes)					
Mass customization and fast response/flexibility					
Zero defect production					
Pocesses for multi-materials and new materials					
Pocesses for circularity					
Instrumentation and metrology for characterization, monitoring and control					
Flexible Supply Chains and Marketplaces					

Overall, priority will be set on activities aimed at delivering concrete and relevant MIMs use cases with **qualified and substantial impacts on health, environment, the society and the economy,** in alignment with the expected outcome of the European Industrial Strategy and the twin green and digital transition.

Activities prioritised by AMI2030 will be described in the upcoming Strategic Research and Innovation Agenda, whose structure is supported by a finite number of high-level actions - or **specific actions** - described in Chapter 2.

Although AMI2030 aims to benefit all MIMs, some **priority should be given to activities that directly impact on the most strategic sectors to the achievement of the Green Deal objectives and the strengthening of EU's open strategic autonomy.**

These include energy, transport, construction and electronics, in line with related recent EU policy initiatives such as the European Chips act, the Critical Raw Materials act and the Net-zero industries act. If appropriate, activities successfully deployed for these sectors will then be extended to other sectors.

2. SPECIFIC ACTIONS OF THE ADVANCED MATERIALS INITIATIVE

Eight specific actions have been defined **to address the main challenges identified in Advanced Materials** from different perspectives, in a complementary approach and with the shared ambition **to contribute qualitatively and significantly to the general objectives set on AMI2030.**

Each specific action is introduced in terms of *challenge, scope, output* and *impact.* The **challenge**, which can be multifaceted, is a variation (by specific action) of the main challenges on Advanced Materials (Part 2.2). The **scope** is setting the area of intervention according to AMI2030's ambition (Part 2.3). The **output** is defining the direct results to be delivered by AMI2030 (the Advanced Materials toolbox) while the **impact** is defining the consolidated indirect results generated by all future beneficiaries of AMI2030 (the Advanced Materials toolbox's users).

2.1. Leverage game-changing technologies for the rapid development of scalable advanced materials solutions

CHALLENGE

Disruptive innovation with new engineering mind-sets is required to ensure fast-paced, predictive, efficient and scalable approaches to developing novel advanced materials while operating within new regulatory frameworks and ever more stringent market needs. As a whole, new solutions are required to reduce costs and risks, and to accelerate and shorten materials development and uptake cycles (contributing to main Challenge 1).

Furthermore, the use and re-use of advanced materials between different innovation markets is limited by the lack of tightly connected networks of technologies across value chains that can enable synergies and promote common innovation ground, contributing to innovation uptake, leadership and competitiveness (contributing to main Challenge 4).

SCOPE

To address this challenge, AMI2030 will leverage game-changing digital and physical technologies covering all segments of the advanced materials value chain. A holistic approach will be essential, involving multidimensional assessments of materials, production set-ups, and final product performance to develop safer and sustainable products (see Specific Action 2).

These game-changing technologies will be at the centre of the accelerated development, transformation & integration of advanced materials into components and products. For example, the horizon of possibilities for product designers and end-users of materials will be radically transformed by combining digital technologies (such as modelling, simulation and 3D printing) with materials domain knowledge.

Materials sourcing and procurement can be made more efficient and accelerated by means of ontology-based, digitalised information enabling comparison of materials grades based on different standards[9] . Further transformative possibilities arise when such systems can include not just materials available for purchase but also extend to materials under development or even virtual materials[10]. The combined (or simultaneous) design and development of advanced materials and related technologies can be tremendously accelerated by means of automation, simulation and AI/ML technologies[11]

Materials recycling technologies (including high performance dismantling and disassembling) will be covered to close the loop towards circular value chains. Regarding the use phase, technologies will be supported to provide deep insights into material performance and efficiency to master the complete life cycle and feed the generated knowledge back into the development process. As another example, materials models and in-use data can be integrated in a digital twin of products to enable lower maintenance efforts and lifetime extension in products[12].

Advanced materials technologies supported by AMI2030 will demonstrate unprecedented performance, in both qualitative (conceptual/technical novelty, functionality, durability, accuracy, resolution, flexibility…) and/or quantitative (volume, speed, cost, turnover…) dimension, by a combination of digital and physical technological building blocks. From a value chain perspective, technologies will preferentially be inter-connected and intertwined over the complete materials life cycle.

The existence of relevant complementarities and synergies with the work developed by other European initiatives, such as Processes4Planet, Made in Europe, AI-Data-Robotics, Key Digital Technologies, European Metrology, justify the establishment of joint activities, namely road mapping, knowledge and results exchange and, eventually, joint calls.

This type of development and resulting projects will be mainly developed at European level and could be funded by instruments like RIA and IA.

OUTPUT

- Set of interlinked digital tools for materials (including modelling and simulation, Artificial Intelligence, machine learning, informatics, ontologies) to accelerate the development, transformation and integration of advanced materials into new products and services.

- Flexible, automated tools, equipment and approaches on manufacturability and recyclability to develop, transform and integrate advanced materials in dimensions yet unexplored.

- Multi-dimensional experimental and characterisation techniques to complement the emergence of a next generation of tools and equipment (sets) and to support the investigation of virgin experimentation windows in advanced materials development and engineering across different fields of application.

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9 https://ontocommons.eu/ontocommons-demonstrators#OntoCommons%20Demonstrators
10 Vision 2040: A Roadmap for Integrated, Multiscale Modeling and Simulation of Materials and Systems, https://ntrs.nasa.gov/citations/20180002010
11 Fully automated intelligent expert system for high-throughput glass development, https://www.materialdigital.de/project/4
12 SensoTwin, Extending the service life of wind turbines using digital twins https://www.materialdigital.de/project/5

■ Monitoring techniques and approaches covering the full lifecycle of advanced materials to capture all relevant data and information that will benefit the development, transformation, and integration phases but also the advanced materials optimal exploitation during the use phase and beyond.

IMPACT

■ Integration of downstream phases starting at the conceptual phase **i)** anticipating required conditions for optimum and long-lasting use of products, and guiding the design of materials accordingly, **ii)** ensuring continuous materials data and information flow along the full life cycle for appropriate re-use of advanced materials (components) as secondary advanced materials or a source thereof; and **iii)** supporting decision-making during the use phase of materials, including maintenance, repair, and potential life-time extension of products.

■ Far-extended boundaries on manufacturability and recyclability meeting exacerbated by market needs induced by an ever-more competitive economic context, as well as by new policies and regulatory framework requirements with new product specifications that current advanced materials cannot satisfy. Paradigm changes in the way tools and equipment are conceptualized will open up new fields in advanced materials engineering and manufacturing. This also applies to the recycling end-segment of the value chains where pioneering technologies and new boundaries will ensure the successful transformation of primary advanced materials into secondary advanced materials.

■ New concepts and capabilities of experimentation ensuring the rational and successful exploration of new experimentation pathways and gaps in coverage on advanced materials characterisation (in terms of accuracy, resolution, flexibility, automation, speed, inter-operability, multi-analysis, implementing digital tools,) to create and launch advanced materials solutions with bespoke composition, structure and resulting properties responding to new market and regulation needs.

■ Accelerated development cycles by advanced monitoring of data and information over the full lifecycle of advanced materials. Monitoring of materials over the experimental phase (design, processing and characterisation) will be key to project the outcomes of this phase towards the following ones and to take full advantage of materials digitalisation.

2.2. Develop safe and sustainable advanced materials technologies with low environmental footprint and circular business models.

CHALLENGES

Climate neutrality refers to achieving net-zero greenhouse gas (GHG) emissions. However, there are numerous impacts resulting from the intense exploitation of natural resources for production and utilization of materials in a purely linear economic model. Hence, the challenges with regard to reaching fully sustainable materials value chains are substantial and require pragmatic and systematic, systemic and global approaches together with a shared vision and long-term commitment of all stakeholders (contributing to main Challenge 4).

One challenge is to replace critical raw materials or to reduce their usage – this is also valid for harmful substances and materials. Even if critical raw materials usually represent only a marginal part of a product's overall material balance, their availability will, on current trajectories, not keep up with the demand. In addition, many critical raw materials are produced outside the EU and are imported from countries with lower environmental

and social standards, and/or unstable political situations. Therefore, it has become a fundamental need for Europe to drastically reduce its dependency on critical raw materials while securing resilient supply chains for those raw materials that cannot be entirely substituted (contributing to main Challenge 3).

Another challenge is to re-think, in a holistic manner, the way advanced materials are developed, transformed, integrated and used to minimize their overall environmental impact over the full material lifecycle. The environmental footprint of a material is predetermined by its nature and origin, its use as part of a component/product and by the intended use (and re-use) of the latter. Besides, considering the up- and down-stream effects of (design) choices will determine how, and for how long, a material will perform but also how easily it can be recovered, recycled and then potentially re-used. This also disrupts the current life cycle analysis methods which should thus be adapted to the new paradigm (contributing to main Challenge 1).

