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Advanced Materials for Industrial Leadership

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Advanced Materials for Industrial Leadership

1. INTRODUCTION

With this Communication the Commission sets out a European strategy to ensure industrial leadership in advanced materials, a key enabling technology. Materials have shaped human development ever since the stone age. Thanks to today's scientific understanding and computing power, materials with a superior performance or special functions can be developed with unprecedented speed. **These intentionally designed and engineered materials are referred to as *advanced materials* by the OECD** ([1]).

Advanced materials are an important factor for the competitiveness of European industries ([2]) and are crucial building blocks for the **EU's resilience and open strategic autonomy.** They are included in the list of 10 critical technology areas for the Union's economic security ([3]).

Advanced materials offer a wealth of solutions for a successful implementation of the European Green Deal. They drive innovations in new clean energy technologies provided for in the Net-Zero Industry Act and have the potential to substitute certain Critical Raw Materials (CRMs), thus contributing to the objectives of the CRM Act. Advanced materials can also replace hazardous substances, improve the environmental performance of products and processes, and facilitate circularity. They therefore enhance the transition of our economy and industry in many ways; contributing to the chemicals strategy for sustainability, the circular economy action plan and the implementation of the 'Fit for 55' legislation. They are also essential in the context of the Chips Act given their role in the next generation of semiconductor technologies. Advanced materials also play a paramount role in areas such as space and defence, with enhanced properties in harsh environments, increasing the safety, security and protection of personnel and allowing the functionality of equipment and strategic infrastructure. They also have potential applications in agriculture (such as for the replacement of pesticides), agri-food (such as for packaging) or in pharmaceuticals and healthcare. This Communication will be complemented by the forthcoming initiative on biotech and biomanufacturing in the move towards alternative feedstock to produce advanced materials and increase the use of renewable sources and materials for their production.

([1]) Advanced materials are understood as materials that are rationally designed to have (i) new or enhanced properties, and/or (ii) targeted or enhanced structural features with the objective to achieve specific or improved functional performance. This includes both new emerging manufactured materials (high tech materials), and materials that are manufactured from traditional materials (low tech materials). OECD working description on advanced materials https://one.oecd.org/document/ENV/CBC/MONO(2022)29/en/pdf

([2]) Materials 2030 Manifesto https://www.ami2030.eu/wp-content/uploads/2022/06/advanced-materials-2030-manifesto-Published-on-7-Feb-2022.pdf

([3]) Critical technology areas for the EU's economic security for further risk assessment with Member States, C(2023) 6689 final

The demand for advanced materials is expected to significantly increase in the coming years ([4])**,** for instance for the production of renewable energy ([5]), batteries ([6]), zero-emission buildings ([7]), semiconductors ([8]), medicines and medical devices, satellites, space launchers, planes, or for other dual-use applications as well as defence equipment.

Europe needs to deliver on the twin transition to **maintain its global industrial leadership and achieve open strategic autonomy.** To contribute to this objective, the EU should: **(i) accelerate its research and technology development in advanced materials; (ii) scale up its innovation and manufacturing capacity; and (iii) accelerate the industrial uptake of advanced materials.** This requires the creation of an environment that builds on existing strengths, retains research and innovation investments and production in the EU, and drives competitiveness, resilience and growth in advanced materials and manufacturing.

The **overall objective of this Communication** is therefore to create **a dynamic, secure and inclusive ecosystem for advanced materials in Europe** that both ensures leadership in research and fast-tracks innovations to the single market. To achieve this:

(1) EU, national and regional priorities on research and innovation for advanced materials must be coordinated in a European approach and private investments substantially increased;

(2) innovators and small and medium-sized companies must be supported to design and test materials with superior performance and properties for circularity and sustainability;

(3) the larger-scale and more rapid deployment of advanced materials must act as market catalysts for the twin transition and increase EU resilience and economic security.

2. CHALLENGES FOR CREATING AN INCLUSIVE ECOSYSTEM FOR ADVANCED MATERIALS

To meet these objectives Europe needs to address the following challenges:

(1) **Fragmentation of the research and innovation (R&I) ecosystem**: The EU has traditionally led the world in materials science, enabled through both: (i) strong support under national programmes covering different application domains; and (ii) the EU framework programmes for R&I. However, only a small minority of Member States have specific materials strategies, while others address materials research in general national programmes. In the absence of a joint and coordinated strategy, public resources on R&I in advanced materials are fragmented and do not sufficiently strengthen EU competitiveness and innovation capacity in the twin transition and for EU resilience.

(2) **Private investments are not commensurate to increasing needs:** The Green Deal industrial plan underlines the need for the EU to ensure its capital markets can

([4]) Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/386650, JRC132889

([5]) European Wind Power Action Plan, COM(2023) 669 final

([6]) https://environment.ec.europa.eu/topics/waste-and-recycling/batteries_en

([7]) https://www.consilium.europa.eu/en/press/press-releases/2023/12/07/fit-for-55-council-and-parliament-reach-deal-on-proposal-to-revise-energy-performance-of-buildings-directive/

([8]) Chips Act (EU) 2021/694

support the volume and variety of funding needed by EU companies in strategic sectors. The EU industrial R&I investments on advanced materials are not even half of those in the United States of America (EUR 19.8 billion investment in 2020 compared to EUR 50.3 billion), closely followed by South Korea and Japan (with EUR 19.6 billion, EUR 14.0 billion respectively), with lower investments by Chinese industry (EUR 7.7 billion([9]). Moreover, the EU's global position in industry-owned patents is weakening and ranks fifth, behind the US, Japan, South Korea and China in 2019([9]).

