# PRIORITY 4: Raw materials in new products and applications

By 2050, a greater demand for new complex materials, including alloys, hybrid and composite materials, nanomaterials, is foreseen, that are expected to confer enhanced performances to advanced products in response to consumers demand. The substitution of scarce or energy-intensive materials can be in turn achieved by developing applications with an equivalent technology that does not rely on the same raw materials.

New advanced products include the emerging biobased solutions and applications that will be key enablers in the shift from fossil-fuels towards a sustainable low-carbon society. The trend highlights the development of new material properties for new products and greater flexibility in manufacturing and production contributing a wiser use of raw materials through product design.

**Key research and innovation areas**

4.1 Substitution of (critical) raw materials in new technology & energy applications

4.2 Development of new biobased products

4.3 Development of new material applications & new markets

## 4.1 Substitution of critical raw materials

#### Rationale

The substitution of critical raw materials is strongly related to the secured supply of raw materials in the EU. R&D results are expected to heavily impact on the substitution of critical raw materials, particularly in the following sectors:

**In transportation**, the main driver is energy efficiency, related to the issues of weight reduction and electrification. Weight reduction can be achieved by replacing traditional raw materials with composites and alloys, i.e. multi-materials. Electrification of cars pushes the market to develop new battery storage systems and/or more durable hydrogen fuel cells, as well as to permit higher density electric motors to be used.

**Electronics and consumer goods** are becoming smarter and more complex, most of them including more than 50 raw materials to provide all functionalities. The technology lifetime of these appliances is substantially shorter than the lifetime of raw materials. Product replacement is mostly triggered by next generation products, providing high level of performances for the same or less cost. Use of critical and expensive raw materials in these products is continuously reduced by down-gauging, ICT technology, new production technologies, for example circuit board printing and thin film, using less raw material quantity for same or better functional performance.

**Energy sector** is seeking for a continuous growth of volume of advanced materials, permitting to generate, convert and transport energy at the highest efficiency and with minimum losses. This has a particular emphasis when dealing with renewable, as is the case of photovoltaic energy. The higher efficiency demanded from the process industry is related to the intensive use of **catalysts**, optimizing the use of raw materials and intermediates, limiting the use of polluting or noxious chemicals, and increasing yield in a sustainable way.

In the **construction sector**, there is an increased demand for advanced materials with new (multi) functionalities as (self) monitoring, self-healing as well as ability to improve the durability, the energy efficiency, the health and comfort of environments.

The European **medical and diagnostics sectors** heavily rely on critical raw material resources to sustain the level of excellence worldwide. Therefore, either a reliable source of raw materials or a high value substitution need to be guaranteed.

#### State of play

As of 2017, the list of critical raw materials (CRM) counts 20 materials[[1]](#footnote-1). The methodology for assessing criticality has been defined in 2010, and since 2011 every three years the list is updated, on the basis of the technical and market demand of materials, as well as the socio-economic world conditions. It is understood that there will always be critical materials, needed by the industry for their technological functions. The list of such material will evolve with time and with the industrial priorities. The efforts of substitution will be concentrated on ensuring access to the relevant function, enabled by the critical materials, overcoming the risk of shortage.

Currently, substitution projects are lacking propulsion to cross the “valley of death” and to bring the results of R&D activities into products solving the issues of criticality addressed. The aspects of strategic relevance and long-term vision of such projects usually clash against the difficulties in terms of entrepreneurship to sponsor long term investments, as well as the inherent risk in substituting something that risks becoming obsolete by natural product cycle.

#### Expected achievements by 2030

A number of (critical) raw materials, such as rare earth elements (REE) and platinum group metals (PGMs), are substituted in consumer goods or in large energy generation and storage facilities, permitting this strategic segment to reduce the risks of disruption. For example, the volume of supply of neodymium (Nd) and dysprosium (Dy) for magnets has been reduced by 40% with respect to the levels of 2015 while the volume of supply of cobalt (Co) for batteries has been reduced by 50% with respect to the levels of 2015. Despite the higher volume of goods consumed, the EU has achieved the reduction of net import of critical raw materials by more than 25%. LINKS

#### Expected achievements by 2050

Substitution projects for critical raw materials are implemented with success leading to a global process of consumer products re-thinking, if not a substantial revolution. The way energy is produced, transformed, stored and transported is involved as well, generating a common understanding of the problem and a common front from the side of consumers. Innovative generation of products has encompassed the current concepts, and a holistic process starting from the conception phase, drive the phases of manufacturing and consumption. Aspects of awareness, training and education are fundamental to ensure the penetration of the substitution efforts, in particular whenever the substitute is not in an optimal cost-performance position.

