Strategic Research & Innovation Agenda

Co-funded European partnership on raw materials for the green and digital transition

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Co-funded European Partnership on Sustainable Supply and Use of Raw Materials for the Green and Digital Transition

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ERA•MIN 3

Raw Materials for the Sustainable Development and the Circular Economy

Foreword

The European Union is in the process of transforming Europe's landscape to meet the current and urgent challenges in relation to environment, climate, energy, and (cyber) security. In this Strategic Research and Innovation Agenda, the most important research and innovation themes in support of a sustainable supply and use of raw materials towards a sustainable and resilient economy and society are outlined. These themes have been identified and discussed following a mission-based, quadruple-helix approach, with guidance from relevant high-level authorities and actors (e.g. European Commission, ETP-SMR, EIT RawMaterials), as well as support from more than 200 experts and stakeholders from academia, industry, the public sector as well as civil society during the years 2023 and 2024.

The agenda gives a comprehensive and aligned overview of challenges, visions, impact goals and desired outcomes from research and innovation throughout the value chain of non-fuel, non-food raw materials, including all aspects of the circular economy. In addition, it covers important transversal research and innovation themes connected to policy development, societal benefits, and innovation capacity, which are crucial for a sustainable development. The agenda is envisaged to support and guide an EU co-funded partnership on sustainable supply and use of raw materials for the green and digital transition, to be implemented under the framework of Horizon Europe.

The Strategic Research and Innovation Agenda has been written by Tobias C. Kampmann, Pontus Westrin, Ana Luísa Lavado, Holger Grünewald, Dina Carrilho, Jorge Sotelo Santos, Jean-François Renault and Raquel Fernández Reyes, members of the Executive Committee (i.e. representatives of national research funding organizations based in the European Union) of the ERA-NET Co-fund on Raw Materials (ERA-MIN3), with the following main authorship responsibilities:

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15th of May 2024

Executive Summary

As the European Union transitions from a fossil-based economy to a near-zero waste and emission economy, the focus on the raw materials value chain and on the Critical and Strategic Raw Materials are of utmost importance to achieve the green and digital transition.

However, the demand for raw materials is high and ever increasing, with the European Union overly dependent on very few third countries as suppliers bringing about new challenges that endanger this transition alongside the already existing ones that are interdependent with the raw materials availability, such as climate change, environmental degradation, and social sustainability.

The publication of several regulations, such as the European Green Deal, the Critical Raw Materials Act, and the Critical Raw Materials Action Plan, aim to address these challenges by strengthening the raw materials value chain through strong investment in research & innovation focused on strategic projects within extraction, processing, recycling, and development of substitute materials.

Although there already exist well implemented research & innovation funding schemes, such as the Horizon Europe and EIT RawMaterials Calls, there is a gap that needs to be addressed by creating a new European Union co-funded partnership built upon the experience fostered by the ERA-MIN network during the last decade.

This funding scheme has a focus on needs-driven, basic and applied, research at lower to medium Technology Readiness Levels, it would also focus on funding projects with smaller but transnational consortia with a duration up to 36 months and with usually a lower amount for funding (between €0.5M to €1.5M).

The approval and implementation of such a funding scheme by the European Commission requires the creation and design of a Strategic Research and Innovation Agenda, setting a framework for future research & innovation with a clear contribution to the sustainable supply and use of raw materials for the green and digital transition.

This Strategic Research and Innovation Agenda outlines the co-creation and methodological approach together with the European innovation system, as well as its mission, the challenges to be tackled and, most importantly, how it paves the way to the elaboration and implementation of the Partnership on Raw Materials for the Green and Digital Transition.

The Partnership on Raw Materials for the Green and Digital Transition is a new funding scheme with its own mission and goals; it will not only launch call for proposals but will also organise and implement additional activities that will contribute to achieve the several goals and benchmarks of the previously mentioned EU Green Deal initiatives and regulations. The Partnership will also engage with similar initiatives and relevant stakeholders throughout its timeline to enhance its results and impacts.

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Reading guide

First chapter: Introduction

The background, context and state-of-the-art on the importance of raw materials (RM) for the green and digital transition are described in this chapter, as well as the definition of important concepts, such as Critical Raw Materials (CRM), primary and secondary RM; also addressed are the contextual regulations and political incentives by the European Commission that are the basis of this document, namely the Critical Raw Materials Act (CRM Act) and the European Green Deal. Also included is an overview of and collaboration opportunities with the international strategic partnerships with third countries that have the same or similar goals towards the RM value chain.

Second chapter: Strategic Research and Innovation Agenda

The Strategic Research and Innovation Agenda (SRIA), its context, mission and goals are detailed. In this chapter, the methodological approach is described to create and design the SRIA as the guideline for a new co-funded European Union funding scheme – the Partnership on Raw Materials for the Green and Digital Transition.

The SRIA addresses the RM-related challenges mentioned in the previous chapter, ensuring the support and enhancement of relevant European Policies, such as the CRM Act, guaranteeing the achievement of the set targets and benchmarks.

Third chapter: The Partnership

This chapter describes the context and the background for the Partnership, its mission and goals, and the way it addresses the overall challenges of RM supply and use for the green and digital transition.

The Partnership's scope is designed as complimentary to other initiatives, but also as a tool on its own that will fill the identified gap in the RM research and innovation (R&I) landscape. The Partnership is based on three pillars: economic, environmental, and social sustainability, detailed in section 3.2.

Also explained under this chapter is the list of overarching key performance indicators (KPI) that will be used to measure the performance of the Partnership.

Fourth chapter: Partnership Implementation Plan

This chapter explains how the Partnership's objectives and goals will be put into practice through transnational Joint Calls for R&I proposals and other additional activities/actions. While the SRIA encompasses the overall strategy, the actual implementation of the Partnership will be outlined in a separate document, herein referred to as the Implementation plan (Annual work plans/programmes). The methodology used for the plan is described in this chapter.

Fifth chapter: Thematic Scope

This chapter describes the set of themes carefully selected to be aligned with and to achieve the Partnership's mission and objectives. Each of the six themes has a sub-section where one can find the underlying intervention logic involving the different challenges, vision and impact objectives, context for outcomes and the list of the respective monitoring KPIs.

The core and transversal themes outlined in this chapter aim to inspire the design of the Partnership future Joint Calls for Proposals and other actions to be specified in the Implementation plan.

Sixth chapter: References

List of all documents, papers, journals, and websites accessed and used as references while writing the SRIA.