(3) **A lack of progress in circularity and material efficiency**: The EU circular material use rate is currently stagnating below 12% ([10]) and R&I on materials is still not focusing enough on circularity, for example due to lack of in-depth knowledge of material flows. Sustainability and circularity are important to enhance the transition of our economy and industry and to maintain competitiveness of our companies on the global market. They are key to achieve the goals of the Ecodesign for Sustainable Products Regulation and the Critical Raw Materials Act. New advanced materials should strive to be 'safe and sustainable by design' ([11]) to achieve the Green Deal's ambitions for zero pollution and a toxic-free environment.

(4) **Long innovation processes and an insufficient level of digitalisation**: The time needed to develop advanced materials with conventional methods can take between 10 and 30 years ([12]). The digitalisation of research and development has the potential to accelerate the discovery of innovative materials, and Europe could benefit from better exploitation of digital tools in this area. For example, the power of artificial intelligence recently helped researchers to predict nearly 400,000 stable crystal structures, paving the way for significant progress in the fields of clean energy and electronics ([13]). The speed and complexity of innovation is increasing, and significant capital investment is required to upscale and manufacture advanced materials.

(5) **Disconnect between innovative research and uptake in industrial applications and processes:** The gap between groundbreaking research and industrial application leads to limited collaboration and strategic alignment, hindering the integration of advanced materials into industries. Without strong links and synergies between industrial needs and research ambitions, the European Union's position as an innovation leader is at risk, leaving industries struggling to use advanced materials solutions.

(6) **A lack of testing and experimentation facilities**: Technology infrastructures with facilities for experimentation, prototyping, testing and piloting help bring products to the market faster. Tech industries, notably start-ups and Small and Medium Enterprises (SMEs) often cannot afford in-house infrastructure and therefore need better access to such facilities to be able to validate and optimise new and essential

([9]) Industrial R&D&I investments and market analysis in advanced materials https://research-and-innovation.ec.europa.eu/document/8f77caee-3a2c-4ef9-8ca2-65fd6c900581_en. Figures include industrial advanced materials investments excluding the pharmaceutical sector.

([10]) Eurostat https://ec.europa.eu/eurostat/web/circular-economy/monitoring-framework

([11]) Establishing a European assessment framework for 'safe and sustainable by design' chemicals and materials (EU) 2022/2510

([12]) Muench, S., Stoermer, E., Jensen, K., Asikainen, T., Salvi, M. and Scapolo, F., *Towards a green and digital future*, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/54, JRC129319

([13]) Peplow, M., *Google AI and robots join forces to build new materials*, Nature, 2023, doi:https://doi.org/10.1038/d41586-023-03745-5, https://www.nature.com/articles/d41586-023-03745-5

technologies before commercialisation. To spread excellence across Europe and support broader participation in the European Research Area, it is important to connect existing infrastructures in different regions and support their smart specialisation ([14]).

(7) **Need for harmonised standards:** Standards are particularly relevant in: (i) building investor and consumer trust and confidence in new innovative solutions; and (ii) enabling digitalisation. For example, progress in the digital transition is hampered by proliferation of diverging approaches to digitalisation, e.g., data description and formats. To promote market uptake and ease the regulatory process, it is equally, important to ensure the harmonisation of standards for materials characterisation, materials performance and safety and sustainability assessment methodologies.

(8) **A lack of skills**: Increasing the innovation capacity and production of advanced materials requires EU-based technical skills of researchers and workers across a variety of disciplines. However, labour and skills shortages, as reported under the Green Deal industrial plan ([15]), doubled between 2015 and 2021 in sectors considered key for the green transition. This is amplified by the under-representation of women in Science, Technology, Engineering, and Mathematics (STEM) sub-fields that are highly relevant for advanced materials. Increasing the pool of professionals is especially relevant for deep and clean tech, skilled founders are needed for start-ups ([16]), as well as for upskilling researchers and workers in making use of digital tools, including AI.

Against this background, this Communication is structured around five pillars: (i) European R&I on advanced materials: a launchpad for the twin transition, EU resilience and open strategic autonomy; (ii) fast track from lab to fab; (iii) increasing capital investment and access to financing; (iv) fostering the production and use of advanced materials; and (v) the overall governance framework.

3. EUROPEAN R&I ON ADVANCED MATERIALS: A LAUNCHPAD FOR THE TWIN TRANSITION, EU RESILIENCE AND OPEN STRATEGIC AUTONOMY

To accelerate the deployment of clean technologies and deep tech innovation in Europe, achieving EU resilience and open strategic autonomy in critical technologies, targeted public and private funding for blue sky and applied research plays a key role. This calls for defining between EU Member States, Associated countries and stakeholders common objectives and priorities to: (i) foster innovation and manufacturing capacity on advanced materials; (ii) strengthen the European scientific and industrial base; (iii) reduce dependencies on critical resources and (iv) seek synergies on activities related to advanced materials across all sectors.

Europe will benefit from an inclusive ecosystem for advanced materials in which stakeholders can work together, scattered and uncoordinated initiatives are avoided, and knowledge sharing and peer-learning activities are encouraged.