SCOPE

To address these challenges, AMI2030 will align with recently announced European policies and new regulatory frameworks calling for safer, more responsible, and environmentally friendly technologies, products and practices, while at the same time preserving EU resilience and open strategic autonomy. Safety and sustainability will be thus put at the core of the initiative, implementing SSbD in a systematic way and as a paradigm shift towards climate neutrality with the still-standing overarching challenge to develop and produce advanced materials ever more performant and less costly. Holistic approaches will be favoured, reflecting the compromises on performance, environmental footprint, and life cycle cost of a product, by addressing raw material shortages, manufacturing friendliness and design for recycling.

From a sourcing perspective, avoidance or reduction of critical raw materials will be sought favouring i) advanced material with lower/no content of CRM and ii) partial/full substitution of CRMs by non-critical advanced materials.

Circular business models alongside industrial and economic conditions for transforming advanced materials at the end of their use into secondary advanced materials (second life) will be addressed to both reduce the pressure on supply chains and to reduce the overall environmental footprint of materials.

The existence of relevant complementarities and synergies with the work developed by other European initiatives/partnerships, such as Processes4Planet, Made in Europe, AI-Data-Robotics, etc., justify the establishment of joint activities, namely roadmapping, knowledge and results exchange, as well as potential joint calls.

OUTPUT

- Concepts and toolboxes for safe & sustainable Advanced Materials design to seamlessly implement the necessary safety and sustainability principles at the materials design stage, in compliance with the SSbD framework (Specific Action 6), thus facilitating its deployment. This will include guidance regarding decision-making on trade-offs, such as the use of critical raw materials and harmful substances versus superior performance of the material.

- Framework for low environmental and social footprint Advanced Materials technologies promoting.

  - Sustainable and responsible sourcing with non-primary non-fossil-based feedstock enforced for the design of Advanced Materials and feedstock materials imported from Countries with high environmental and social standards.

  - Sustainable processing and manufacturing with, for instance, rationalized energy and water use or minimized resource usage and waste creation (e.g., customized and net-shape processing and manufacturing).

  - Material efficiency via the 9 Rs' framework (Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle and Recover).

■ Holistic approaches to assess net environmental balances, based on above-mentioned SSbD concepts and toolboxes and LCA methods, as support to the definition of new and circular business models.

IMPACT

■ Coordinated approach and knowledge-sharing on SSbD best practices, identification and pooling of main critical safety and sustainability needs across the industry and markets in order to provide common guidance on associated risks and the overall environmental footprint over the complete materials lifecycle (LCA).

■ Low environmental and social footprint-driven shared vision for advanced materials to minimize impacts on the environment in a deterministic manner and at significant scales, implementing notably the 9Rs' circular economic framework that examines how materials can be used and reused at their highest value while minimizing waste and environmental impact.

■ Contribute to the transition from a linear to a circular economy, identifying and demonstrating potential applications and industrial cases where the role and impact of advanced materials and physical & digital technologies for materials can be beneficial from the environmental, economic and societal perspectives.

2.3. Support innovation uptake and access to infrastructures and services

CHALLENGE

Infrastructures are required to provide resources and services for the research communities to conduct research and to foster innovation in their respective fields, including notably major equipment, sets of instruments, knowledge-related facilities, archives, scientific data infrastructures, computing systems, communication networks, etc. (contributing to main Challenge 4).

On the one hand, research infrastructures are already in place in Europe with dedicated strategies, policies and work programme. Implemented in Horizon Europe, the work programme targets **i)** the consolidation of the landscape of European and National research infrastructures and services, **ii)** their opening, integration and interconnection, **iii)** the reinforcement of European research infrastructure policy and international cooperation, and finally, **iv)** development of the innovation potential of European research infrastructures and activities for innovation and training.

On the other hand, other types of infrastructures have arisen over more recent years, increasingly driven by technology transfer and development (demonstrators, OITBs, DIHs, piloting facilities, living labs…). These infrastructures typically provide resources to enable smaller companies to test and scale up their innovations. Over the past few years, the Commission has been aiming to consolidate policy on technology infrastructures; it is one of the action areas in the European Research Area (ERA) framework that aims to create a single market for research. The challenge remains to recognize these technology infrastructures and services as key assets and dedicate a European strategy and policy to them and their implementation, along with research infrastructures, in R&I programmes.

SCOPE

To address the above-described challenges, AMI2030 will consider the landscape consolidation of relevant infrastructures and services, whatever their types and origins (Regional, National, European), to connect blue-sky research with industrial R&I on advanced materials, providing a continuum of services to all stakeholders along the advanced materials value chain. Reciprocally, infrastructures will take full benefit of multi-sectorial industrial cases brought to them by the users, taking advantage of their needs to better connect the community.

An appropriate set of supporting programmes and instruments is fundamental to achieve these goals and a multilevel funding scheme will be necessary to cover all types of infrastructures, services and activities. While most of the research and technological activities will have to be funded mainly at the national or regional level (in line with current practice), large-scale (Europe-wide) or smaller demonstrators and pilot lines, plus the related European network, will be supported directly with European programmes. Finally, co-funding mechanisms are becoming popular to incentivise and support the multi-level coordination and shared investments (like in the case of EDIH).

AMI2030 will contribute to the implementation of an operational model for this network of inter-connected infrastructures and organize access in a simple and efficient way, while widely advertising the unique value of an instrument integrated on such a scale. This type of activity will be developed at European level and could be supported with a CSA.

OUTPUT

- Network of cross-border infrastructures mapped out, organised and connected, which will be actionable via a single-entry point and a joint registry detailing available capacities, services and conditions of access to materials R&I stakeholders.

- As part of this network, digital infrastructures mapped out, organised and connected to support a data-driven approach, including federated materials data spaces for data exchange and exploitation along/across materials value chains that will guarantee data sovereignty and security while supporting societal and regulatory demands on traceability and transparency. (Data spaces will rely on the tools set for materials cited in Action 1 above).

- As part of this network, specialised technology infrastructures and pilot lines mapped out, organised and connected to take full advantage of the revolutionary advances in digital and physical technologies (like 3D printing, automation and robotics combined with AI) that are profoundly changing the game of materials innovation and processing. This will be particularly relevant to support SME's in developing and testing new materials and the respective production and processing technologies/solutions.

- Portfolio of innovation services available from the network of infrastructures covering R&I services but also the non-technical and complementary services such as product and service design, marketing strategy, business model development, access to private and public funding, networking… necessary to reach and capture new markets in a profitable and long-term way.

IMPACT

- Key contribution to the defragmentation of R&I resources, competences and services in Europe thanks to the setup of a unique and comprehensive network of infrastructures accessible to all advanced materials stakeholders, in particular to SMEs needing to quickly develop, scale-up and test innovations and successfully enter the market.

- Delivering on the opportunities of the digital transition, breaking down barriers to co-innovation, overcoming data issues for SSbD and life-cycle assessment, delivering on transparency and information requirements for citizens with a game-changing approach to accessing and sharing data and information on materials from inception to end of life and closing the loop (federated data spaces).

- Delivering on the opportunities of combining digital and physical technologies, like automation, robotics and AI, for instance, with key infrastructures like self-driving laboratories (Materials Acceleration Platforms – MAPs) to accelerate materials discovery via autonomous experimentation or dedicated demonstrators and pilot lines, integrating materials development/testing, production and processing (including end of use).

2.4. Outreach, dissemination and further exploitation

CHALLENGE

This action targets three main communication challenges to achieving the full scale and impact of AMI2030 initiative (contributing to main Challenges 1-4):

1. Reach citizens and consumers: individuals and NGOs should have an active and relevant role in the acceptance and implementation of AMI2030 goals and developments, both as consumers/customers of safe and sustainable products and as citizens/voters, demanding a better and long-lasting future. A structured dialogue is to be launched with the wider society, addressing the impact and interplay of Advanced Materials and civil society. Citizens and societal stakeholders will be consulted to learn how to address societal impacts, technology consequences, potential concerns in a trusted, well intelligible way. Best practices should be implemented for communicating; incorporate participatory methodologies for societal engagement and dialogue; integration between communities having different languages, objectives, and priorities. Best communication & dissemination practices developed in on-going or past projects will be explored. EU projects dealing with societal aspects and citizens' engagement will be approached, if necessary. The Green Transition demands considerable behavioural changes and it is very important that all stakeholders understand the scope and consequences of their choices and actions.

2. Reach all sectors and value chains: the cross-cutting nature of AMI2030 activities make them relevant and applicable to a large number of sectors and value chains, meaning that the related information needs to be disseminated to a large and diversified community and in several locations (especially considering the ecosystem of SMEs, more reachable at regional/local level). Organizations need to know and understand the new technologies and solutions to develop, produce and use Advanced Materials and the impact they can have in their business, particularly with regard to their economic and environmental sustainability.