Glossary

Acronym/Term	Description/Definition/Link
AI	Artificial Intelligence.
ASGMI	Association of Iberoamerican Geological and Mining Surveys.
BAT	Best available techniques according to the 'Sevilla process'[1].
BREF	Best Available Techniques Reference documents.
CEAP	Circular Economy Action Plan[2].
CRM	Critical Raw Material, definition according to[3].
CRM Act	European Critical Raw Materials Act[4].
DG GROW	Directorate-General of the European Commission for Internal Market, Industry, Entrepreneurship and SMEs.
ERA-LEARN	ERA-LEARN is a support platform for the R&I partnership community, funded as a support action by Horizon Europe.
ERA-MIN3	ERA-NET Cofund on Raw Materials. ERA-MIN3 is a global, innovative and flexible pan-European network of research funding organisations, supported by EU Horizon 2020, that builds on the experience of the FP7 ERA-NET ERA-MIN (2011 to 2015) and Horizon 2020 (FP8) ERA-MIN 2 (2016-2022).
ERMA	European Raw Materials Alliance is an open and inclusive alliance that provides an open and independent forum for discussion and analysis, as well as a mechanism for translating potential projects into actual activities and infrastructures that will contribute to creating long-lasting added value and jobs for Europe. It is managed by EIT RawMaterials.
EIT RawMaterials	European Institute of Innovation & Technology on Raw Materials is a key European actor established in 2015 to advance Europe's transition into a sustainable economy. Its overarching mandate is to support securing the supply of critical raw materials to the European industry by driving innovation along the raw materials value chain.
EIPPCB	European Integrated Pollution Prevention and Control Bureau.
EC	European Commission European Commission, official website - European Commission.
EEA	European Economic Area.

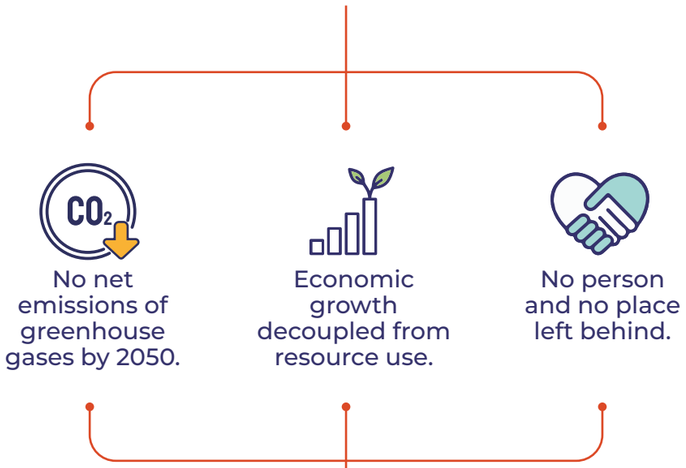
Acronym/Term	Description/Definition/Link
EGS	EuroGeoSurveys, a not-for-profit organisation representing the Geological Surveys of Europe.
ETP SMR	European Technology Platform on Sustainable Mineral Resources.
EU	European Union.
GHG	Greenhouse gas.
GSEU	A Geological Service for Europe. EU funded project Grant agreement ID: 101075609.
Horizon 2020	The research and innovation framework programme (FP8[5]) under the umbrella of which ERA-MIN2 and ERA-MIN 3 were funded.
Horizon Europe	The research and innovation framework programme (FP9) under the umbrella of which the Partnership is envisaged to be funded.
ICE-SRM	International Centres of Excellence on Sustainable Resource Management.
IEA	International Energy Agency.
Intervention logic	Intervention or programme logic model helps to identify and set out the relationship between the socio-economic needs to be addressed by the intervention/programme, and its vision, impact goals, outcomes, objectives and goals.
INTERMIN	International Network Of Raw Materials Training Centres EU funded project Grant agreement ID: 776642.
IoT	Internet of Things, is a technology that connects physical devices and sensors to the internet, allowing them to collect and exchange data.
JRC	Joint Research Centre, a Directorate-General of the European Commission.
KPI	Key performance indicator(s) are a set of quantifiable measurements used to gauge the Partnership overall medium- and long-term performance that are closely linked with its activities and actions. It also is a measurable goal as part of an intervention logic.
LCA	Life Cycle Assessment.
LCI	Life Cycle Inventory.

Acronym/Term	Description/Definition/Link
Mission	Mission as per Horizon Europe definition. A new way to bring concrete solutions to some of EU's greatest challenges. Missions have ambitious goals and will deliver concrete results within a defined timeframe, put research and innovation into a new role, combined with new forms of governance and collaboration, as well as by engaging citizens.
MoU	Memorandum of Understanding.
NGOs	Non-governmental Organisations.
OECD	Organisation for Economic Co-operation and Development.
OEM	Original Equipment Manufacturer - generally perceived as a company that produces parts and equipment that may be marketed by another manufacturer.
PanAfGeo	Pan-African Support to the EuroGeoSurveys – Organisation of African Geological Surveys (EGS-OAGS) Partnership (PanAfGeo), is a project that supports the training of geoscientific staff from African Geological Surveys.
Partnership	If not specified otherwise, this refers to the EU co-funded partnership on raw materials for the green and digital transition, proposed to be implemented in the Horizon Europe work programme 2025.
PhD	Doctor of Philosophy – highest academic grade.
PI	Principal Investigator.
PSRM	Policy and Strategy for Raw Materials.
RFOs	Research Funding Organisations.
R&I	Research and Innovation.
RM	Raw Materials - Refers to all raw materials under the scope of this agenda, i.e. non-fuel, non-food raw materials.
RMIS	Raw Materials Information System is the Commission's reference web-based knowledge platform on non-fuel, non-agricultural raw materials from primary and secondary sources.
SCREEN	Synergic Circular Economy across European Regions EU funded project Grant agreement ID: 730313.
SDGs	Sustainable Development Goals.
SIP	Strategic Implementation Plan.
SME	Small- and mid-size enterprise, as defined by the European Commission (2003)[6].
SRIA	Strategic Research and Innovation Agenda.
SSbD	Safe and sustainable by design.
Strategic Partnership	A commitment between the EU and a third country to increase cooperation related to the RM value chain that is established through a non-binding instrument setting out concrete actions of mutual interest. Strategic partnerships shall facilitate beneficial outcomes for both partners including the sharing of knowledge.
Solar PV	Solar Photovoltaic System.
Third country	A country that is neither a member state of the EU nor a country associated with Horizon Europe[7].
TRL	Technology Readiness Level according to the definition used in the Horizon 2020 and Horizon Europe framework programmes[5].
UNECE	United Nations Economic Commission for Europe.
UNFC	United Nations Framework Classification for Resources.
Young Researcher	A Young Researcher is defined as a postgraduate or early career researcher of any discipline actively pursuing a research career, usually without being fully established, yet. She/ he will have received a PhD or an equivalent doctoral qualification up to 10 years ago and is usually between 30 and 40 years old.