#### Required Research and Innovation Activities by 2030

1. Substitute critical raw materials by composition, including the application in energy, ICT, alloys; demonstration and implementation projects covering the following subjects:
   1. Demonstrate the energy conversion, for example in wind turbines, electric motors, by exploiting permanent magnets with more than 30% reduced content of critical raw materials
   2. Demonstrate the use of photovoltaic materials with reduced content of critical raw materials remaining below 30% of current standards.
   3. Create energy storage which is enabled through a low content of critical raw materials, with 50% reduction with respect to current state-of-the-art batteries, and with improved energy density.
   4. Explore new materials, such as ceramics, composites, independent on the super-alloying elements of critical raw materials that provide advantages in terms of density, thermal resistance, toughness and mechanical performances.
2. Substitute critical raw materials by integrated design and whole value chain approach, leading to more sustainable and high added value materials and value chains for new productions through the demonstration of:
   1. New materials embedded into new products by design
   2. Smart solutions and new business models associated to a material revolution leading to EU independency from critical raw materials

#### Required Research and Innovation Activities by 2050

*To be developed*

## 4.2 Development of new biobased products

#### Rationale

Building a circular bioeconomy in Europe requires significant investment in the development of new and sustainable alternatives to current fossil-based materials. Converted from renewable biological resources, biobased products and applications cover several sectors ranging from the forest industry to chemicals and biocomposites, cross-cutting the society and human needs in our everyday life.

The rich and complex chemical and physical composition of wood, bark and other parts of a tree, contain great potential for a broad range of innovative properties to be exploited and incorporated in future wood-based products. Advanced properties improving the application of biobased products include light-weight, biodegradability, composite properties as well as functioning as natural thermal and electrical insulators. New products from cellulose, lignin or hemicellulose and resins will become valuable resources in a world that craves more raw materials.

#### State of play

Today, cellulose pulp and sawn wood are the primary products of the forest-based industries. These are further refined into a spectrum of products, ranging from commodity to consumer products. Yet, many new applications are under development or are yet to be ready for mass deployment and commercialisation. Clear trends are however visible, as the development of new non-wood fibre sources, bio-composites, printed electronics, micro-fibrillated cellulose, exciting new packaging concepts, new paper qualities. Rubber-based products are essential for the automotive industry and speciality products. However, research is needed to determine optimal or “good enough” purity levels in materials that offer solutions with higher strength, lower resistance, lighter weight, increased control of light spectrum, and greater chemical reactivity, among other benefits, for new applications.

#### Expected achievements by 2030

Several new biobased products and applications have been commercialised and are largely used as substitutes for materials from non-renewable sources. Applications ranging from clothing to skyscrapers have been developed creating green growth and jobs. Wood and fibre-based building constructions, furnishing and storing considerable amounts of carbon and have increased substitution of many fossil-based products. Additive manufacturing has substantially improved production processes through the integration of enhanced material properties, such as connectivity, anti-counterfeiting and water-repellence to existing wood-based products. The durability of wood has been upgraded using specific additives and conditioning processes. Advanced biocomposites used for instance in automotive parts, new construction materials have been introduced while bioplasticswill bring novel solutions to the packaging sector. Meanwhile new wood-based products with self-healing properties will significantly reduce maintenance needs.

#### Expected achievements by 2050

The biobased products have taken over the markets providing highest possible value added from primary and secondary raw materials. The renewable and recyclable products satisfy the demands of the 2050 consumer and society. Wood-based construction materials have helped the sector achieve an 80 % CO2 emission reduction by providing a carbon storage while replacing other energy and carbon-intensive construction materials. Packaging plays even a greater role in society offering advanced and smart solutions for smaller- and larger-sized packaging based on advanced design and nanotechnology while producing less waste. Investment in research, development and innovation has led to the full deployment of new biorefinery processes to produce textiles, chemicals and new materials, including composites and pharmaceutical products, for customized market needs.[[2]](#footnote-2)

#### Required Research and Innovation Actions by 2030

1. Develop value-added applications of extracted wood polymers, nanofibrils, lignin, xylan, pulp fibres and paper, for example, for carbon fibres or ultra-lightweight composites.
2. Adapt biomimetic design approaches and, in general, the integration of recycling-oriented product design criteria into the development processes of new biobased products.
3. Improve existing, long-lasting adhesive systems for flake boards, medium density fibre board (MDF), oriented strand board (OSB) and plywood boards as well as for glulam by using ingredients which are not based on fossil resources and are free of emissions (e.g. long-lasting adhesive systems based on renewable resources).
4. Develop new weatherproof panels, fibre-based insulation materials and wood-polymer composites suitable for exterior use.
5. Improve the performance of packages and wood- or fibre-based packaging materials, not limited to mechanical properties but including, for example, resistance to moisture and microbial contamination, in particular prevention of microbial activity in food packages with the help of shielding gases or active substances.
6. Integrate sensor and information systems in packaging materials – printing applications using functional inks and tags carrying anti-counterfeiting information.
7. Develop smart and intelligent features for applications based on printed electronics or printed biosensors, e.g. in packaging.
8. Develop enhanced lightweight and hi-tech products in the future that will be moulded, extruded or assembled from wood components.