3. Cross-fertilization and further exploitation: the work described in point 2 will generate multiple opportunities for cross-fertilization and further exploitation, bringing the results of the initial developments to other companies, sectors and geographies. Advanced Materials and supporting technologies will have to be transferred, adapted and adopted by other MIMs and beyond, benefiting and impacting a vast number of stakeholders and the most relevant European value chains. This large-scale upscaling will call for Open Innovation methodologies and practices, and demand multiple actions and support (funding) at all levels, particularly at national/regional level.

SCOPE

This Action will consist in two main streams of activities:

a) The first one will be a broader effort of information exchange, aiming at communicating the key enabling role of Advanced Materials in achieving the twin green and digital transitions, EU resilience and open strategic autonomy, targeting both citizens and industry. It will include:

- Development of a communication strategy and channels for information exchange with social, NGOs and citizens associations.

- Development of a communication strategy and channels for information exchange with industrial sectors, particularly with the 9 MIMs, in close cooperation with relevant sectorial organizations, hubs, initiatives and clusters.

- Publication of a white paper on the role of Advanced Materials and needs to achieve the twin green and digital transitions, EU resilience and open strategic autonomy.

- Publication of recommendations on the translation of excellent European R&I expertise into impactful Advanced Materials innovation.

b) The second activity stream aims at taking full advantage of the multi-sectorial nature of AMI2030, to promote its results and support their cross-fertilization and further valorisation by all interested sectors. This will boost the use of advanced materials to develop and produce more sustainable products, across the entire European industry (more sectors, more regions), and to create the conditions for the implementation of a widespread Circular Economy model within the European space. These objectives call for a multi-level, multi-disciplinary intervention that includes:

- A framework to promote and support Open Science and Open Innovation concepts and practices, namely the further development of programmes, initiatives and tools like the Horizon Results Booster platform and the Innovation Radar, plus the implementation of a fast and affordable European Patent mechanism.

- The broad dissemination of relevant results from research projects, (particularly the EU-funded ones), including at sectorial and regional level.

- The creation of funding and financing programmes to support projects that promote cross fertilization and further exploitation of research results and their uptake. Considering the number of sectors and geographies potentially involved, a combination of programmes and instruments at European, interregional and national/regional level needs to be used.

OUTPUT

- Public visibility and understanding of the relevance of advanced materials R&I in Europe, involving all stakeholders of the value chain, including SMEs, public organizations and citizens.

The development and deployment of a R&I roadmap can be enriched by utilizing effective channels for interaction with stakeholders and citizens, including Communities of Practice as recently launched by DG-RTD. These channels can support feedback loops on anticipated priorities and activities, incorporate the views and needs of stakeholders and citizens, and facilitate their effective involvement in implementing a safe and sustainable design, as well as promoting a circular economy of materials.

- Broad, fast and effective adoption of relevant results from European Advanced Materials programmes and investments, benefiting and impacting a vast number of companies, sectors and regions and fostering alignment on investments and priorities setting.

IMPACT

- Increased consumer and citizen's awareness (upstream) and acceptance (downstream) of new materials solutions to be launched and incorporated in future products and services. Enabling informed buying/consuming decisions.

- Enhanced materials knowledge-sharing across sectors and accelerated implementation and scale up of advanced materials solutions along value chains.

- Broad outreach of European Advanced Materials programmes and investments, paving the way for a better and more viable economy and society.

2.5. Support regulatory preparedness and contribute to an efficient implementation of key regulations, codes and standards supporting the design, development and uptake of Advanced Materials

CHALLENGE

Improving the consistency across various levels, including policies, standards/codes, and regulations, is crucial for expediting the development and market entry of new and enhanced advanced materials (contributing to Main Challenge 1).

The absence of a comprehensive definition of advanced materials, makes it difficult to regulate, and results in test guidelines being only partially applicable or meaningful. The most significant challenge is the discrepancy between the pace of innovation progress and regulatory preparedness. It is vital to ensure that regulatory readiness keeps up with the development process' dynamics. Inadequate and outdated regulation, which fails to reflect the complexity of the situation and adapt to new discoveries, can impede innovation rather than facilitate it (contributing to Main Challenge 1).

SCOPE

The implementation of key legislation relevant to advanced materials plays a crucial role in promoting efficiency and sustainability in the use of these materials. Instruments such as the Critical Raw Materials Act, OECD Test Guidelines, the SSbD Framework as part of the ChemicalsStrategy for Sustainability, the EU Eco-design Directive, REACH, the Single-Use Plastics Directive, the Circular Economy Action Plan, and the EU Waste Directive, all support the development of safer and more sustainable, circular, efficient Advanced Materials, also including their responsible use.

These instruments encourage the development of safer and more sustainable materials, as well as the adoption of more efficient production methods and the use of more environmentally friendly products. They also help to ensure that the materials are used in a way that minimizes their impact on human health and the environment and supports the transition towards a circular economy. They therefore play a crucial role in promoting efficiency and sustainability in the use of advanced materials, and in driving innovation in this field.

Digital aspects will increasingly impact innovation in Advanced Materials, as regulations such as the EU Eco design Directive and industry-specific regulations call for the establishment of Digital Product Passports, while the demand for a trustworthy dataspace for material-specific data along the value chain grows.

In the context of Advanced Materials, the challenge of the policy hierarchy of regulations, guidelines, and standards is even more pronounced. There is a requirement for Advanced Materials to develop frameworks and 'best practices' within and in support of legislation and regulation. Advanced Materials offer exciting new possibilities for a wide range of applications, from consumer goods to critical infrastructure. For example, the development of new materials that are lighter, stronger, and more durable than traditional materials have the potential to revolutionize many industries. However, there is a need for regulations to keep pace to stimulate the development of these materials and the potential benefits they offer, including ensuring that they are safe and sustainable.

Standards for advanced materials also play a critical role in ensuring the quality and performance of these materials. For example, standards may define the mechanical properties of a material, such as its strength, toughness, and ductility, or they may specify the environmental performance of a material, such as its resistance to weathering and UV radiation. In this way, standards and OECD Test Guidelines help to ensure that advanced materials are used in a safe and responsible manner, and that they deliver the benefits that they promise. OECD Test Guidelines (TGs) are internationally accepted standards for the safety testing of chemicals and materials; they support the implementation and enforcement of legislation. The development of TGs is essential for safe and sustainable innovation and the competitiveness of the industry.

The challenge of the policy hierarchy of regulations, guidelines, and standards for Advanced Materials lies in balancing the need for safety, sustainability and protection of humans and the environment with the need for innovation and progress. Effective policies must be based on factual scientific knowledge and practical considerations and must be flexible enough to accommodate new developments and changes in the market.

These activities have links with several programmes and initiatives such as- HSBooster.eu to help EU Projects with potential in standarization, EURAMET that address metrology and standardization needs of materials) the NanoSafety Cluster, the Malta Initiative, the IRISS project network, and the Working Party of Manufactured Nanomaterials (specifically the Steering Groups on Advanced Materials and SSbD Innovation Approach).

OUTPUT

■ A practical and impactful safe and sustainable by design framework for new materials early in the innovation process and pipeline, including pre-market safety and sustainability regulatory identification and science needs to **i)** improve the connection between innovation and regulatory policy and **ii)** guarantee that innovations can easily comply with regulations, optimize life cycles, and incorporate co-creation within value chains to support the European Innovation Principle and regulatory preparedness.

■ An inclusive EU-wide network for expert input on all relevant policy fields. The network will expand the Nano Safety Cluster's knowledge to advanced materials and connect with industry-specific policy networks. It aims to promote harmonization and international collaboration on regulatory frameworks, including risk and data governance. Experts will share insights to develop effective and inclusive policies for the safe and sustainable use of Advanced Materials.

■ Digital Material Passports as a necessity in dedicated Materials Innovation Markets: Digital material passports are crucial for traceability and accountability in advanced materials markets. They provide valuable information throughout the material's life cycle, supporting innovation and promoting transparency. Compliance with digital regulation is critical for the development of trusted digital platforms for material tracking and traceability.

IMPACT

■ Harmonized Standards and Guidelines: To ensure the safety and sustainability of Advanced Materials, harmonized testing methods and guidelines must be used. This includes characterizing and handling materials and assessing their impact on humans and the environment. Harmonization ensures consistency and reliability in testing across the many regulations and standards in the Materials Innovation Markets, facilitating the adoption of innovative materials and accelerating market and technological diffusion.

■ Linking policy to innovation. Creating a comprehensive inventory of relevant policies and regulations, and establishing collaborative processes and frameworks between policy makers, regulators, and innovators is essential to facilitate the compliance of advanced materials with legal and policy requirements. Feedback mechanisms guide regulatory R&I agendas and programs, aligning policy and innovation to develop compliant Advanced Materials.

■ Flexible and Adaptive Regulatory Environment: Regulatory sandboxes can test new regulatory boundaries for Advanced Materials, emphasizing circular economy business models. Feedback loops through co-creation processes can ensure agile and responsive policies. The goal is to support advanced materials growth and development while protecting health and the environment.

2.6. Education and Skills (Knowledge Management)

CHALLENGE

At a time when technological development runs at unprecedented speed and considering the broad scope of this initiative, education and training domain will represent a significant challenge (contributing to main Challenges 1-4).