01

Introduction

Climate change and environmental degradation are an existential threat to Europe and the world. To overcome these challenges, the European Green Deal will transform the European Union into a modern, resource-efficient, and competitive economy, ensuring:



Source: The European Green Deal[8]

The European Green Deal for the European Union (EU) and its citizens is a response to tackling climate- and environment-related challenges. It is a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy[7]. The European Green Deal includes an initial roadmap of key policies and measures needed to achieve the deal objectives; it is expected that all future EU actions, measures, and policies will also contribute to these.

To achieve a European society with no net emissions of greenhouse gases by 2050 and an economic thrive and growth decoupled from the excessive use of natural resources, as stated in the European Green Deal, it is vital to transition from the fossil-based economy to a green and digital near-zero waste and emission economy. However, this green and digital transformation, contrary to what is the intended effect, drives a drastic increase in demand for RM, on average between four and six times from 2020 to 2040 according to the International Energy Agency[9a].

Due to their importance as an essential element for the industrial and economic development of the EU, prices of many RM are reaching values never seen before, and organisations from different parts of the world try to control the criticality of different materials by publishing lists of CRM and by putting forward actions related to security of supply.

For the EU, CRM are considered to be those that have high economic importance (based on the value added of corresponding EU manufacturing sectors, corrected by a substitution index) and a high supply risk (based on supply concentration at a global levels weighted by a governance performance index, corrected for recycling and substitution parameters)[3]. The updated list of CRM also includes strategic RM, which score high in terms of strategic importance, forecasted demand growth and difficulty of increasing production (the strategic importance is determined in accordance with Annex I, Section 2 of the Critical Raw Materials Act[4]).

The global production of many RM is heavily concentrated on singular countries (see Figs. 1 and 2), increasing the risk of supply disruptions in a world drastically impacted by the climate crisis as well as geopolitical conflicts. The EU is overly dependent on very few of these third countries[b] for the supply of CRM. The need for both short- and long-term actions with the aim of securing a resilient and sustainable supply of RM for the green and digital transition is evident.

With regards to sustainable supply and use of RM, it is important to define primary and secondary RM. Consequently, considering the RM value chain, primary resources are all those that are extracted or mined from the original source[10] outside of the technosphere, while secondary resources are all those extracted from mine tailings, industrial waste, mining waste, and urban waste[11]. In the context of this document, RM refers to all non-fuel and non-food Raw Materials

[a]Certain materials, such as lithium, cobalt, and graphite, have projected global demand growths of over 20 times the current demand by 2040[9].
[b]Definition of Third Country by the EC[7]

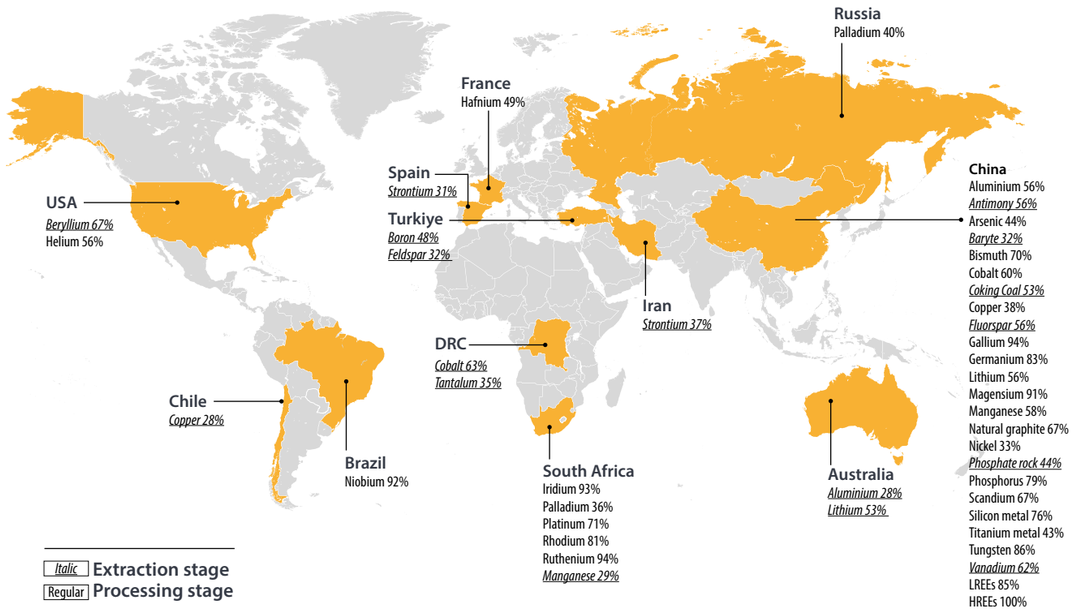
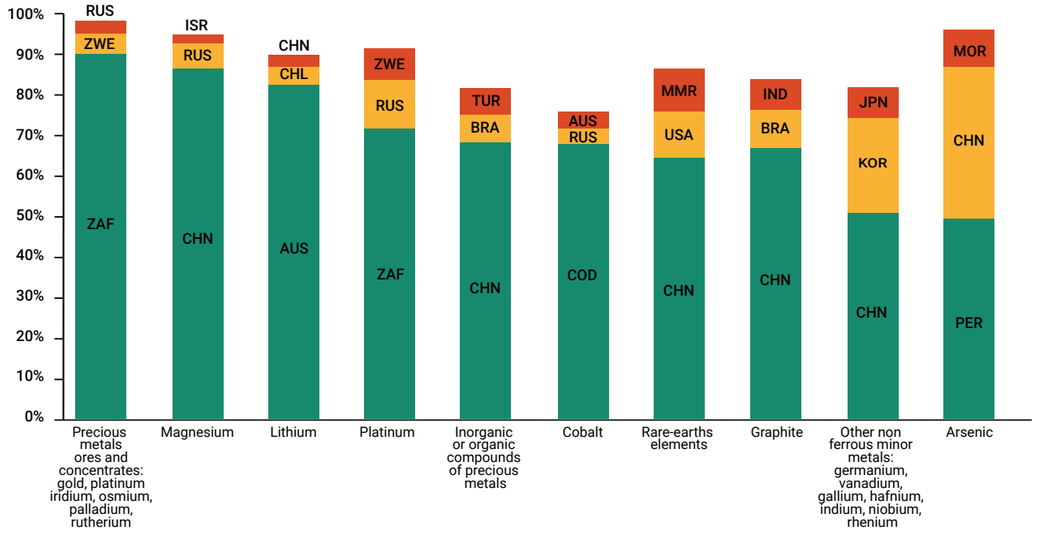