#### Required Research and Innovation Actions by 2050

*To be developed*

## 4.3 Raw materials for hybrid and composite materials and applications

#### Rationale

The product manufacturing has evolved from the mass production of the past, when a small range of products were designed, to a job-shop manufacturing of the present, where customers can select the most preferable and suitable product for their need from within a wide range of products. High performance, high quality and low cost are the key aspects together with as short as possible product development time. Moreover, recently the life-cycle energetic cost of the product, its durability and the possibility of recycling plays a more and more crucial role.

To satisfy the demands of customers, the use of sophisticated optimization techniques is rapidly growing with the development of nano-structured and nano-functionalised materials. At the same time, the development of new manufacturing processes, such as additive manufacturing responses to the requirements for more light-weight materials, biomimicry with a view to customizing the needs in medical implants, for example.

Composites combine different materials in order to create a new material with improved properties and performance. Composites could include both biotic and abiotic material sheets in a wide range of applications from transportation to construction, ranging from metal composites and reinforced plastics such as fibre-reinforced polymers applied in aeronautics and automotive to concrete and mortars panels used in building and infrastructures.

Hybrid materials are composites including two materials mixed at the microscopic scale – nanometric or molecular level – in order to create more homogenous or even new material properties.

#### State of play

The fabrication of composite structures and products is evolving from manually labour intensive to automated manufacturing methods, including the use of intelligent feedback monitoring systems and robotic technology. Developments in automated integration of the pre-form fabrication and moulding make already available technologies more desirable for economics and productivity.

#### Expected achievements by 2030

Composites are widely employed in building materials and in consumers goods, giving rise to a revolution in product design. New types of composites concepts can be derived from hybrid construction systems, combining the best properties of biotic and abiotic materials in high performance, prefabricated and fully finished modular elements and structures for housing. Miniaturisation and nanotechnology development are key enablers for advanced (neuro)bionics, for which biocompatibility is likely to be much more of an issue than design for recycling.

Harmonised data exchange along the supply chain and between stakeholders will increase the performance of the industry. Business models will be based on consumer and end-user perceptions. Interactive communication will play an important role.

#### Expected achievements by 2050

The technology adaptions such as additive manufacturing, biomimicry of materials, self-healing of materials have substituted many linear economy solutions. Large diffusion on nano-structured and nano-functionalised materials have been achieved.

#### Required Research and Innovation Actions by 2030

1. Develop biocompatibility, miniaturization and nanotechnology for applications in advanced (neuro)bionics.
2. Create business models to open up a raw material pool and conversion of traditional mills to new markets.
3. Develop cost-effective integrated prefabricated building systems including hybrid and composite materials, timber and other biobased construction materials.
4. Further develop the multi-material concepts and multi-functionality for wood and wood-based products in interior fittings, furniture and everyday products.
5. Develop indoor system solutions that promote flexibility regarding changes in use (ageing inhabitants, changing family structures, growing children).
6. Develop cheap, more durable and resistant composites, alloys and multilayer materials that enable the extension of product life time
7. Develop construction products that can ensure the comfort and health of environments for occupants.
8. Develop monitoring systems to improve the durability of construction products.
9. Develop construction products that can be dismantled and modularised considering also the reversibility of the manufacture, in order to collect raw materials during maintenance or product end-of-life without (or with small) further chemical/physical/mechanical operations
10. Explore new building materials installation and fixation systems focused on the development of new industrialized construction methodologies.
11. Develop applications that allow the use of secondary materials with higher concentrations of impurities or degraded molecules, thus offering new market opportunities for recyclates.

#### Required Research and Innovation Actions by 2050

*To be developed*

1. Or element groups: heavy rare earth (RE), light RE, platinum group metals (PGMs) [↑](#footnote-ref-1)
2. Unfold the future – 2050 Roadmap to a low-carbon bioeconomy, CEPI, 2011 <http://www.cepi.org/system/files/public/documents/publications/environment/2011/roadmap_final-20111110-00019-01-E.pdf> [↑](#footnote-ref-2)