Recent years showed the importance of adequate skills to ensure the successful and timely development and uptake of new technologies. Lack of skills is often identified as the main barrier to a faster and broader development and adoption of digital technologies, as borne out by the fact that the digital divide within Europe is still quite significant, as illustrated by the Digital Economy and Society Index (DESI).[13]

By covering the entire Advanced Materials value chain and most of its innovation cycle, AMI2030 will have to address 5 levels:

· **The researchers:** responsible for the development of the new technologies.

· **The developers:** those capable of developing the new products (materials, components, products, etc.), services, processes and business models, based on the research results.

· **The entrepreneurs:** this initiative will create significant opportunities to launch new high-tech start-ups or new product lines and business areas in existing companies, with the speed and flexibility to bring radical innovation to the market.

· **Policy makers and regulators/regulatory risk assessors:** get them prepared for innovations of Advanced Materials in the light of regulatory preparedness.

· **The consumers/users:** in several cases, consumers/users will also need to be informed and trained.

A large number of people will potentially be involved, calling for an effort of a scale that can only be matched by a combination of actions and policies on education and training at all levels (European, national and regional). This effort will particularly focus on connecting the different stakeholders at different levels in a coherent approach, for instance identifying and promoting a shared vocabulary to enable and enhance common understanding (contributing to main Challenge 4).

SCOPE

The main objective will be to identify specific needs (e.g., what kind of knowledge should new hires already have? What kind of training would be useful to offer?) and promote a common ground for education, training (including upskilling & re-skilling) and entrepreneurship related to Advanced Materials, in particular regarding the twin green and digital transitions. AMI2030 will promote international training and education to build a bridge between academia, science, policy and industry and expanded access to training and education (summer schools, industry workshops) for those in less developed regions.

The concept of Advanced Materials itself, the simultaneous development of Advanced Materials and the respective production processes (namely using digital twins), the development and utilization of common data spaces by relevant stakeholders, the applicable legislation and regulation, the new business models for sustainable circularity are only a few examples of topics that call for specific education and training activities.

By defining the relevant content for each one of the targeted groups and consolidating it under an integrated framework, aligned with the challenges and needs of the AMI2030 strategy and Action Plan, the outcome of this work will serve as a reference for the actions that need to be developed and implemented at the different levels and by different stakeholders and initiatives, paving the way for a more effective and efficient implementation of comprehensive, coherent and unified educational and training materials.

13 The Digital Economy and Society Index (DESI) | Shaping Europe's digital future (europa.eu)

This action will be mainly developed at European level. It has relevant complementarities and synergies with other initiatives and programmes, such as the Marie Skłodowska-Curie Actions and the EIT-KICs (particularly EIT Raw Materials and EIT Manufacturing), and its funding approach matches the characteristics of the CSA instrument.

OUTPUT

- Recommendations on educational programme content, mainly targeting the high-level education, namely the MSc and PhD and the new entrants into the labour market, providing the specific content needed for the development and uptake of Advanced Materials.

- Recommendations on skills and training programme content, that, in a similar way, address the Vocational Education and Training (VET) needs of the new entrants (students) and also the existing workforce, from both the materials and the manufacturing industries.

- Recommendations on entrepreneurship programme content that goes beyond standard skills on entrepreneurship and addresses AMI2030-specific challenges, including the complementary knowledge and methods that need to be integrated in the actionable skill set of the candidates, to increase their job market value. These points will include frameworks and tools for Advanced Materials in innovation and value chains, methodologies such as Safe and Sustainable by Design (SSbD) as well as circular economy, in which Advanced Materials will act as enablers and innovation catalysts.

- Recommendations on consumers/users' awareness and empowerment programme content, that provides this relevant group of stakeholders with the understanding of the importance of their contribution in examing the role of Advanced Materials in society and a common understanding of SSbD along different value chain steps, as well as the information and tools (particularly digital ones) needed to perform it.

IMPACT

- A unified, coordinated and pan-European approach to education and training on Advanced Materials, sharing and aligning on common contents and linking programmes along curricula and across competences.

- Existence of a European base of highly-skilled workers with all the necessary competences to secure a world-competitive landscape of talented resources, necessary to boost European investments in Advanced Materials R&I that will ultimately benefit Europe's economy and society.

2.7. Building a European Advanced Materials Innovation Eco-system

One major challenge in building up a comprehensive and cohesive ecosystem on Advanced Materials is to address jointly the **Advanced Materials value chain** (from materials development to end of use and recycling) and the **Advanced Materials innovation cycle** (from research to market uptake, including also education and training, standards, etc.) (contributing to main Challenge 4). This calls for the involvement of different sectors of economy and stakeholders, namely:

- Several sectors along the Advanced Materials value chain, namely materials developers, processing and manufacturing industries, operators/users recycling companies, etc.
- Technologies, systems and services providers (digital systems, machinery and equipment, engineering companies, etc.
- Research, innovation and education and training services.
- Supporting infrastructures and other services (research and technology infrastructures, clusters, etc.)

A high level of political and financial support is also needed to mobilize stakeholders, reducing the inherent barriers and risks, boosting private investments and combining policies, R&I programmes and funding instruments at all levels. Despite the significant steps already achieved in the last years towards a more integrated European funding and financing landscape, namely with the Smart Specialization Strategies, the creation of the EIC and with the recent publication on synergies[14], major efforts still need to be made, to take full advantage of new opportunities (contributing to main Challenge 2).

An ecosystem requires an efficient organisational structure in order to facilitate multi-stakeholder and multi-sectoral interactions. Also, Member States should have a place in the organisational structure.

SCOPE

AMI2030 will build upon those existing initiatives that mostly address the specific segments and scopes of the Advanced Materials value chain and/or of the Advanced Materials innovation cycle (Figure 5) to propose a complete and integrated framework, providing the entire community with a comprehensive reference model on how to achieve a holistic and integrated approach.

Interfaces will be defined, and the related collaboration areas detailed. During the development phase of the Strategic Research and Innovation Agenda, a cooperation strategy will be set based on:

- Identified gaps in existing initiatives and programmes in terms of Advanced Materials innovation uptake.
- AMI2030 action plan on identified gaps, crossing Materials Innovation Markets.
- Maximized impacts enabled by AMI2030 on the main objectives shared by most initiatives in terms of industrial competitiveness, sovereignty and autonomy and dual green and digital transitions.

14 https://www.horizon-europe.gouv.fr/enhancing-synergies-between-eic-and-startup-europe-24545

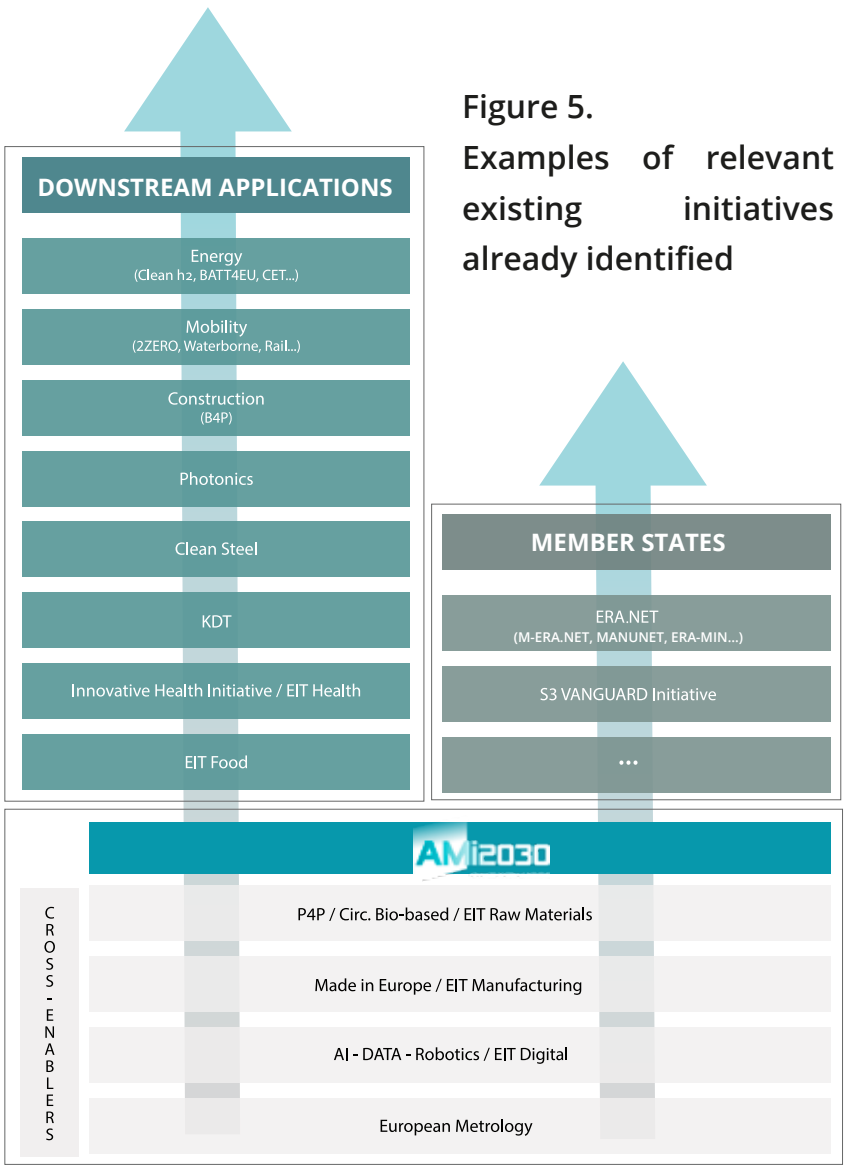

Figure 5. Examples of relevant existing initiatives already identified

This framework will also provide the necessary information to identify and mobilise the most relevant supporting policies (complementing the specific action described in 2.5), programmes and instruments. Building an adequate funding and financing landscape, capable of supporting multiple activities, at the right level and with the right characteristics, is crucial for AMI2030 objectives and foreseen impact.

