PRIORITY 2: Resource efficient processing, refining and converting of raw materials

Activities to foster resource efficiency in processing, refining and converting of primary and secondary raw materials have resulted in a continued relative reduction in energy and water use and material input in the European raw material industries per tonne of material produced. However, the deployment of new technologies with in-built artificial intelligence and the big data will not only contribute to a more resource efficient production but allow for adjusting raw material input to a new era of customised manufacturing imposed by conscious customers and shifting market demands. Meanwhile, the circular economy will open up new business models for production side streams that become valuable raw materials for new products and reuse, paving the way for integrated industrial symbiosis that benefit from old and new value chains.

The EU's roadmap for a resource-efficient Europe outlines a vision of structural and technological changes that are required to move towards a decreased concentration of carbon-dioxide and other green-house gases, resource-efficient and climate-resilient economy by 2050. To achieve these goals requires further technological innovation that can reduce material input into production and optimise the use of raw materials allowing for consumer-driven flexibility which will be enabled by automation and data-driven production sites. Moreover, developing integrated technologies for industrial symbiosis will help develop and integrate new and old value chains, creating conditions for cross-sectorial collaboration following the principles of the circular economy.

Key research and innovation areas

2.1 Development of resource-efficient processing, refining and converting technologies

2.2 Minimisation and valorisation of production residues

2.1 Development of resource efficient processing, refining and converting technologies

Rationale

Satisfying demanding consumers demands a transition to agile production and mass customization tailored to market demands. This in turn requires more flexible, on-demand production and assembly processes. At the same time, automated processes and big data solutions, such as planted sensors, will help control and adjust material flows and steer processes towards a new phase of customization-orientated production that is not only focused on increasing productivity and efficiency but on agility and responsiveness. The development of new innovative technologies to foster resource efficient material use will continue to play a key role by offering many opportunities to improve raw material quality and functionalities while saving on energy and water throughout processing, refining and converting.

State of play

Thanks to the deployment of advanced technologies improving the purity of raw materials, today's mills and plants produce more from smaller amounts of raw materials, which also reduces the environmental footprint. Nevertheless, resource-efficient processes imply integrated production and processing chains that supply resources 'on demand'-basis.

Pulp and paper production is characterised by highly-efficient production facilities with high capital costs. Breakthrough innovations in wood and fibre industry technologies, pulping, water recycling, energy recovery and process control may also require changes in demanded and preferable wood and fibre deliveries.

In **mineral processing**, the major difficulties encountered to supply in-demand, critical metals to the market are cost and energy efficient beneficiation/pre-processing and metallurgical processing which enables the refining of such elements in addition to the base metals metallurgical cost. Moreover, a majority of the unrecoverable losses lie today at macro-scale, and will expand tomorrow since primary ore bodies particles size will tend to shift towards smaller particles.

In **metallurgy and metals recovery,** securing raw materials supply requires tackling the complete value chain, particularly the relation between a resource and a process. Because primary or secondary resources tend to continue to become more complex and lower grade, while environmental requirements drastically change, the associated metallurgical processes will continue to raise more technical challenges.

Expected achievements by 2030

New resource-efficient production technologies have significantly helped achieve the targets set in the EU's strategy for a low carbon economy. More flexible production units, to respond to future consumer needs and with a highly skilled workforce, will have made an important contribution to higher production efficiency. Deployment of technologies to reduce heavy industry emissions have contributed to the reduction of energy and water demand and carbon footprint. The positive impact will result in lighter tailor-made products, lower demand for raw materials and additives, increased by-product valorisation and an overall reduction in waste.

Expected achievements by 2050

In customer-driven manufacturing, optimised production and material flows have been achieved through the use of big data applications. Seamless data exchange along the value chain from exploration and harvesting to the production of material efficient products contribute to reduced resource consumption and supplying markets and suppliers with customised products.

Required Research and Innovation Actions by 2030

The abiotic and biotic sector

A. Develop production technologies of both primary and secondary raw material resources that satisfy more demanding processor's and manufacturers' specifications to comply with changing standards and legislation
B. Invent functional surface treatment to enable bulk material reduction, enhance durability or extend life-cycle
C. Develop enhanced separation and fractionation technologies for material components to enable their optimal use for adapted processes and products, especially in dry conditions to reduce water consumption
D. Develop production technologies with significantly optimised energy efficiency and energy management throughout production
E. Use information and communications technology (ICT) to meet highest process efficiency, improving material flow, resource efficiency, process stability, machine productivity, etc.
F. Enhance the microbiological stability of industrial water systems
G. Develop innovative energy-efficient screening, classification and de-watering technology
H. Apply new product design approaches from less material and energy input
I. Develop purification in hydrometallurgy as well as pyrometallurgy and wood-based deliveries

The abiotic sector

J. Create innovative crushing and grinding technologies, the most energy-intensive parts of mineral processing, to reduce energy use

The biotic sector

K. Analyse the possibilities for primary refining processes at forest harvesting to fully utilise the great variability of forest wood and fibre properties
L. Develop production technologies with significantly optimised energy efficiency and energy management in defibration of wood, drying of sawn timber, production of panels, paper and board or in transportation.