A joint strategic approach will also facilitate dynamic coordination and alignment on key objectives. Such a joint strategic approach will promote cooperation, mutual learning and

([14]) https://ec.europa.eu/regional_policy/policy/communities-and-networks/s3-community-of-practice_en

([15]) A Green Deal Industrial Plan for the Net-Zero Age, COM(2023) 62 final

([16]) Tübke, A., Evgeniev, E., Gavigan, J., Compañó, R. & Confraria, H.: Leveraging the Deep-Tech Green Transition & Digital Solutions to Transform EU Industrial Ecosystems, European Commission, Seville, 2023, JRC133774

the development of mutually beneficial R&I strategies for advanced materials. As part of the activities of the Technology Council (see section 7), and in line with the Horizon Europe strategic planning process, the Commission will work with Member States and countries associated to Horizon Europe to **draw up a set of common objectives and priorities for advanced materials R&I**, starting with energy, mobility, construction and electronics as preliminary priorities to be extended regularly to other areas depending on common needs identified. Table 1 exemplifies for these preliminary selected areas the corresponding research and innovation priorities. Annex 1 provides a full outline of corresponding research and innovation priorities, developed with Member States and industry stakeholders. The criteria for selecting these and possible future areas include the capacity to reduce emissions and resources use, enhance energy efficiency, improve recyclability as well as their relevance to reduce EU's dependencies, strengthen resilience and increase competitiveness. Once common priorities will be agreed, Member States will be encouraged to coordinate strategies, taking into account their national and regional endowments, and ensure complementarity with the agreed priorities for the implementation.

Table 1 Preliminary R&I priorities for strategic areas, see annex for more details.

Strategic area	Advanced materials R&I priorities
Energy	Materials needed for conversion and generation of renewable and low carbon energy, energy storage and increased energy efficiency
Mobility	Materials for energy storage and use, robust, lightweight materials for transport means and assets, protection and durability, circularity and environmental performance, ability to perform in harsh environments
Construction	Materials for more energy efficient buildings, more robust building structures and structural integrity monitoring, enhanced wellbeing in buildings, materials increasing circularity and improved environmental performance
Electronics	Materials for improved performance and new functionalities of electronic components, sensors, novel computing concepts, chips production, greater efficiency in the next generation of communication technologies and ability to perform in harsh environments

One of the key strategies is the substitution of CRM and reduction of their use, in order to improve material efficiency and reduce dependencies on critical resources. The Commission will seek to identify what **R&I is needed to help promote the substitution of CRMs** with alternative advanced materials. The substitution analysis will be performed in close collaboration with the Strategic Energy Technology (SET) Plan Implementation Working Groups addressing materials. It will be aligned with substitution needs as identified in the Critical Raw Materials Act, and benefit from the Raw Materials Information System ([17]).

The Commission and Member States will:

- *define common objectives and priorities for R&I investments for advanced materials and develop by the end of 2024 a joint strategic approach for advanced*

([17]) RMIS - Raw Materials Information System (europa.eu), https://rmis.jrc.ec.europa.eu/

materials to support EU twin transition, resilience and open strategic autonomy, to be updated regularly to take into account socio-economic, scientific or technological developments.

- *update regularly the priority areas to take into account socio-economic, scientific or technological developments, or following the further identification of common needs for joint action.*

The Commission will:

- *identify additional R&I needs for the substitution of Critical Raw Materials with advanced materials with first results in Q1 2025.*

4. FAST TRACK FROM LAB TO FAB

Following the objectives of the Green Deal industrial plan, the New European Innovation Agenda, Digital Europe and the EU Economic Security Strategy, activities in the current chapter aim to accelerate the scale up and manufacturing capacity (from lab to fab) of advanced materials, addressing all the stages of development of advanced materials. The aim is to help boost digitalisation, improve access to testing and experimenting facilities, creating a paradigm shift that shortens the overall innovation process and time to market for innovation on advanced materials.

An overarching goal is to create a long term sustainable **European digital infrastructure for advanced materials R&I, the materials commons ([18]).** This digital infrastructure will help researchers and innovators to significantly accelerate the design, development and testing of new advanced materials in a controlled environment, supported by AI tools. The material commons must be trustworthy for all stakeholders, including researchers, research organisations, industry and SMEs, and based on FAIR ([19]) principles. It will take into account safety and sustainability by enabling access to data and tools based on technologies such as artificial intelligence. To help build the materials commons, the Commission will join efforts with Member States, and will explore the possibility of **launching a European Digital Infrastructure Consortium** ([20]). It will build on experience acquired with research infrastructures and the European Open Science Cloud ([21]) (EOSC) and ensure efficient synergies with European data spaces such as the Manufacturing Data Space and EOSC, with national strategies and initiatives, such as MaterialDigital ([22]) and Diadem ([23]), and with EU funded projects like BIG-MAP ([24]) which develops a materials acceleration platform for batteries. The materials commons will foster common materials taxonomies, ontologies and data interoperability, while also supporting both the virtual design of materials and the digitalisation of manufacturing processes. To create synergies and opportunities for spin-ins, this European Digital Infrastructure Consortium should be accessible across sectors.

([18]) Materials 2030 Roadmap
https://www.ami2030.eu/wp-content/uploads/2022/12/2022-12-09_Materials_2030_RoadMap_VF4.pdf
([19]) Findable, Accessible, Interoperable and Reusable
([20]) Establishing the Digital Decade Policy Programme 2030, (EU) 2022/2481
([21]) https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/open-science/european-open-science-cloud-eosc_en
([22]) https://www.materialdigital.de/
([23]) https://www.cnrs.fr/en/pepr/pepr-exploratoire-diademe-materiaux
([24]) https://www.big-map.eu/

Provisions under the Data Act and the Data Governance Act set the ground for interoperability between different platforms, such as those mentioned above. These provisions should enable the **connection of R&I digital spaces with sectorial and regulatory data spaces.** Achieving a circular economy requires optimised interoperability among data infrastructures to promote in-depth knowledge on material flows. Furthermore, the ability to trace materials, components, and products based on factors such as composition, qualities or grades will be essential for appropriate identification and classification. The forthcoming digital product passport will contribute to this traceability goal.