Figure 1. Share of global supply of critical and strategic RM by country

According to[3]



Note: AUS - Australia; BRA - Brazil; CHN - China; CHL - Chile; COD - Democratic Republic of Congo; ISR - Israel; KOR - Korea; MOR -Morocco; MMR - Myanmar; MOZ - Mozambique; PER - Peru; TUR - Türkiye; RUS - Russian Federation; ZAF - South Africa; ZWE - Zimbabwe. Shares in global production based on gross weight of production. Source: OECD calculations based on the United States Geological Survey data.

Figure 2. Top 3 producers of the top 10 most production-concentrated CRM

According to[12]

To deliver the Green Deal, access to resources is also a strategic security concern. Ensuring the sustainable supply of RM, and in particular of CRM necessary for green technologies, digital, space and defence applications, by diversifying supply from both primary and secondary sources, is therefore one of the pre-requisites to achieve the green, digital and climate neutrality transition.

This transition is also an opportunity to expand sustainable and job-intensive economic activity under the umbrella of the Green Deal and the Circular Economy Action Plan. It will help the EU economy and draw benefits from the opportunities of the blooming RM circular economy, which includes a sustainable products policy (reuse, repair, refurbish) and strong investments in recycling technologies.

1.1 The Critical Raw Materials Act

The European Green Deal states that all EU actions and policies will have to contribute to its objectives. Since the challenges are complex and interlinked, the policy response must be bold and comprehensive and seek to maximise benefits for health, quality of life, resilience and competitiveness. It will require intense coordination to exploit the available synergies across all policy areas.

The CRM Act is consistent with the European Green Deal strategy and the European Climate Law, as well as with several other policies that are focused on climate change, economy, social perception etc. The CRM Act aims to address the challenges of increasing demand and price of CRM in combination with tackling climate change impacts, environmental degradation and social sustainability in the EU that aims for a smooth economic and energetic transition. In addition, it aims to forecast the assessment of RM for a better resilience to its future supply, demand and criticality[3].

The CRM Act is an EU initiative with the general objective of improving the functioning of the internal market by establishing a framework to ensure the EU's access to a secure and sustainable supply of CRM. It aims to fill the gaps within the current regulatory framework in order to address the main issues and risks related with CRM, from their supply to their substitution, recycling and disposal within the EU. The Act aims to strengthen the EU's CRM capacities along all stages of the value chain and, by 2030, to increase EU's resilience by reducing dependencies, increasing preparedness, and promoting supply chain sustainability and circularity. To achieve these aims, it has set out five pillars:

- Building European capacities
- Improving resilience
- Investing in research, innovation, and skills
- Promoting a more sustainable and circular CRM economy
- Setting clear priorities for action

Translating the clear priorities for action into benchmarks for domestic capacities along the strategic RM supply chain and for its supply diversification, the Act sets the following benchmark targets to be achieved by 2030:

- at least 10% of the EU's annual consumption for extraction
- at least 40% of the EU's annual consumption for processing
- at least 25% of the EU's annual consumption for recycling

In parallel to strengthening the different stages of the strategic RM value chain, the regulation also aims to:

- diversify the Union's imports of strategic RM with a view to ensure that, by 2030, the EU's annual consumption of each strategic RM at any relevant stage of processing can rely on imports from several third countries, none of which provides more than 65% of the EU's annual consumption;

- improve the EU's ability to monitor and mitigate the supply risk related to CRM;
- ensure the free movement of CRM and products containing CRM placed on the EU market while ensuring a high level of environmental protection, by improving their circularity and sustainability.

The way in which the results of the Partnership and the implementation of the RM SRIA contribute to the goals and aims of the CRM Act will depend on the established links, the Partnership activities and the funded project results. However, there are several sections of the regulation than can be highlighted in particular:

- **Chapter 3 Strengthening the Union RM value chain – Section 1 Strategic Projects:** Funded projects under the Partnership will be able to scale up to other funding opportunities, from EIT Raw Materials to Horizon Europe and other calls, and Strategic Projects recognised under the Act.
- **Chapter 3 Strengthening the Union RM value chain – Section 4 Exploration:** Each Member State shall draw up a national programme for general exploration targeted at CRM that shall include measures to increase available information on the EU's CRM occurrences, including deep ore deposits. They shall include a series of measures that can be addressed under the Joint Calls topics.
- **Chapter 4 Risk Monitoring and Mitigation:** The Partnership can contribute to the foreseen free access website (article 4) with the funded projects results and/or additional activities.
- **Chapter 5 Sustainability – Section 1 Circularity:** Each Member State adopts and implements national programmes containing measures designed to increase the recovery of CRM from waste (urban, electronic, extractive, etc.), the use of secondary CRM in manufacturing, the technological maturity of recycling technologies for CRM, and to promote materials efficiency and the substitution of CRM in applications. The funding of new technologies or any other activity that aims to implement these programmes can be addressed under the Joint Call Topics.
- **Article 6 Classification of projects according to the United Nations Framework Classification for Resources (UNFC):** If appropriate, the partnership-funded projects and additional activities will be required to follow the classification of identified mineral occurrences according to UNFC guidelines. Overall, the Partnership will ensure increased synergy with Member States and Third Countries by funding projects throughout the whole RM value chain, as well as promoting and implementing additional activities with the aim of collaborating towards the achievement of the objectives of the CRM Act.

Efforts will be made to connect the Partnership with the following two sub-groups of the European CRM Board:

- The subgroup bringing together national geological institutes or surveys or the relevant national authority in charge of general exploration, with the purpose of contributing to the coordination of national exploration programmes (article 18), and
- the subgroup bringing together national supply and information agencies covering CRM or the relevant national authority in charge of that matter, with the purpose of contributing to the monitoring (article 19).

The CRM Act also highlights the need for public policy interventions in a broad range of actions, not only to increase the immediate extraction and processing capabilities within the EU, but also to strengthen R&I activities for a sustainable future to ensure a sustainable and secure supply of CRM in the EU.