Required Research and Innovation Actions by 2050

To be developed

2.2 Valorisation of production residues

Rationale

A near-to-zero-waste concept aims at minimising waste and by-products throughout the production process. Turning residues into "feed" materials across industrial value chains help create fully-integrated industrial symbiosis across the raw material sectors. This results in novel business opportunities building on new and old value chains that enhance cross-sectorial cooperation following the principles of a circular economy. Such strategies for industrial symbiosis, in which waste or by-products of one industrial process is re-inserted as a resource in another, contributes in turn to boosting the competitiveness of European industries globally.

State of Play

Already today, residues and side-streams are more and more being treated as by-products demonstrating examples of how processing residues can be turned into added value with advanced functionalities to substitute fossil-based materials.

During the processing, refining and converting of raw materials within **the abiotic value chain,** typically by-products, side-streams or wastes are produced simultaneously. There is a huge potential to reduce waste or increase the value of current low value side-streams or by-products.

In the biotic value chain, an increased use of residues from raw material processing, for example bark, chips, sawdust, to make wood panels or pulp have significantly increased resource efficiency since 1990. Nevertheless, further progress is essential – including new possibilities for extraction and utilization of forest based materials also including branches, needles and stumps. These biotic resources are partly needed for soil rutting protection, nutrient balances, but still a considerable amount 10-25% of the entire stem volume (depending on region, species etc.) might be utilized as additional raw material sources from forestry.

Expected achievements by 2030

Integrated production of primary and secondary raw materials surpasses the traditional division of the value chains resulting in improved input of residues as a source of raw materials into another sector. Innovative industrial symbiosis that integrate various value-chains and create new raw material sources have been put into practice involving multiple stakeholders and emerging value chains.

Innovative technologies for secondary processing have been developed to make waste a resource, residues as an asset, including critical raw materials. Raw materials and nutrients can be recovered from wastewater streams, such as phosphorus, or from tailings or industrial side streams, including the utilisation of the rest of the residues as well, for example, in the forms of aluminosilicate-based products on the other industrial or consumer sector. The developed new and improved technologies shall be used for piloting the reprocessing of suitable old tailings and end-of-life material streams.

Expected achievements by 2050

Highly integrated, circular, flexible and modular concept of factory is developed and deployed, permitting the industrial symbiosis within and between biotic and abiotic sectors.

The production of waste is minimised or valorised by the recovery of valuable elements from complex and low-grade feedstocks combined with technologies for residual matrix valorisation, while providing safe sinks for toxic remnants in inert slags, sludges and aggregates.

Required Research and Innovation Actions by 2030

The abiotic and biotic sector

A. Develop value-added products from by-products and extracted components from process water
B. Develop additive manufacturing in production, for example 3D-printing, injection moulding etc.
C. Develop concepts for turning the wastewater treatment plant into an energy-producing entity
D. Generate knowledge of useful or harmful chemical compounds / innovation for the removal of chemicals, inks, additives etc.
E. Invent new concepts for the re-use of treated water, for example, industrial symbiosis.
F. Recovery of valuable substances from (sewage) slags such as Phosphorus
G. Research dust confinement and analysis techniques

The abiotic sector

H. Develop hydrometallurgical processes for low-grade and non-conventional ore deposits, for example complex polymetallic ores.
I. Enhance biometallurgical processes (extraction and concentration of metals)
J. Improve treatment of complex ores and secondary material streams
K. Optimise metal yields and energy efficiency of metallurgical processes
L. Develop thermodynamics of complex metal mixes
M. Research into CO2 sequestration and industrial symbiosis in order to find solutions for processing of carbonaceous minerals
N. Develop high energy/intensity processes (plasma technology, electro-beam, etc.)
O. Develop new separation technologies (hydrometallurgy and/or pyrometallurgy or combination of both)
P. Improve recovery of energy from slags
Q. Research into CO2 sequestration and industrial symbiosis in order to find solutions for processing of carbonaceous minerals
A. Develop life cycle analyses (LCA) of products taking entire value chains into the system boundaries.

Required Research and Innovation Actions by 2050

To be developed