Technology infrastructures, including open innovation test beds (OITBs) and digital innovation hubs, play a key role in helping to commercialise innovation in advanced materials ([25]). These technology infrastructures offer facilities, equipment and capabilities with which industrial players can explore new products, processes and services, while ensuring compliance with EU regulations. Currently there are OITBs operating in the areas of energy, construction and electronics. The mobility sector could also benefit from OITBs to assess the recyclability, durability and safety of advanced materials. The Chips Joint Undertaking has launched calls ([26]) for pilot lines for cutting-edge and next-generation semiconductor technologies where materials are addressed as a key innovation driver. However, an analysis identified large regional differences in terms of financial support, fragmentation, risk of duplication and transnational access difficulties for companies across Europe seeking to access technology infrastructures ([27]). To address these issues **a single-entry catalogue will be launched online** to provide guidance to companies on how to access existing technology infrastructures supported by the Commission and Member States, including also the services they provide. This online catalogue will also make it easier for technological industries and SMEs to access the testing facilities and encourage networking among technology infrastructures. The central website will also include information on financial support available at EU and national level. An analysis of industry needs will be carried out, with the objective of **identifying gaps and proposing, where needed, new technology infrastructures** relevant to advanced materials.

To encourage the further deployment and industrial uptake of Horizon Europe results in the field of advanced materials, **dedicated outreach activities**, including matchmaking events for industry and academia, will be regularly organised as part of Horizon Europe dissemination and exploitation activities.

The Commission and Member States will:

- *develop a long term sustainable European digital infrastructure for advanced materials R&I, - the 'materials commons'- by mid-2025, aimed at accelerating the R&I processes for advanced materials.*

The Commission will:

- *help innovators and SMEs to access relevant technology infrastructures, by 2024, with a single-entry catalogue for testing and upscaling innovative advanced*

([25]) https://op.europa.eu/en/publication-detail/-/publication/0aaf1e05-2082-11ee-94cb-01aa75ed71a1/language-en/format-PDF/source-289339785
([26]) https://www.chips-ju.europa.eu/Pilot-lines/
([27]) Technology infrastructures https://op.europa.eu/en/publication-detail/-/publication/0df85f8b-7b72-11e9-9f05-01aa75ed71a1

materials focusing in particular on the key areas identified in the annex; and examine with stakeholders the possibility of funding new OITBs for applications of advanced materials related to mobility.

5. INCREASING CAPITAL INVESTMENT AND ACCESS TO FINANCE

The increase of public and private funding and investment for research and deployment of advanced materials will be key. The Commission will explore the whole set of tools available to increase and facilitate investments and develop innovative funding possibilities bringing together public and private resources.

To strengthen the EU's strategic cooperation with industry, **a new co-programmed public-private partnership 'Innovative Materials for EU' has been proposed under Horizon Europe ([28])**. This partnership should offer the opportunity to unlock private capital, doubling the EU's expected contribution of EUR 250 million for 2025-2027, allowing to scale and accelerate the deployment of advanced materials.

Important projects of common European interest (IPCEI) enable Member States to cooperate in breakthrough innovations or large-scale infrastructure projects in key sectors and technologies, funded from their national budgets, preserving the integrity of the Single Market and respecting EU's international obligations. An IPCEI could cover the first industrial deployment of new technologies but not mass production. In autumn 2023 the Commission has set up the Joint European Forum for IPCEI (JEF-IPCEI). The forum, which is a partnership between the Commission and Member States, aims to increase the efficiency and effectiveness of IPCEIs as an instrument for industrial competitiveness, by (i) aligning potential new IPCEIs with the EU's objectives or strategies such as the EU industrial strategy, and (ii) improving the process, speed, design and implementation of IPCEIs, according to State aid rules. The JEF-IPCEI will explore the opportunity of IPCEIs for developing advanced materials with a view to leverage more funding for first industrial deployment of **R&I** results through public and private investments. ([29]).

The **Innovation Fund** ([30]) aims to bring to the market solutions to decarbonise European industry and support its transition to climate neutrality, with a budget of EUR 40 billion available from 2020 to 2030 (assuming a carbon price of EUR 75/CO2). In the context of the manufacturing of clean technologies equipment (renewable energy installations, including their connection to the grid, electrolysers and fuel cells, energy storage solutions, and heat pumps), the Fund can support the manufacturing of materials (except mining materials) that contribute significantly to the reduction of GHG emissions. Selected projects so far address, for instance, lightweight solar panels, innovative roof components for buildings, or thermoplastic lignin production. Activities relating to recycling or reusing critical materials to be used in clean technologies equipment or components thereof can also supported by the Fund, with the current open call providing EUR 4 billion for net-zero technologies ([31]).

([28]) https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/commission-proposals-new-candidate-european-partnerships-are-now-public-2023-07-17_en

([29]) At the JEF-IPCEI technical meeting of 26 January 2024, Member States were invited to examine potential IPCEIs on areas advanced materials.