The Joint Research Centre (JRC), under the umbrella of the European Commission, has done a foresight study on *Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU*[13]. In this study, several conclusions were drawn, and policy recommendations were listed that closely relate to promoting R&I, skills, competences, and capabilities of the EU. These recommendations span from more resource-efficient production lines and substitution of CRM in certain components, to developing resource diversification strategies, skills, and innovation for the outline and implementation of environmentally, economically, and socially efficient processes.

Fostering international collaboration within the area, together with international strategic partnerships along the value chain, remains a vital part of the EU strategic approach.

1.2 International Strategic Partnerships on Raw Materials

The EU has been actively engaging with several countries and regions to establish strategic partnerships focusing on RM[14]. These partnerships aim at ensuring a secure, sustainable, diverse, and responsible supply of CRM necessary for the EU green and digital transition[15].

In September 2020, the Commission adopted the CRM Action Plan that identified current and future challenges, and proposed actions to reduce Europe's dependency on third countries, diversifying supply from both primary and secondary sources and improving resource efficiency and circularity while promoting responsible sourcing worldwide[16,17]. This Action Plan presented ten concrete actions to tackle vulnerabilities in the RM supply chains. Action 9 entails the development of strategic international partnerships and associated funding with resource-rich third countries, making use of all external policy instruments and respecting its international obligations to secure a diversified and sustainable supply of CRM.

Action 9 of the CRM Action Plan entails the development of strategic international partnerships and associated funding with resource-rich third countries, making use of all external policy instruments and respecting its international obligations to secure a diversified and sustainable supply of CRM.

Strategic Partnerships

15 June 2021 **Canada**

13 July 2021 **Ukraine**

7 November 2022 **Kazakhstan**

8 November 2022 **Namibia**

13 June 2023 **Argentina**

18 July 2023 **Chile**

26 October 2023 **Zambia**
Democratic Republic of Congo

30 November 2023 **Greenland**

19 February 2024 **Rwanda**

21 March 2024 **Norway**

5 April 2024 **Uzbekistan**

28 May 2024 **Australia**

Currently, there are different degrees of agreements that have been established between the EU and other territories (see Fig. 3). Some established strategic partnerships have detailed roadmaps and action plans, in other cases they are still framed as a memorandum of understanding (MoU) and, in many others, conversations are still in the negotiation phase. The following list aims to be a summary of the agreements achieved according to DG GROW (see Fig. 3).

- **Canada:** On June 2021[18], the first strategic partnership between the EU and a third country was signed. This partnership aims to advance the value, security, and sustainability of trade and investment into resilient RM and downstream value chains across Canada and the EU. It includes amongst other areas of cooperation: science, technology, and innovation.
- **Ukraine:** On July 2021, the EU and Ukraine signed a strategic partnership[19] and provided a detailed roadmap for its implementation, which included a closer collaboration in research and innovation along both RM and battery value chains. Areas of collaboration included decarbonisation of extractive industry, greening of mining processes or mining and urban waste management.
- **Kazakhstan:** On November 2022, and agreement between the EU and Kazakhstan was reached to establish the strategic partnership[20] on sustainable RM, batteries, and renewable hydrogen value chains. Its roadmap for implementation along 2023 and 2024 established cooperation on Capacity-Building and Research, focusing on decarbonization, sustainability, and efficient mining processes.
- In November 2022 a MoU between the EU and **Nabia**[21] was signed on common interests and to promote integration of the raw materials and renewable hydrogen value chains.
- Both **Argentina** (June 2023)[22] and **Chile** (July 2023)[23] signed MoUs to establish the roadmap for partnerships on sustainable RM value chains. Some of the key issues for collaboration included R&I on areas such as minerals knowledge, minimizing environmental and climate footprint, and advancing circular economy practices.
- In November 2023 the African countries **Zambia**[24], **Democratic Republic of Congo**[25] signed MoUs with the EU on sustainable RM which established the groundworks for collaboration to facilitate closer cooperation on research and innovation along the RM value chain, including advanced exploration, earth observation, innovative extractive, processing, refining and recycling technologies.
- **Greenland:** In November 2023, a MoU between the EU and the Government of Greenland on a strategic partnership on sustainable RM value chains was signed[26]. It supports the development of the mineral resources in Greenland, and amongst other things, the establishment of sustainable RM value chains for the green transition in the EU.
- **Rwanda:** In February 2024, the EU and Rwanda signed a MoU[27] on sustainable RM Value Chains with the plan to establish a roadmap with concrete actions to be developed together within six months, thus putting the strategic partnership into practice. Areas of collaboration include R&I and sharing of knowledge and technologies related to sustainable exploration, extraction, refining, processing, valorisation and recycling of critical and strategic RM, their substitution, waste management and monitoring of supply risks.
- **Norway:** In March 2024, the EU signed a MoU with the Kingdom of Norway[28] launching a strategic partnership to develop sustainable land-based RM and battery value chains. The MoU establishes close cooperation between the EU and Norway in five main areas: (i) integration of RM and batteries value chains, (ii) cooperation on R&I, (iii) application of high environmental, social and governance standards, (iv) mobilisation of financial and investment instruments, and (v) (developing necessary skills for high-quality jobs in RM and battery sectors).
- **Uzbekistan:** In April 2024, the EU and Uzbekistan signed a MoU[29] launching a strategic partnership on critical raw materials (CRMs). This important agreement marks a significant step towards securing a diversified and sustainable supply of CRMs for the green and digital transitions both in the EU and Uzbekistan.
- **Australia:** In May 2024, the EU and Australia signed a MoU[30] for a bilateral partnership to cooperate on sustainable critical and strategic minerals. It aims to support several common objectives, while based on mutual benefits, it seeks to enable the EU to diversify its supplies of materials necessary for the green and digital transitions, whilst contributing to the development of Australia's domestic critical minerals sector, focusing on reducing environmental impacts and benefiting local communities.

Figure 3. EU strategic partnerships with third countries on Raw Materials (2024)

Action 1 of the CRM Action plan was accomplished with the launch of the European Raw Materials Alliance (ERMA) that aims to diversify RM supply to achieve open strategic autonomy in sectors related to the rare earths magnets and motors as well as energy storage and conversion. At a later stage, it could expand to other CRM and base metal needs. The alliance involves all relevant stakeholders, including industrial actors along the value chain, EU countries and regions, trade unions, civil society, research and technology organisations, investors, and Non-Governmental Organisations (NGOs).