Thus, AMI2030 will establish and ensure a long-lasting coordination:

- across application markets (MIMs) to identify and address strategic and cross-cutting needs and complementarities for maximizing impacts on European economy and jobs.
- along industrial sectors' value chains towards fast Advanced Materials uptake and circularity (from primary to secondary materials).
- between industry, research and the public sector (EC and MS) to maximize impacts across European and National R&I programmes and initiatives.

The development of this framework will be carried out mainly at European level, in close contact and collaboration with the different initiatives and programmes, including the interregional, national and regional levels and could be supported by funding instruments like CSAs.

OUTPUT

- Established synergies with partnerships linked with the MIMs (Energy, Mobility, Construction, Health, Electronics, etc.), incl. multilateral ones (i.e., across more than two partnerships). This will include collaborative roadmap activities, segmentation between sector-specific and cross-sectorial challenges, joint development or demonstration projects, dissemination and cross-fertilization activities, etc.

- Established synergies with partnerships addressing cross-cutting enabling technologies (P4P, Made in Europe, EIT, Metrology, etc.), incl. multilateral ones (i.e., across more than two partnerships). In this case, activities will be collaborative road-mapping, identification of existing technologies to be used by AMI2030, joint developments, etc.

- Established synergies across Regional, National and EU R&I programmes & funding, based on a joint endorsement of AMI2030's vision and SRIA by industry, research and the public sector, paving the way for a better coverage of the entire innovation cycle and also unleashing the full potential of AMI2030, by reaching a vast number of regions, intermediary organizations and sectors. This will also include interregional collaboration and programmes like ERA-NET, EUREKA, etc.

- Developed organisational form for multi-stakeholder interactions and management using research and experiences of the Nano-Safety Community.

IMPACT

■ More efficient and effective European Advanced Materials eco-system: by providing a complete and integrated reference model for the Advanced Materials area, populating it with the most relevant existing initiatives and stakeholders and defining the role of each one of them. AMI2030 will maximize their individual and collective contribution, minimize duplications and overlaps and ensure the conditions for the realization of its overarching objectives in the most efficient and effective way.

■ Coverage of the complete innovation cycle by the different funding programmes: the co-creation and implementation of policies, strategies and programmes will facilitate horizontal (namely between Horizon Europe Pillars) and vertical (European, national and regional levels) synergies and complementarities, providing stakeholders with a complete and comprehensive set of supporting programmes and tools.

2.8. International cooperation

CHALLENGE

Advanced Materials are a global industry with a high degree of complexity and internationalization in research, development, production, further processing and application, use, and end-of-life.

Europe's leading position is due to a long tradition of innovation in Advanced Materials, especially in the automotive, aerospace and healthcare sectors. But other regions have also recognized the key role of Advanced Materials and are promoting these technologies in a very targeted way.

The challenge for AMI2030 is to define the right focus in the selection of appropriate technologies in order to secure and further develop Europe's lead in selected Advanced Materials fields (contributing to main Challenge 2).

On the other hand, access to specific know-how must be ensured through suitable and balanced cooperation approaches, and win-win approaches must be sought (contributing to main Challenge 3). For example, the Materials Genome Initiative (MGI)[15] has been running for more than a decade in the US for discovering, manufacturing, and deploying Advanced Materials twice as fast and at a fraction of the cost compared to traditional methods.

The following challenges need to be addressed:

Regulatory barriers: Different regions have different regulations and standards for Advanced Materials, which can create challenges for companies looking to sell their products in international markets. Compliance with regulations and standards can be time-consuming and expensive.

Intellectual property protection: Protecting intellectual property can be challenging when entering international markets, as laws and regulations around intellectual property vary widely from country to country. Companies must navigate complex legal systems to protect their inventions.

Supply chain complexities: Advanced Materials often require complex supply chains with specialized equipment and materials. Companies must navigate logistical challenges when shipping materials and equipment across borders and dealing with customs regulations.

Competition: Advanced Materials is a competitive industry and companies must be prepared to compete with other firms from around the world. Local companies in foreign markets may have advantages such as established networks and government support.

15 https://www.mgi.gov

SCOPE

AMI2030 shares similarities with initiatives in other regions of the world, but also has its own unique priorities and areas of focus based on Europe's particular strengths and challenges. On top of intra-European collaboration, AMI2030 will also place emphasis on international collaboration, given the global nature of the Advanced Materials industry. The specific shape and scope of international collaborations will depend on a variety of factors, including funding, political priorities, and the industry needs.

International regulations and standard setting: AMI2030 will focus on regulations and standards for Advanced Materials and materials data management to ensure safety, sustainability, quality, and compatibility across different markets. The development of global standards will be extremely beneficial for a faster penetration of different markets with new materials.

Sustainability: with its focus on sustainability technologies, AMI2030 will contribute to Europe's leadership on climate change and environmental issues.

This type of activities will be developed in close collaboration with European and international organizations and initiatives such as Mission Innovation, OECD, the Research Data Alliance (RDA), the International Data Spaces Association (IDSA), the AMPT Network, IUMRS, IRISS International Network, and the Working Party of Manufactured Nanomaterials (WPMN) of the OECD (specifically the Steering Groups on Advanced Materials and Safe(r)-and-Sustainable Innovation Approach), and could be supported by funding instruments such as CSAs.

OUTPUT

Joint R&I programs for Advanced Materials with countries that commit to AMI2030 targets and EU political targets to help **i)** enhance scientific and technological cooperation between countries, leading to the development of new and innovative technologies, **ii)** improve the competitiveness of industries in different countries by developing Advanced Materials technologies for various applications and **iii)** address global challenges, such as climate change, by developing more sustainable Advanced Materials and contribute to reducing carbon emissions.

IMPACT

Increased international awareness of EU policy targets: The EU has set numerous policy targets in various areas, including climate change, digitalization, R&I, and trade. Increased international awareness of EU policy targets is essential to ensure that other countries and regions can have optimal alignment between their policy targets and the EU's own policies in order to support common goals.

Support of EU climate protection targets. EU has set ambitious targets regarding climate change. The EU aims to become climate-neutral by 2050. To achieve this goal, the EU has set intermediate targets, such as the reduction of greenhouse gas emissions by 40%, an increase in the share of renewable energies to 32% and a 32.5% improvement in energy efficiency by 2030[16]. Better communication with third countries on the respective climate targets and actions will improve coordination and knowledge sharing.

Acceleration of tackling global challenges. Internationalization plays a crucial role in solving global challenges, as many of these, such as climate change, resource efficiency and circular economy require global cooperation and coordination.

16 https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2030-climate-energy-framework_en#:~:text=Key%20targets%20for%202030%3A,share%20for%20renewable%20energyEN&text=At%20least%2032.5%25%20improvement%20in%20energy%20efficiencyEN

3. PROPOSED INSTRUMENTS & GOVERNANCE

3.1. Setting of instrument selection

AMI2030 aims to develop its unique profile in the landscape of already existing various initiatives, platforms and networks. The unique profile derives from the ambitious objectives and broad range of the activities of the initiative. The selection of appropriate instruments which must target the involvement of both industry and research stakeholders, preferably with the leadership of industry, will be influenced by several factors. Regarding these objectives and activities, three main factors can be identified:

- Involvement of the industry and research sectors
- Integration of non-classical material sectors, such as digital and manufacturing technologies, into the advanced materials sector, targeting integrated value chains.
- Focus on sustainability and the circular economy.

Additionally, the instrument(s) must be flexible enough to integrate additional relevant sectors and cover the most relevant stages of the innovation cycle. Finally, AMI2030 will create a common framework for European Research & Innovation on Advanced Materials - the “Materials Commons“.