([30]) What is the Innovation Fund? - European Commission (europa.eu), https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund/what-innovation-fund_en

([31]) https://ec.europa.eu/commission/presscorner/detail/en/IP_23_5948

The **Strategic Technologies for Europe Platform (STEP) ([32]) is expected to enter into force in March 2024**. STEP aims to boost investments in critical technologies across the digital, clean and biotech sectors. Advanced materials are anticipated to be part of the scope. Investments are expected to be carried out using existing funding instruments, such as the Horizon Europe Programme, the European Defence Fund, InvestEU or cohesion policy funds and the Recovery and Resilience Facility plans. The first projects funded under STEP can be expected towards the end of 2024.

The **European Innovation Council (EIC) work programme ([33])** for 2024 continues to support innovation in advanced materials innovation with EUR 132 million related to the twin transition. The work programme also plays a key role in nurturing the EU innovation ecosystem for advanced materials. The 2024 work programme includes the EIC Challenges addressing relevant innovation in the areas of concrete production, nanomaterials, and solar-to-x technologies as well as scale up innovations in the areas of quantum components and renewable energy sources. The EIC brings together large corporations with start-ups, scaleups and research projects, integrating innovation on advanced materials directly into their business models.

The European Enterprise Network ([34]) will facilitate connections with potential funding partners via matchmaking events. Additionally, it will continue to **help innovative SMEs** by disseminating information about relevant European/national legislation, as well as about national/regional/European funding and support programmes, through workshops and training sessions.

InvestEU is the EU's instrument for catalysing private investments in EU priority areas, making it well placed to boost investments in advanced materials within the EU. The European Investment Bank already approved in 2023 an Invest EU operation ([35]) for a fund that will invest in early-stage hardware companies with focus on innovation in advanced materials.

The Capital Markets Union (CMU) aims to open new sources of funding for businesses and to improve the access to finance, especially SMEs, thereby providing an important potential source to finance private investment in advanced materials. This should benefit innovative companies investing in advanced materials.

The **Global Gateway** ([36]) sets out a climate-neutral strategy to speed up sustainable development, by investing in developing infrastructures that are clean, climate-resilient and aligned with pathways towards net zero emissions, while providing a level playing field for potential investors. Advanced materials are crucial to achieve such objectives, and the Global Gateway offers opportunities to increase their deployment at international scale. The Global Gateway Business Advisory Group will serve as a forum to have a strategic exchange with private sector representatives. In addition, advanced materials will also be put on the agenda of bilateral Global Gateway exchanges with Member States, the European Investment Bank and European Bank for Reconstruction and Development.

([32]) https://commission.europa.eu/strategy-and-policy/eu-budget/strategic-technologies-europe-platform_en
([33]) https://eic.ec.europa.eu/eic-2024-work-programme_en
([34]) https://een.ec.europa.eu/
([35])https://www.eib.org/en/products/egf/index?sortColumn=projectsSignedDate&sortDir=desc&pageNumber=0&itemPerPage=10&pageable=true&la=EN&deLa=EN&orCountries=true&orBeneficiaries=true&orWebsite=true
([36]) See JOIN(2021)30

The Commission and industry will:

- *mobilise under a co-programmed Horizon Europe partnership EUR 500 million, of which industry should contribute at least EUR 250 million to match the EU contribution;*

The Commission and Member States will:

- *work closely within the Joint European Forum for IPCEI on potential IPCEIs related to advanced materials;*

The Commission will:

- *boost the development and scale up of advanced materials with EIC support and investments, fostering start-ups engagement into advanced materials;*

- *reinforce, leverage and steer public and private investments in technology development and deployment for advanced materials through EU instruments, in particular the Innovation Fund, STEP and InvestEU.*

6. FOSTERING THE PRODUCTION & USE OF ADVANCED MATERIALS

The use of advanced materials must be promoted to improve the Union's resilience and competitiveness and achieve circularity, materials efficiency and overall sustainability targets. To enable industry to produce these new advanced materials, there is a need for adequate standards to facilitate industrial uptake and an increase of the pool of skilled professionals. Advanced materials demand can be reinforced through informed procurement and engagement of regional players.

By creating stable public demand and opening up markets **public procurement** has a crucial role to play in fostering the uptake of advanced materials. Public procurers can play a leading role in driving innovation and should assess the value added of new enablers like advanced materials for the twin transition and EU's resilience and economic security. For instance, the 2023 Energy Efficiency Directive ([37]) requires that public procurers should only purchase products, services, buildings and works offering high energy efficiency performance. More generally, the EU Public Procurement Directives allow contracts to be awarded not only based on lowest price, but also on other criteria linked to the subject matter of the contract, such as improved performance / functionalities provided by advanced materials.

The Commission also launched its "**Big Buyers Working Together**" ([38]) project to support collaboration between public buyers with strong purchasing power and to promote the wider use of strategic public procurement for innovative and sustainable solutions. Sharing information about advanced materials within the "Big Buyers Working Together" and advising public procurers on how to make them safe, sustainable and fit for circularity can help to open new markets more quickly and reduce the costs of available innovations. By working together and pooling their resources, cities, central purchasing bodies, and other major public buyers can maximise their market power.

([37]) Energy Efficiency Directive, (EU) 2023/1791
([38]) https://public-buyers-community.ec.europa.eu/about/big-buyers-working-together

There is also a need to analyse the production and use of advanced materials within the European industrial sectors and Single Market. The set up of a dedicated **monitoring process** will help to identify leading innovations and technologies, analyse supply chains, and assess the potential economic impact and contribution of these materials to the twin transition, EU resilience and competitiveness. It will determine, categorise, and measure the evolution and uptake of advanced materials innovation. It will offer insights into Europe's position in the global landscape of advanced materials, enabling an in-depth comparison with key global players such as the US and China. Such monitoring process should be performed in cooperation with the proposed new Horizon Europe public-private co-programmed partnership "Innovative Materials for EU.