02

Strategic Research and Innovation Agenda

This Strategic Research & Innovation Agenda (SRIA) is set in the context and state-of-the-art detailed previously. The mentioned challenges that the SRIA addresses are explained at length in policy statements by IEA, OECD, EU, UNECE among others[12]. The main challenge is that the EU's capacity to produce all the RM that are needed for its sustainable development is currently very low; in combination with an increased risk of depending on a few third (non-EU) countries (over 90%) for several CRM.

This SRIA is the foundation and guideline document of the future **Partnership on Raw Materials for the Green and Digital Transition**[c].

[c] From now on mentioned as Partnership.

The SRIA's mission is to enable the green and digital transition by focusing on the Raw Materials value chain. To achieve this there are pathways that need to be addressed, such as:

- Creation and improvement of the sustainable and resilient value chains needed to supply the transition;
- Guidelines for the needed research and its funding to systematically increase the knowledge of the Raw Materials value chain (how to locate RM, how to process them, use them more efficiently, and manage them responsibly in a circular economy);
- Capitalization on created and gained knowledge into solutions related to challenges within industry, governance structures, ecosystems, and society;
- Work along the whole value chain focusing on sustainable supply and use of raw materials to meet the climate change benchmarks.

2.1 The Co-Creation Methodology

The SRIA has been elaborated by the consortium of ERA-MIN3, an ERA-NET scheme under Horizon 2020, using a co-creation methodology by engaging with stakeholders of the RM R&I Community and will be the guideline for the actions and activities implemented by the Partnership. The co-creation approach was designed to gather feedback on the process and receive direct impact from the RM community on the actions and Key Performance Indicators (KPI) designed to be implemented by the Partnership.

It involved both open and invite-only, physical and digital, workshops with participants from both the member states and international partners as well as RM-relevant stakeholders. Validation of the content has been done through several steps as part of the co-creation process, especially as part of the final document drafting, where a selection of independent external experts (Advisory group) reviewed the document in detail.

2.2 The Guideline for the Partnership

The SRIA, as the guideline for the Partnership, is designed to contribute to ***the sustainable supply and use of raw materials for the green and digital transition***. It aims to reach its mission through the implementation of the Partnership.

For this reason, the SRIA focus is on the Thematic Scope of the Partnership, this is sub-divided into six different thematic areas (further explained in chapter 5). The challenges previously described, and the several policy statements issued by international organisations, give a strong emphasis on the need for structured R&I along the whole RM value chain with a focus on diversifying the supply sources. RM are fundamental enablers of the green and digital transition, and without the necessary focus on exploring for and producing these in a resilient, sustainable way, the climate crisis will be impossible to tackle.

The implementation of the Partnership is a separate process that will have its own document as guideline – the implementation plan (more details in chapter 4). This distinction is made to give emphasis to the co-creation of the thematic scope including the KPIs, thus providing the flexibility both documents require for an easier review and update whenever the need arises.

03

The Partnership

The Partnership builds on the experience of the existing ERA-NET ERA-MIN3 (2022–2025) and the experience gained during the implementation of its predecessors ERA-MIN2 (2016–2022) and ERA-MIN (2011–2015).

The Partnership consortium has the ERA-MIN consortium as its basis which is composed of Research Funding Organisations (RFOs) from EU Member States (MS) and regions, EU-associated countries and third countries that cover entirely or partially the RM value chain in their national or regional strategies and priorities. All efforts are being made to expand the existing consortium to new MS and third countries as well as regions, in particular to those which are negotiating and/or have signed strategic partnerships with the EU (see chapter 1.2), but also to other countries willing to cooperate with EU countries in the RM R&I field.

The existing ERA-MIN network successfully aligned the funding with the partners' thematic priorities, attracted RFOs from new countries and regions, and continuously increased the financial commitments to the ERA-MIN calls for proposals. The expansion of this network and a better alignment between EU policy priorities and national/regional priorities are necessary to reach EU policy objectives, namely the ones established in the CRM Act.

The overarching mission of the Partnership is to enable the sustainable supply and use of Raw Materials for the green and digital transition, through a holistic perspective that covers the entire value-chain, with a strong emphasis on the circular economy by building strong research and innovation systems and networks mainly through funding.

Under Horizon Europe, the Partnership mission matches well with the scope of Cluster 4 – Digital, Industry and Space. Just as ERA-MIN, the Partnership will cover R&I under all Technology Readiness Levels (TRL), but with a focus on low to medium TRL (1–6) on innovative and needs-driven small-scale R&I projects in consortia with academia, research institutes, civil society, SMEs, as well as large industry. With this approach, the Partnership will cover a gap within the EU R&I funding system, ensuring the possibility to develop and progress less TRL-mature, idea-driven R&I. Both RM-related calls of Horizon Europe (including future funding programmes) and EIT Raw Materials Calls represent natural upscaling opportunities towards commercialization for successful Partnership-funded projects.

3.1
The objectives of the Partnership

An important factor of the SRIA process is to target the current main challenges, while still being able to adapt to future challenges, implying that both the SRIA and the Partnership must be sufficiently flexible and adaptable to not limit the R&I community that it aims to support. While today's emerging technologies are closely monitored using the EU instrument of *Advanced Technologies for Industry*[d, 31], tthe Partnership will stay agnostic in the sense of the specific directions in which future technologies might evolve, and which technological path will become most competitive and dominant in the future.

The Partnership has the following proposed objectives (which will be further developed during the writing of the Implementation Plan for the Partnership) that ensure that its mission and the SRIA mission are achieved:

1. Support and promote R&I cooperation within and beyond Europe;
2. reduce fragmentation and gaps of R&I funding in non-fuel, non-food RM value chain across Europe and globally;
3. provide a pan-European support network and financial resources to improve synergies, coordination and collaboration;
4. strengthen R&I along the entire RM value chain to ensure secure, resilient and diverse supply of RM;
5. enable the circular economy through R&I on reuse, repair, refurbishment of products as well as substitution of CRM;
6. improve economic, environmental and social sustainability within the green and digital transition;
7. improve competitiveness, environmental, health, and safety performance of non-fuel, non-food RM operations.

[d]Advanced Technologies for Industry (ATI) is a project aimed to systematically monitor technological trends and make data available to industry, policymakers, and academia. The project focuses on the following advanced technologies: 1. Advanced Manufacturing Technology, 2. Advanced Materials, 3. Artificial Intelligence, 4. Augmented and Virtual Reality, 5. Big Data, 6. Blockchain, 7. Cloud computing, 8. Connectivity, 9. Industrial Biotechnology, 10. Internet of Things, 11. Micro- and Nanoelectronics, 12. Mobility, 13. Nanotechnology, 14. Photonics, 15. Robotics, 16. Security. Source: Izsak et al., 2020.