3.2. Selection process and assessment

AMI2030 seeks to transform the European advanced materials sector sustainably. Thus, since the publication of the Manifesto, the objective of AMI2030 has been to institutionalise and channel the planned activities and collaborations into an instrument at European level. Given that the European Commission governs many existing types of funding programmes and initiatives within the Framework Programmes, a first approach has been to assess various existing instruments available to check which could provide the best fit to implement the planned initiative and in particular the specific actions (Ch.2). Various instruments under the Research and Innovation Framework Programme ‘Horizon Europe’ and Interregional Innovation Investments under ERDF were analysed. In total, 10 instruments were assessed as presented in the table below:

HE Pillar I	European Research Infrastructure Consortium (ERIC)
	Research Infrastructures Doctoral Networks;
HE Pillar II	Marie Sklodowska-Curie Action
	Co-Programmed Partnership
	Co-Funded Partnership
	Partnership under Article 185 TFEU
	Partnership under Article 187 TFEU
	Missions
HE Pillar III	European Innovation Ecosystems
	EIT Knowledge and Innovation Communities
Outside Horizon	Interregional Innovation Investments; ERDF

An evaluation was conducted based on 13 criteria (Annex 4) which will be relevant for the implementation of AMI2030, such as influence on agenda-setting, funding duration or addressed TRL which were weighted differently. The 10 instruments were finally ranked based on this evaluation. The best-ranked instrument that came out of the analysis was the co-programmed partnership. With its private-public focus, it provides a great option to involve and secure industry commitment to the partnership and to cover the most significant stages of the innovation cycle (TRL). Furthermore, the duration length of the *co-programmed partnership* and its degree of flexibility in the agenda setting would provide the initiative sufficient time and responsiveness to change the European landscape in the advanced materials sector sustainably. Moreover, considering the wide scope of the initiative's goals, selecting the partnership should assure the inclusion of potential partners at different levels (see table below) who could give decisive input for the implementation.

Industry, Research and Education	The participation of large companies and SME covering all MIMs pre-identified in the Manifesto and now partners of AMI2030 [17] is essential to end the fragmentation within the advanced materials value chain and to align it regarding the increasing complexity in the development and uptake of new materials to respond to societal and environmental challenges. Complementarily, the research sector builds the basis for the development of materials and supporting technologies. A close collaboration and exchange between both sectors are indispensable to respond to the variety of four main challenges described in Chapter 1.
European Commission	The European Union responds to the challenges of our time with policies and strategies, hence, having the European Commission as partner would allow AMI2030 to elaborate its specific actions in a collaborative way.
Member States	Involving the Member States brings another dimension into the initiative. It opens the door for certain stakeholders (such as the representatives of national governments, on ministerial or regional level depending on country governance) which would be left out if the initiative only operates on the European level. The Member States with their unique knowledge about their own regional funding landscape and specialization, bring specific insights into the initiative.
Society / Citizens	Since AMI2030 is intended to be an initiative for everyone and ultimately citizens will be affected above all by every decision, they will also make an important contribution to achieving the goals.

However, although the co-programmed partnership is promising with its characteristics to largely fulfil the abovementioned three factors, the assessment has shown that not all actions and deliverables can be covered by a single instrument.

Consequently, to implement all specific actions of AMI2030, more than one instrument on European level would have to be used.

17
https://www.ami2030.eu/partners/

3.3. The need for a new, custom-made funding instrument for Advanced Materials

Following the selection process and assessment (3.2), a two-pronged approach is proposed by which AMI2030 will become the interconnector for already existing funding initiatives and instruments on regional, national and European level:

It entails the creation of the European Ecosystem for Advanced Materials, bringing together all stakeholders along the entire material value chain and the innovation cycle (TRL 3-8). The AMI2030 Partnership will be the actual new and additional funding instrument between the European Commission and the Initiative AMI2030 (including Industry and Research stakeholders and universities).

The European Ecosystem for Advanced Materials, as an open and transparent forum to bring together, connect and provide a permanent platform for exchange between individual stakeholders and the leaders of regional / national / European funding programmes and initiatives is crucial to make sure that the challenges facing Advanced Materials are tackled. This will be done through the existing **AMI2030 initiative.**

Secondly, the **AMI2030 Partnership** which will be a new funding instrument bringing together matching funds from the European Commission and Industry. While the initiative AMI2030 will focus on TRL 3 – 8, it will deploy a variable configuration with respect to funding ratios from European Commission, industry and member states. In the lower TRL 3 – 4, regional and national programmes are most important topped up with European funding from e.g., Horizon Europe Pillars I and II, Digital Europe. In case of activities targeting TRL 5 – 6, which covers an important part in the upscaling and relevant environment demonstration, funding should be allocated in a balanced ratio between European level and industry. The closer we move to the market and leaving the pre-competitive environment, funding from public sources should be reduced while industry is stepping in to a larger extent, in TRLs 7 – 8.

Activities will consider the different steps of the advanced materials innovation cycle (and associated technologies), dovetailing upstream research with downstream applications from the advanced materials design phase over material processing and production and transformation into components or products to their recovery as secondary raw materials at the product end-of-use phase.

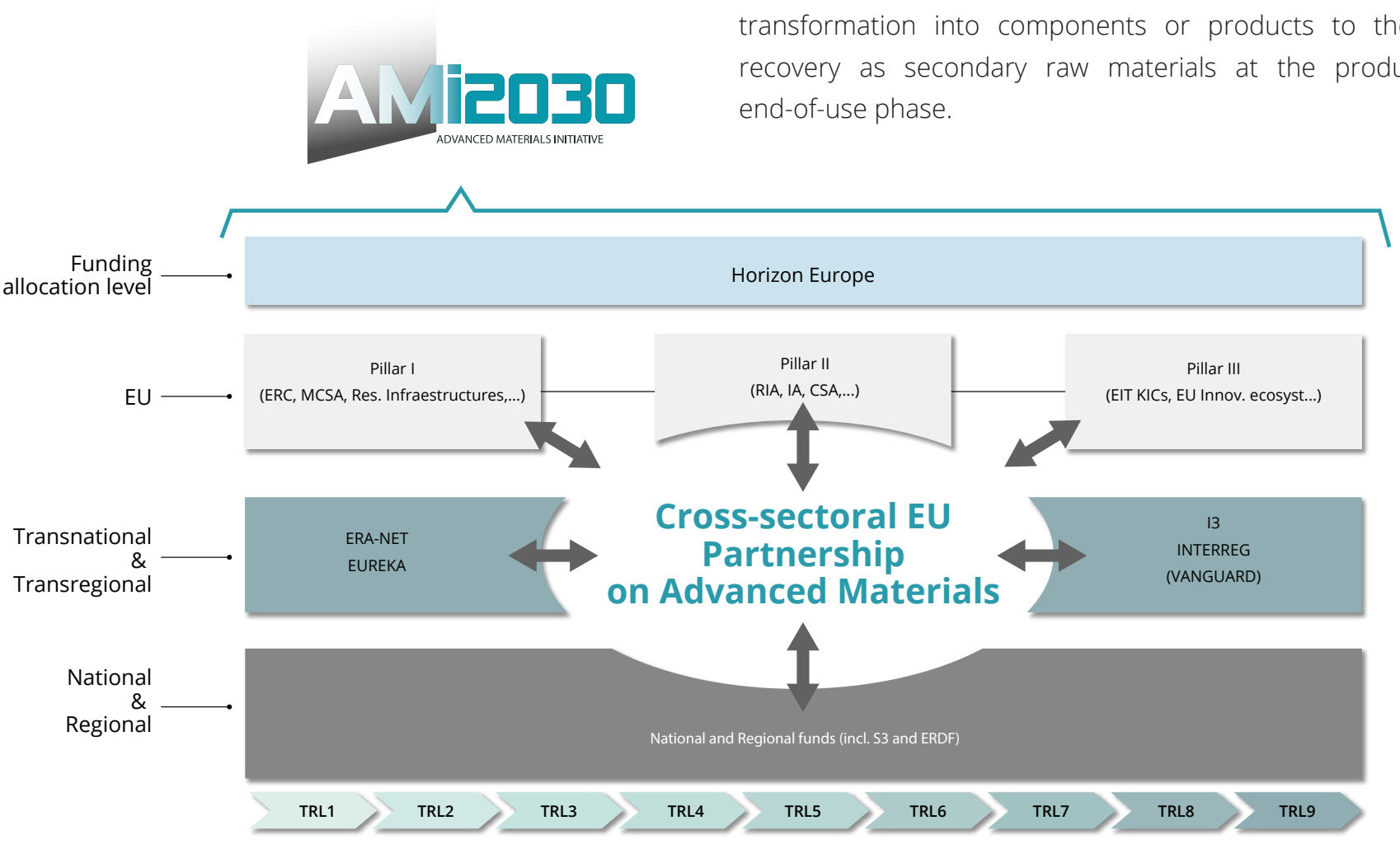

Figure 6: Overview of AMI2030 initiative (platform) and AMI2030 new and custom-made funding instrument

3.4. Governance structure

AMI2030 will provide a common and shared framework for all advanced materials stakeholders. By integrating all strands of stakeholders, from upstream developers, downstream users, citizens and all stakeholders in between, the initiative covers the full range of the supply chain and considers the different needs and challenges along the materials lifecycle. A well-structured governance will allow the involvement of the different stakeholders in the future AMI2030 Partnership. In the following, the main parts of the governance are described, although their name might be preliminary.