Standards offer a basis for the integration of technologies into complex, innovative systems and solutions. Standards enable interoperability between components, products and services, mitigating vendor 'lock-in' and providing more choice for customers globally. The Commission Recommendation for a Code of Practice on Standardisation ([39]) is key to strengthening the link between research, innovation and standardisation. The pilot Standardisation Booster([40]) provides services to Horizon Europe projects to increase the uptake of new technologies resulting from standardisation activities. To promote the adoption of EU and international standards for advanced materials, the Commission will collaborate with internationally recognised standardisation bodies including CEN/CENELEC/ETSI, ISO including through the proposed new Horizon Europe co-programmed partnership "Innovative Materials for EU". The objective is to systematically identify existing standards and identify gaps and resulting priorities and to launch standardisation requests based on the analysis.

It is important to ensure that innovations in advanced materials are compliant with existing regulations and fit for purpose, this makes it necessary to put in harmonised **methods and assessment tools for the characterisation and testing** of advanced materials. It is also important for these harmonised methods and assessment tools to have gained regulatory acceptance. When developing a product, it is key that manufacturers are also aware - as early as possible - of the **regulatory requirements** that concern them, such as requirements on the protection of human health and the environment as well as recyclability. A major challenge in this area is that advanced materials can have unique properties that are not necessarily well understood in the context of existing toxicological or environmental studies. For these reasons, it is also relevant that regulators are informed and understand the latest innovations. For example, the upcoming sustainability requirements under the Ecodesign for Sustainable Products Regulation will consider innovation on advanced materials innovations and support the uptake of these innovations. For this uptake to be successful, adequate tools and methods to describe and share relevant information need to be in place.

In line with the Commission Communication on making the most of the EU's innovation potential ([41]) it is important to analyse the identified challenges in the area of **patents,** and more generally the protection of **intellectual property rights**, specifically for the advanced materials sector where a new study published on R&I industrial investments ([42])

([39]) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023H0498&qid=1678171117168
([40]) https://www.hsbooster.eu/
([41]) https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52020DC0760
([42]) Industrial R&D&I investments and market analysis in advanced materials https://research-and-innovation.ec.europa.eu/document/8f77caee-3a2c-4ef9-8ca2-65fd6c900581_en

shows the EU is losing ground in this area. It is therefore essential to encourage developers of advanced materials to make best use of the guidance for knowledge valorisation. To build better insight into the reasons for EU weaknesses in patenting, the Commission will perform an **analysis of the patent landscape and the needs of industry**. This analysis will also explore the need for an intermediary to centralise and manage scattered patent rights in the field.

New **skills** are needed in the areas of innovative methods, tools and the design and development of new materials. Skills in this area are specially needed in materials science, chemistry, engineering and information technologies. Multidisciplinary skills are also needed. These skills need to be identified and to feature in national education and training systems. This includes, for example, the development and promotion of corresponding curricula and vocational education and training programmes for upskilling the future and current workforce. Efforts should be made in particular to harness women's talent by addressing their under-representation in Science, Technology, Engineering, and Mathematics (STEM) studies. In the same vein this is also relevant for persons with disabilities. The Pact for Skills is playing a central role in preparing workers for the jobs of tomorrow, including in sectors using advanced materials, by bringing together public and private organisations to upskill and reskill people in the skills in demand.

A competitive call between the different Communities of the European Institute of Innovation and Technology (EIT) will be launched in 2024 for the establishment of an **Advanced Materials Academy**, which in total receive a seed-funding of EUR 10 million. The proposed action responds to New European Innovation Agenda ([43]) Flagship 4 on deep tech talents and follows the patterns of the Net Zero Industry Academies. The academy will develop curricula equipping the next generation of material scientists with the new skills required, offering as well support to the education and training providers and develop credentials for voluntary use by Member States. It will cooperate with Centres of Vocational Excellence to provide high quality skills leading to employment and career-long opportunities, as well as with Member States and the European University Alliance to facilitate the uptake of new curricula in national education systems.

The Commission will:

- *mobilise the "Big Buyers" community management authorities under regional funding and players in the global gateway to stimulate advanced materials innovation markets through public demand;*

- *launch an Advanced Materials Academy with the European Institute of Innovation and Technology based on a competitive call in 2024, to accelerate the development of curricula and credentials for skills in the sector;*

- *improve the development and setting of standards on advanced materials for areas and cross-cutting characteristics listed in the annex in collaboration with CEN/CENELEC/ETSI and ISO in 2024;*

([43]) https://research-and-innovation.ec.europa.eu/strategy/support-policy-making/shaping-eu-research-and-innovation-policy/new-european-innovation-agenda_en

- *launch studies to perform an in-depth analysis of production and use of advanced materials, as well as of the patent landscape by 2025.*

7. OVERALL GOVERNANCE FRAMEWORK

Advanced materials are designed, developed and used in many different applications and across scientific and industrial sectors. A coordinated approach involving the different actors in Europe be they from academia, industry, funders or policy makers, requires a common reference body. Equally the implementation of the actions listed in this Communication requires a strategic steer by Member States and industry players at all levels to both successfully agree upon the details of the actions and oversee their implementation.