The Partnership strives to build upon its objectives and to be in line with the established benchmarks by the CRM Act, through increasing efforts in investing and funding R&I, but also in strengthening the R&I community and expert networks through a variety of complementary actions and activities.

3.2
The Partnership Pillars

The concept of sustainability refers to operations and development that meet the needs of the present generation without compromising or jeopardising the ability of future generations to meet their needs. The mission and objectives of the Partnership can be highlighted and supported by the three sustainability pillars: Economic, Environmental, and Social Sustainability.

Supplying CRM on the scale projected requires a vast increase in investment in the mining and processing industries. If the increase in mining is implemented according to current global mainstream practices, it will result in considerable social and environmental damage, affecting mostly the local communities close to which the mines are located. Unavoidable conflicts will pose a threat to the transition towards a near-zero waste and emission economy on a timescale consistent with the Paris Agreement.

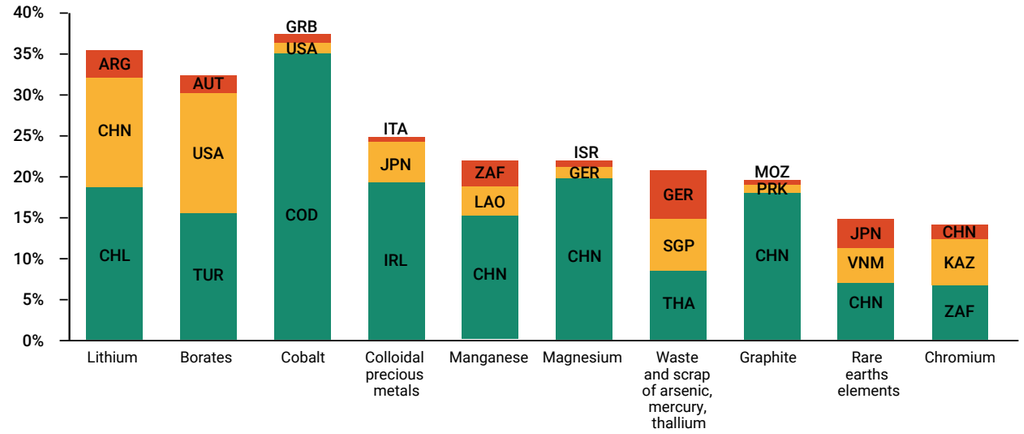
To get acceptance for the projected expansion of mining in countries with significant CRM deposits, a considerable improvement will be required in the environmental and social governance and performance of the mining industry. The relevant issues to be addressed include the equitable sharing between stakeholders in the value created by mining, with relevant issues for the host country and community such as local content and value addition, technology and knowledge transfer, employment and gender equity, respect for indigenous and other human rights, as well as environmental sustainability, especially in relation to biodiversity, water resources, waste and tailings management and greenhouse gas emissions[32].

Essential economic activity to reach climate and energy transition goals under the Paris Agreement, could at the same time cause detrimental effect on efforts to accelerate progress on Agenda 2030 and multilateral agreements on e.g. biodiversity[33] and the Aarhus Convention[34] on access to information, public participation in decision-making and access to justice in environmental matters. Decisions about investments must therefore be followed by a clear understanding of conflicting goals, as well as environmental and social consequences.

3.2.1 Pillar Economic Sustainability

Europe consumes a quarter of the world's resources, but only produces around 3% of resources[11]. The products that the EU needs are most often made on other continents/countries (see Fig. 4), while waste products that could be a resource are shipped out of the EU to be deposited in landfills in third countries. On the other hand, CRM are faced with increasing export restrictions, approximately five-fold since 2009, with about 10 % of them behind some measure of export restriction[12]. The availability of RM has a large impact on product pricing and, in extension, the potential economic sustainability of EU industries. While global production of RM has doubled since 1990, the demand is still bound to increase substantially during the coming decades[9].

The mission and objectives of the Partnership can be highlighted and supported by the three sustainability pillars: Economic, Environmental, and Social Sustainability.



Note: ARG -Argentina; AUS - Australia; AUT- Austria; CHN - China; CHL - Chile; COD - Democratic Republic of Congo; GER - Germany; GBR - United Kingdom; IT A - Italy; ISR - Israel; JPN - Japan; KAZ - Kazakhstan; LAO- Lap People's Democratic Republic; MAR - Morocco; MMR - Myanmar; MOZ - Mozambique; PER - Peru; PRT - Portugal; TUR - Turkiye; RUS - Russian Federation; USA - United States; VNM - Viet Nam; ZAF -South Africa; ZWE-Zimbabwe. Source: OECD calculations using the BACI data.

Figure 4. Top 3 exporters of the top 10 most export-concentrated CRM.
According to[12].

Known exploration, mining and recovery potential exists in the EU for many of the CRM, but projects are often faced with a variety of challenges in the development phase, for example, due to lack of economic incentives for sustainability, long- and uncertain-time frames for permitting processes, need for technical development or the large risks associated with the substantial investments required.

The global competitiveness of the European industry and its global economic sustainability are key to develop an increasingly sustainable supply and use of RM. For example, while a growth in locally produced RM will lead to lower climate impact from transportation, this also connects to opportunities for stronger environmental control[35]. This has an impact on recycling and (re) use of secondary RM, where a larger control on the ratio of recycled material in the production sector will be an important factor. For most critical raw materials, today, recycling plays a minor role. Forecasts indicate that mining will continue to grow and dominate the supply of RM, only projected to potentially decouple from overall economic growth and decrease in relative production shares after 2030, i.e., in favour of more recycling[36].