The **Steering Board** will be the head of the governance and will include secondees, who will represent the industry and research sector as well as the European Commission officials. Together, they will decide on the direction and challenge the development of AMI2030.

The **Core or Management Team** will be the working operational body within the partnership. Similar to the Steering Board, industry and research representatives will populate the Core Team to develop the right actions for the initiative based on the Steering Board's philosophy and decisions.

Under the coordination of the Core Team, **Working Groups** will elaborate the tasks in their respective field while they are guided by the Core Team. Appropriate working groups will be established according to needs evaluated during the establishment of the Partnership.

Additionally, an **Advisory Board** will consist of AMI2030 representatives, the European Commission and the Member States. Within the Advisory Board, the collaboration between Member States shall be fostered to ensure the relation between European level and the national/regional level. Furthermore, other initiatives (Part 2.) will be invited to nourish an efficient and enriching cooperation among the existing initiatives, on both European and regional level. This can involve establishing regular communication and collaboration between industry, government, and academia, creating working groups or committees to facilitate information sharing and identifying common interests.

The **Multi-stakeholder platform** will be the guarantee to include other existing platforms and initiatives which have a stake in advanced materials, whether through a specific application area or where advanced materials have a substantial impact on their objective (e.g., stakeholder groups particularly dependent on advanced materials). The Multi-stakeholder platform will be established through an open call for expression of interest and will convene at least twice a year. It will consist of two parts: a technical one, and a non-technical part to assure a structured exchange with both the technique-driven initiatives as well as with the Societal stakeholders (non-technical), addressing the impact and interplay of advanced materials with civil society.

The technical component of the multi-stakeholder platform should be a balanced representation of platforms/initiatives including SMEs from diverse sectors, geographical and gender background. SMEs are a vital component of the materials industry and a driving force for the development of advanced materials due to their flexibility, innovation, and adaptability, which allow them to respond quickly to changes in market demand and emerging trends and to their significant contribution (65%) to the overall employment in the business economy[18].

The non-technical component of the multi-stakeholder platform will include individual people, NGOs, regulators, legislators, and standard-setting bodies. They will have a relevant role in the public awareness, acceptance and implementation of AMI2030, both as consumers/customers of safe and sustainable products and as citizens, demanding a better and long-lasting future.

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18 Annual Report on European SMEs 2021/2022 SMEs and environmental sustainability Background document

3.5. Operational guiding principles

At the operational level, AMI2030 will strive to implement the following guiding principles.

- Agility of processes
- Common framework and organisational form
- Multi-stakeholder involvement incl. synergies with other initiatives and engagement with regulators & legislators

Agility of processes

A shared vision between the AMI2030 community, the EC and Member states regarding main challenges, priorities, activities and needed resources will pave the way to a more efficient and effective supporting landscape, namely in the area of funding and financing programmes and instruments.

Common framework and organisational form

The initiative aims at providing a common framework (the so-called **'Materials Commons'**) for all stakeholders supporting their collaboration on advanced materials in a systemic approach across different innovation markets. An efficient organisational form is needed to facilitate multi-stakeholder engagement.

Multi-stakeholder involvement

Thanks to the Materials Commons, the **multi-stakeholder platform** will mobilise resources and actors to leverage the interplay between advanced materials, digital technologies, production technologies and circular economy strategies collaboratively.

A key success factor of AMI2030 will be the input of the different stakeholders and an appropriate balance between Research and Industry. Stakeholders from research and industry will share their knowledge, expertise, and concerns and will work together on a common framework of the advanced materials sector in Europe. Their participation in a balanced manner will ensure that the activities will not drift into a narrow TRL range.

Engagement with regulators, legislators, and standard-setting bodies is a critical component of AMI2030. By collaborating with these stakeholders, progress towards political targets can be achieved more effectively.

AMI2030 will build on existing know-how, gather complementary knowledge and expertise and collaborate in key areas (*see table below*). Some basic assessment of AMI2030's collaboration needs with the different initiatives is given in Annex 4. A finer assessment based on the key domains will be done at a later stage.

Technology and Markets	Common/shared technology reviews, GAP analysis, KPIs definition Common/shared market reviews / Statistical data
R&I activities	R&I Programs alignment Complementary/joint calls Projects clustering
Innovation Uptake	Policies and incentives alignment Financial support and investment opportunities Joint initiatives (Techno infrastructures)
Education & Skills	Policies alignment Gaps analysis >Education & training courses Joint initiatives
Regulation, Codes & Standards	Priority actions Implementation support

3.6. Transparency and openness

All companies, organizations, associations, institutes and universities regardless of their size and origin, will be welcome to bring value to AMI2030 and their contribution will be taken into account. AMI2030 will be designed so that openness is a key aspect and a quality contributor; therefore, no artificial barriers or fees shall prevent any entity to participate in the initiative.

The open design requires a transparent leadership of the initiative. Transparency ensures credibility and is seen as an important factor for efficient processes in all stages of the implementation of AMI2030 and facilitates the onboarding of new partners and interested parties during the application process of funding. All achievements and results which are linked to AMI2030 will be publicly accessible and will be widely disseminated.

3.7. Societal engagement

The societal scope of initiative is the “DNA” of AMI2030 and stems from the vision of AMI2030: for people, for environment, for prosperity.

Several measures will be undertaken to guarantee societal engagement, e.g.:

- workshops/sessions that integrate/merge citizens’ visions in distinct societal needs in certain MIMs (e.g., materials for construction to respond to feasible and sustainable housing)

- Workshops/sessions that integrate/merge the ideas and input of young people with distinct societal needs in certain MIMs. These can be organised in schools in form of competitions.

- integrate and work together with social science academic experts to cover the impact of advanced materials on society.

4. ANNEXES

4.1. European policy and regulatory framework

The four objectives presented in Part 2.3.2 will contribute to the implementation of important EU policies and strategic actions, in particular the **"New Industrial Strategy for Europe"**, the **"European Green Deal"** and **"a Europe fit for the digital age"**, globally leading the way out of the crisis and building a greener, more digital and more resilient Europe.

A key policy initiative that determines the regulatory landscape supporting the European Green Deal is the **Circular Economy Action Plan (CEAP)**[19] adopted by the European Commission in March 2020. The CEAP aims to ensure that the regulatory framework is streamlined and fit for purpose to achieve a sustainable future, and that new opportunities from the transition are maximised. The plan sets out initiatives that, among other things, facilitate the uptake of circular practices, products and technologies across industries and service sectors. It recognises the role of circular technologies in that they deliver "material savings throughout value chains and production processes, generate extra value and unlock economic opportunities."

Another main component of the European Green Deal is the EU action plan **"Towards Zero Pollution for Air, Water and Soil"**[20]. It sets out a vision for the EU that by 2050 air, water and soil pollution should be reduced to levels no longer considered harmful to health and natural ecosystems, thus respecting our planetary boundaries. While mainstreaming pollution prevention, the plan targets a significant reduction of total waste generation and a 50% reduction of residual municipal waste.

The set of **EU waste related regulations**[21], including the Waste Framework Directive, Directives on packaging waste, end-of-life cars, batteries, electronics, and landfill waste are another important driver for closing the loops in the EU economies. In addition, other waste related regulations, such as on packaging waste and preventing international shipment of waste, are currently being revised, in line with the ambitions of the CEAP. Furthermore, the European Commission is set to work on a targeted revision of the Waste Framework Directive. All these measures support circular waste management practices and recycling, bringing waste streams back in the loop as a secondary resource. They have set (or plan to set) mandatory targets for the reuse, recycling, and other methods of material recovery for certain types of industrial waste reuse.

The Industrial Emissions Directive (IED)[22] has been one of the most important pieces of environmental legislation that regulates pollutant emissions and thus promotes clean technologies. The IED aims to reduce harmful industrial emissions in the EU, setting out the requirements, which industrial installations need to fulfil based on the application of best available techniques (BATs) in different sectors. The directive applies to large installations of the chemicals, metals and ceramics sectors, as well as cement and textile production. It sets out limit values for atmospheric pollutants and emissions to water and soil. In line with the zero-pollution action plan and the CEAP, the Commission proposal of April 2022 to revise the IED broadens the scope of the directive to increase the investments in new, cleaner technologies that also improve energy use, resource efficiency and water reuse.

As set out in the CEAP, the **Sustainable Product Initiative**[23] of March 2022 put forward several legislative proposals that aim to make products placed on the EU market more sustainable. This initiative affects all industrial ecosystems.