The Commission will therefore set up a **Technology Council for advanced materials ([44])**. This Council will be composed of Member States (ministries in charge of research and sectorial/industrial policy), research and industrial stakeholders and the European Commission. It will provide advice on the European advanced materials ecosystem, support the identification of common objectives and priority areas for coordinated action in advanced materials, responding to the first action announced in this Communication, taking into account all relevant activities on advanced materials in the EU. It will also ensure adequate participation of countries associated to Horizon Europe and, where relevant, other third countries with which the EU has concluded Strategic Partnership Agreements. The Technology Council will involve social partners and integrate knowledge from the relevant Industrial Alliances, the European Industrial Forum, the Strategic Energy Technology (SET) Plan groups and relevant Horizon Europe partnerships.

Additionally, the Technology Council for advanced materials will discuss and build synergies with regional innovation valleys, which aim at the development and deployment of mature innovation; with smart specialisation strategies (S3) under the European Regional Development Fund, and the S3 Community of Practice thematic partnerships, under which regions identify their competitive advantages, their unique strengths and their capabilities to strengthen their capacity for high-quality R&I ([45]).

The Technology Council will also discuss international partnerships, by nurturing excellence and global leadership in advanced materials through dialogue and cooperation with partner countries. The EU has association agreements as well as cooperation agreements in science and technology, with countries that have strong expertise in this area. Further engagement can be sought with other countries in well targeted areas. These agreements will be based on reciprocal openness, the upholding of fundamental values and level playing fields, notably through Horizon Europe and its successor throughout whole R&I cycles, as set out in the Global Approach to Research and Innovation Communication ([46]). Advanced materials are also covered by the annex to the Commission

([44]) To this end the Commission will set up an expert group in accordance with the Commission Decision of 13 May 2016, C(2016)3301 final.

([45]) The area of advanced materials has been identified by several Member States and regions as a S3 priority in the 2021-2027 period. For example, Greece has a thematic priority on "Materials, Construction & Industry" and Austria a priority on 'Materials and intelligent production'. At regional level, advanced materials are S3 priorities, e.g., in West Netherlands (NL), Skåne County (SE), Bucharest (RO). These priorities translate into specific projects: Latvia has launched a project on Smart Materials, Photonics, Technologies, and Engineering Ecosystem, and Slovenia has the MATPRO project focusing on materials and their production to create value chains and networks for joint developments in this field.

([46]) Global Approach to Research and Innovation, COM (2021) 252 final

Recommendation on critical technology areas for the EU's economic security for further risk assessment. In line with the Economic Security Strategy, measures taken can address the need to protect, promote or partner.

The Technology Council will consider all available evidence, including outcomes of the analysis performed on monitoring the production and use of advanced materials. It will also assess the possibility for the Commission or Member States to establish regulatory sandboxes ([47]), that can pave the way for simplification of the process of authorisation/certification for placing advanced materials in the market.

The Commission will:

- *set up the Technology Council on advanced materials in 2024, to advise on steering this initiative with Member States, Countries Associated to Horizon Europe and industry.*

8. CONCLUSIONS

Advanced materials are essential for Europe's prosperity, open strategic autonomy and for the green and digital transition. While the EU still holds a strong position in material science, other key players are strategically increasing their investments in this area and are well placed to adopt and deploy with scale and speed technologies based on advanced materials.

This Communication systematically addresses the EU's advanced materials ecosystem through a combination of 14 mutually reinforcing actions accompanied by a concerted strategy at EU, Member States and industry level. The proposed actions address the entire value creation, spanning from early-stage research to deployment and market uptake. To design, develop, produce and use advanced materials in Europe, the strategy proposes a dynamic and inclusive materials ecosystem, involving Member States, researchers, innovators and industry.

Together these actions will pave the way for :

a) a more coordinated and responsive European ecosystem for advanced materials leveraging public and private investments in strategic areas;
b) new economic opportunities for EU companies relying on these critical technologies or willing to test them in their innoavtion process; and
c) a larger-scale and more rapid deployment of advanced materials as market catalysts for the twin transition, reinforcing EU resilience and open strategic autonomy.

([47]) As foreseen under the Net Zero Industry Act and the New European Innovation Agenda

ANNEX

This annex provides a preliminary list of research and innovation priorities which have been identified through consultation with Member States as particularly relevant for joint action in the area of advanced materials for a successful European twin green and digital transition: energy, mobility, construction and electronics. This list of priority areas will be updated regularly to take into account socio-economic, scientific or technological developments, or following the further identification of common needs for joint action.

The inherent qualities of advanced materials make it indeed possible for them to drive innovation characterized by the principles of: Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Renew and Recover. These priorities should help to meet industrial and societal needs as identified in this communication, aligned with political priorities.

I. Energy

Needs for this area are to be determined in four categories: energy conversion/generation, storage, distribution and transmission grid and renewable fuels.

a) **Renewable and low carbon energy conversion and generation:** this may include advanced materials to improve the durability of devices to convert renewable energy sources (RES); catalysts; coating and impermeability; improve environmental operating conditions (e.g., corrosion resistance); improve conversion efficiency in different RES (e.g., photovoltaics panels, wind turbines or heat pumps).

b) **Energy storage systems:** this may cover advanced circular and more sustainable materials for energy storage technologies like electrochemical technologies (e.g., batteries and supercapacitors), thermal and thermochemical technologies (e.g., phase change materials), or chemical ones.

c) **Energy distribution and the transmission grid**: this may concern advanced materials to increase the efficiency and capacity, reliability and durability of the energy distribution and transmission grid (e.g., high performance coatings protecting infrastructures against corrosion, friction, icing or other solutions with alternative materials).

d) **Renewable fuels:** this may cover advanced materials to produce sustainable fuels, like renewable fuels of non-biological origin and synthetised fuels, addressing the environmental footprint. One of the main challenges is to develop catalysts that are sufficiently active, stable, and low in cost to produce renewable fuels or chemicals in large quantities and at low cost.

II. Mobility

Needs for this area are to be determined in four categories: energy storage needs for transport modes, lighter and more robust means of transport and infrastructures and greater circularity and improved environmental performance.

a) Energy-storage and alternative fuels for different means of transport. For example:

- **advanced batteries (e.g., solid-state)** characterised by higher efficiency, reduced environmental footprint in their production, reduced use and sustainable substitution of critical raw materials, improved safety profile, better durability, performance, higher energy density, and greater recyclability;

- **fuel cells systems** for hydrogen, ammonia and/or methanol with much higher efficiency and focus on waste heat recovery solutions; electrolysers; catalysts.

b) Advanced high-performance materials for lightweight, able to perform in harsh environments, highly reliable and durable transport applications. For example:

- **advanced - lighter - materials** that combine reduced energy consumption with increased safety (e.g., for vehicle occupants as well as for pedestrians, cyclists and other users);
- **advanced composite materials and structures** for vehicles, aerostructures and engine components, including high-performance thermoplastics, adaptive systems, multifunctional requirements (e.g., soldering or processes to reliably join different materials).

c) Increased protection, resilience and durability for transport means and infrastructures. For example:

- **Coatings and paints,** increasing their durability as well as decreasing fuel consumption - relevant for aerospace, waterborne, automotive and road markings;
- **Hybrid manufacturing processes** (e.g., combining extrusion-based additive technologies and automated fibre placement), joining technologies, surface treatments and automated quality inspection/control for large primary aerostructures and engine components.

d) Increasing circularity and addressing environmental performance of materials. For example:

- better materials for **safe and sustainable use** (e.g., recyclable and/or biodegradable composites, batteries and electronics uses in all transport modes);
- new materials that further reduce the **environmental footprint and increase the resilience of transport infrastructure** (e.g., lower lifecycle impact, circular use, longer lasting/more resistant materials for roads/rail tracks, less impact on biodiversity; tyres and breaks with low particulate matter emission);
- **cost-efficient maintenance and repair** of advanced composites, superalloys, coatings, hybrid and adaptive structures for transport applications.

III. Construction

Needs under this chapter are determined under four categories: improved energy efficiency of buildings, more robust and longer lasting buildings, greater wellbeing in buildings, materials to improve circularity and address environmental performance.

a) Improving energy efficiency in buildings. For example: composite foams, thermal insulation and storage materials, integrated energy systems.

b) Making buildings structures more robust and longer lasting and better monitoring of structural integrity. For example: composite materials including graphene-enhanced concrete, lightweight materials, new materials for 3D printing and additive manufacturing, materials for pre-fabrication and modular

construction, materials, and self-monitoring, self-healing or self-protecting materials.

c) **Greater wellbeing in buildings.** For example: materials for increased comfort, noise reduction, materials for lighting, dynamic optically transparent and glazing technologies, transparent oxide-based electronics, electrochromic, thermochromic, gasochromic, photochromic materials, and anti-soiling, anti-ice, anti-slip, anti-corrosion **or** superhydrophobic treatments.

d) Materials **to improve circularity and address environmental performance.** For example: novel bio-based coatings, paint formulations, wood-based insulation, adhesives and composite materials in buildings, and addressing the global warming potential of such materials linked to buildings and their deconstruction.

IV. Electronics

Needs under this chapter are to be determined with a focus on chips, electronic components and systems Needs will be identified under the following two headings:

a) Advanced materials for **better performance, including specific characteristics to perform in harsh environments, reduced energy consumption and new functionalities of electronic components** (for applications in different areas). These advanced materials should also cover: sensors, novel computing and memory concepts, power electronics, communication (including signal transmission and thermal management for the next generations of 5G & 6G networks and beyond), flexible electronics, optoelectronics, photonics and quantum components.

b) Advanced materials for **new chip** production and packaging technologies, including wafers and substrates beyond silicon for enhanced efficiency (for applications in different areas like energy, power and communication), enhanced durability, sustainability and circularity, and reduced dependency on CRMs.

CROSS-CUTTING CHARACTERISTICS

The **digitalisation** of R&I in advanced materials (with data infrastructures, digital modelling tools, common data analytics/ontologies and artificial intelligence) has the potential to accelerate the discovery of new innovative materials by enabling the analysis of vast datasets, enabling the interpretation of data from various characterisation techniques, improving modelling, and by suggesting composition or structure of new materials. This will all serve to strengthen Europe's competitiveness.

At the same time, implementing the **'Safe and Sustainable by Design' concept** will be at the core of the material transformation process. This is a paradigm shift towards advanced materials that contribute to safety and sustainability, while at the same time being cheaper and performing better under all environments. It includes efforts to substitute or reduce as much as possible substances hazardous for human health and the environment. Circularity is also key, and a particular challenge for complex materials mixtures; it is important to ensure that advanced materials at the end of their use can feed into secondary advanced materials, reducing both the pressure on supply chains and the overall environmental footprint of materials.

Other cross-cutting elements for consideration in the priority areas are characterisation, instrumentation, metrology and manufacturing.