The Commission proposal for a new **regulation on ecodesign for sustainable products**[24] is the cornerstone for the EU's approach to more environmentally sustainable and circular products. It will set a wide range of requirements, including on **i)** product durability, **ii)** reusability, **iii)** upgradability and reparability, **iv)** substances that inhibit circularity, v) energy and resource efficiency, **vi)** recycled content, vii) remanufacturing and recycling, **viii)** carbon and environmental footprints, and **ix)** information requirements, including a digital product passport. The proposed new legislation has a significant implication for technological development, as all changes promoted by this legislation will require a massive uptake of technical, and digital solutions, as well as reinventing managerial, logistical, and customer relationship practices.

Along with the Ecodesign Regulation the Commission adopted a proposal for a **Directive on Empowering Consumers for the Green Transition** (March 2022),[25] and is preparing **legislation on green claims for products,**[26] to provide a more harmonised approach for providing reliable environmental information, increasing simplification and reducing administrative burdens, especially for SMEs. These instruments aim to ensure consumers get adequate information on a product's environmental performance, e.g., durability and reparability before purchase. In addition, they will strengthen consumer protection against untrustworthy or false environmental claims and premature obsolescence practices. While these legislative acts do not address technology directly, they help create a favourable environment for circular products and technologies.

The Commission is also proposing a review of the **Directive on packaging and packaging waste** to increase the essential requirements for packaging and establish EU-wide measures and targets for preventing packaging waste. This proposal aims at fully harmonising rules on packaging while tackling negative impacts on the environment and health from packaging and packaging waste. It also aims at ensuring **i)** the free movement of packaging and packaged goods, **ii)** a market for secondary raw materials that works effectively, **iii)** support for compliance with recycling targets for packaging, and **iv)** a reduction in the generation of packaging waste, including by reducing (over) packaging.

The updated **Industrial Strategy**[27] aims to transform the European industry, making it greener and more digital, while remaining competitive on the global stage and avoiding critical dependencies. The strategy also identifies a series of factors to support industrial transformation and partnerships to help industries achieve climate neutrality, to build a more circular economy, and to foster a spirit of industrial innovation among others.

In doing this, the new policies aim at spurring innovation, rewarding frontrunners, helping level the playing field, and help provide long-term investment certainty. All of the above will impact Advanced Materials.

19 COM (2020) 98 final; https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en
20 COM (2021) 400 final; https://environment.ec.europa.eu/strategy/zero-pollution-action-plan_en
21 https://environment.ec.europa.eu/topics/waste-and-recycling_en
22 Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control), OJ L 334, 17.12.2010, p. 17
23 https://ec.europa.eu/growth/industry/sustainability/sustainable-product-policy-ecodesign_en
24 COM (2022) 142 final.
25 COM (2022) 143 final
26 https://ec.europa.eu/environment/eussd/smgp/initiative_on_green_claims.htm; adopted on 30 November 2022
27 https://ec.europa.eu/info/sites/default/files/communication-industrial-strategy-update-2020_en.pdf

4.2. Cross-cutting needs on Advanced Materials production and processing

PRIORITIES	TOPICS
Resources usage optimization and decarbonization	Reduce energy consumption Electrification and incorporation of renewable energy sources in processes Optimize efficiency (energy management) Minimize water usage/consumption (including recycling) Wastewater treatment to prevent environmental contamination. Reduce the use of hazardous chemicals in manufacturing processes and replace them with safer alternatives (green chemistry) Separation process optimization CO2 capture, storage, conversion, use Hydrogen production (with low-carbon footprint), use Set/adjust process characteristics to materials properties, including by on-line (continuous) process monitoring
Integrated Product Design and Engineering (materials, products and processes)	Incorporating SSbD into product development, including designing for maintenance, recyclability, disassembly, etc., and end-of-life management. Optimizing product life span and durability. Holistic assessment of the product's environmental impact from cradle to grave Use of sustainable chemicals
Mass customization and fast response	Increased consumer integration Reconfigurable, flexible and modular processes (engineering, production and logistics), including the supply-chain (management)
Zero defect production	Increased in line product and processing monitoring and feedback to control New, more accurate and inte lligent sensing systems to collect relevant data Simulation at laboratory scale of potential failure mechanisms, accelerated tests, feedback to the process Process and Product tracking along the complete value chain
Processes for multi-materials and new materials	Design methods & tools of materials properties Multi-materials production, joining/assembling & de-assembling Multi-materials 3D/4D printing New or more efficient production and processing technologies, namely for: 1. flexible, transparent polymer/resins; 2. bio-based (including bio-based and/or biodegradable materials as feedstock – Bio and waste based); 3. nanomaterials New materials production and processing, complying with circularity and safety requirements AI based high throughput screening methods
Processes for circularity	Rapid and cost effective assembly, de-assembling, repairing, de & re-manufacturing, recycling of materials, multilayer or hybrid, including re- & de-functionalization Waste valorization processes with emphasis on complex materials mixtures Resilient use of trusted secondary materials (including tracing from sourcing) Catalysts (including biobased)
Instrumentation and metrology for characterization, monitoring and control	Standardisation, protocols, regulation (properties, toxicology, safety, etc.). Characterisation Data and Information Management along the materials value chain and lifecycle Production and processing monitoring and control – tools and methods
Flexible Supply Chains and Marketplaces	Platforms for extended advanced materials marketplaces (including recycled and alternative materials) Platforms for collaborative products/components end-of-use forecast and management (as feedstock for recycling)

4.3. Needs for collaboration across initiatives

AMI2030 will strengthen and bring together ongoing initiatives for the convergence of Advanced Materials technologies towards a sustainable future, building on existing know-how and gathering complementary knowledge and expertise. A basic assessment of the needs for collaboration across initiatives, and across AMI2030 specific actions, was done and presented in the table below in terms of large or targeted scope. This preliminary assessment will be discussed with respective to initiatives and is subject to revision in order to jointly i) set a collaboration map; ii) further assess key domains for collaboration as listed beside; and iii) check if any clustering of needs makes sense between AMI2030 and more than one other initiative (multi-lateral collaboration) on any of the key domains.

Key domains for collaboration

Technology and Markets

R&I activities

Innovation Uptake

Education & Skills

Regulation, Codes & Standards

		Specific actions							
	Initiative	A1	A2	A3	A4	A5	A6	A7	A8
Cross-enabling Initiatives	EIT Raw Materials								
	Made in Europe								
	Process4Planet								
	Circular Bio-based Europe								
	EIT Manufacturing								
	AI - DATA - Robotics								
	EIT Digital								
	European Metrology (EURAMET)								
	European Open Science Cloud								
Downstream/ Aplicative initiatives	2Zero, B4P, BATT4EU, Clean Energy Transition, Europe's Rail, ZWET, Clean Aviation								
	Clean Hydrogen								
	KDT, Photonics								
	Clean Steel								
	Innovative Health Initiative EIT Health								
	EIT Food								
MS-driven initiatives EU networks CSA actions	M-ERA.NET, MANUNET, ERA-MIN								
	S3 Vanguard Initiative								
	ELN - European Lightweighting Network								
	Nano Safety Cluster								
	Malta Initiative								
	IRISS Network								
	EMMC								
	Others to be assessed	RDA		DSSC		RDA		RDA	RDA

A1 - Exploit game-changing technologies for faster development of scalable advanced materials solutions

A2 - Develop advanced materials technologies with lower environmental footprint and circular business models

A3 - Support innovation uptake and access to infraestructures and services

A4 - Regulations, Codes and Standards (RCS) Strategy Coordination

A5 - Education & Skills (Knowledge management)

A6 - Paving the way (building) an European AdMat Innovation Ecosystem

A7 - International cooperation

A8 - Outreach, dissemination and further exploitation

Large scope

Targeted scope

4.4. Evaluation criteria for instrument pre-selection

The first evaluation of existing instruments was based on 13 general criteria which can be divided under the general categories' governance, financing, operations and innovation (see table below). The instruments were firstly evaluated based on the criteria and every instrument was scored from 1 to 5 against the criteria, depending on how the criteria will positively contribute to the implementation of AMI2030. 1 represents the lowest score, 5 the highest. Afterwards, the score of the criteria was multiplied by the weighing which was allocated to the different criteria. This was done since not all criteria were seen as equally important for AMI2030.

Criteria		Description of criteria	Weighting of categories
Governance	Influence on agenda-setting	How much influence does the initiative have on the agenda setting?	3
	Prescribed governance	Is there flexibility of a governance scheme?	3
	Legal base	What is the legal basis between partners and EC, MS.	3
	Preparation intensity	How extensive is the preparation of the instrument before implementation?	2
Financing	Budget sourcing	Where is the budget coming from?	3
	Funding size per project	What funding volume can be allocated per project?	2
	Funding conditions	What kind of co-funding is required?	3
Operations	Pace of implementation	Earliest possible set-up date?	3
	Funding duration	How many years will the initiative be funded?	3
	Business flexibility	Is an adjustment of the planned activities during the implementation possible?	2
	Reporting	How intensive is the reporting?	1
	Partnering regulations	What entities have to be involved?	3
Innovation	Addressed TRL	Which TRLs are covered by the instrument?	3

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