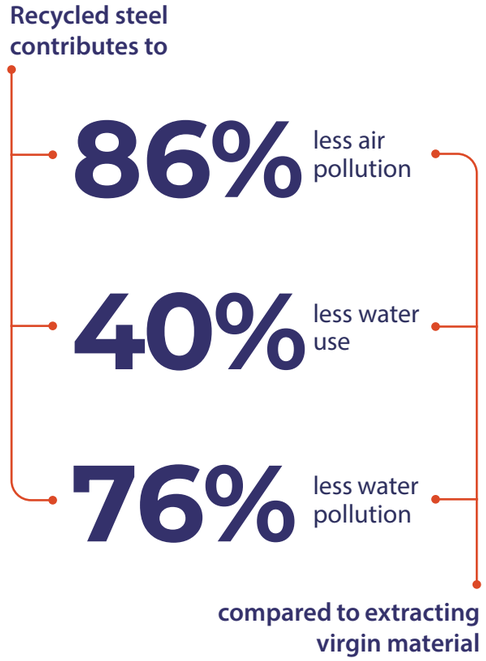
Cost comparisons between mining and recycling will be increasingly important, especially when related to incentives and financing. Even though the costs of recycling of materials is projected to decrease in the coming decades, they will still be higher than the costs of the production of primary RM through mining, in particular due to the tendency of materials dissipation and the complexity of modern products, hence generally high labour intensity of recycling processes[37].

Addressing the economic sustainability of primary and secondary RM production is one of the main objectives of the Partnership. With investment in R&I for the development and implementation of the circular economy, as well as more efficient recycling processes and management strategies, the economic sustainability will improve. Consequently, more data are needed on both primary and secondary RM supply to support policy implementation and development.

There are several barriers that must be overcome to improve collection, sorting, and recycling in ways that make the EU's recycling targets for CRM achievable. Sustainable public and private financing play a crucial role in delivering sustainable extraction and use of CRM. The mining industry within the EU already operates under strict environmental regulations and needs to comply with requirements set by, e.g., the Water Framework Directive[37], the Extractive Waste Directive[38] and the Habitats Directive[39].

Increasing the EU's competitiveness on the global market, as well as building a strong foundation for future technological advancements, is of great importance for the Partnership. The key objectives within this area are to:

- Create opportunities for R&I to support RM supply from both primary and secondary sources as well as substitution of CRM.
- Promote international knowledge exchange by welcoming third countries to the Partnership and increasing the number of joint projects between continents.
- Provide science-based data and methodologies for policy and decision makers in the areas of financing, permitting and circular economy.
- Communicate EU environmental governance and practice on sustainable mining (e.g., corporate sustainable reporting, corporate sustainable mining, due diligence directives and best available technologies).



3.2.2 Pillar Environmental Sustainability

RM extraction and processing, whether from primary or secondary sources, have an impact on the environment. While recycling can release pollutants through, e.g., pre-processing of paints or plastics, it is generally more environmentally friendly than extracting virgin material. For instance, recycled steel contributes to 86% less air pollution, 40% less water use, and 76% less water pollution compared to steel from primary sources[40]. Energy savings can be up to 20 times compared to extracting from primary sources. Generally, higher ratios of recycled RM in products are more sustainable and release less greenhouse gases[41].

Recycling is also associated with other environmental challenges, especially regarding the recycling of complex products. It is also challenging to know what a product contains, and it is important to strive, as far as possible, for design for recycling and good management of toxic substances. Better knowledge on bioavailability of different compounds needs to be built up to ensure appropriate management of health aspects for both primary and secondary extraction. A key objective of the Partnership is to enable the circular economy of RM.

While exploring for and producing more RM from both primary and secondary sources is important to supply EU production industries and meet EU growing needs, one essential goal of the circular economy is to keep products and resources (at their highest value) in use for as long as possible. For this reason, efforts and awareness actions that promote product longevity, repair as well as sustainable use and reuse are included within the scope of the Partnership.

Some of the main environmental challenges within the global raw materials sector relate to[41]:

- Acid mine drainage (AMD)
- Emission to water
- Dam bursts and flooding
- Waste production and tailings management
- Emission to air
- Soil erosion and contamination
- Water availability
- Ecosystem destruction
- Radioactive radiation
- Toxic waste production
- Waste management

A majority of these are related to waste management at mine sites, mainly in regard to waste rock, tailings, and mine water. R&I is needed to minimize the production of waste altogether, followed by preventing any environmental negative impact from the waste by implementing better management practices. Waste minimization measures can include, for example, better spatial understanding of ore bodies through integrated 3D modelling to avoid unnecessary production of waste rock or improve valorisation processes to find uses for larger portion of by-products from ore and gangue minerals. Minimization of waste is one of, if not the most, important aspect to reduce the environmental impact of mining.

Prevention of environmental impacts can be achieved by, for example, increasing the understanding of acid and neutral rock drainage and the efficiency of different waste covers, or developing of more closed-loop systems where contaminated mine water or waste are kept within a controlled environment.

Mitigation measures are the last resort, but an important topic for development to lower the effects on the environment of many industrial operations. Measures can include, but are not limited to, technical studies on passive biological barriers used for mine water or different water treatment methods.

Reduce, redesign, repurposing, recycling and remining waste are other fields of research that need to be developed further, not only to minimize the waste streams but also to support the circular economy. Technical advances, better management practices and new ways to use or recycle waste are important factors for the environmental sustainability of the mining sector.

The risks accompanying large-scale industrial operations are weighted through diligent permitting processes and controlled through EU policy such as the Industrial Emissions Directive[42] and other relevant best available techniques (BAT) reference documents (BREF)[43]. New technologies, management practices and knowledge of the natural systems foster the potential to prevent and mitigate impacts, but policy makers need reliable science-based data to deliver more effective policy solutions addressing environmental issues. An important challenge for the R&I community and the Partnership will be to supply data for policy makers through projects and increased knowledge, for example regarding BAT, base and limit values for environmental toxins and pollutants, as well as to support the circular economy through innovative solutions, while contributing to effective policy development.

Safeguarding the planet and its inhabitants is central to the Partnership. Aspects of environmental sustainability will have to be at the core of each funded project and Partnership activity, striving to provide a better future for coming generations. Key objectives within this pillar include:

- Through R&I, significantly lower the environmental and climate impact of industrial operations, both short- and long-term.
- Enable the circular economy through technological advancements, new business models and increased understanding of raw material value chains.
- Develop supporting data on circular economy, incentives and BAT to policy and decision makers.

3.2.3 Pillar Social Sustainability

As the EU strives to solve the current challenges related to the supply of RM, for example by innovating within industrial operations policy instruments and environmental management, extra care must be taken to not create new challenges, especially related to social sustainability for local communities. To secure the RM needed for the green and digital transition, mining operations within the EU will have to expand their production, recycling factories will have to be built, and the way we use and reuse products will have to change. All these activities will impact local communities and even the public.

There are several challenges related to social sustainability when planning the green and digital transition linked to the RM sector. Due to the pressing need to accelerate the transition, and consequently produce more RM at a faster pace to propel the technology implementation needed, additional risks to human rights violations and the lack of environmental protection arise. Many of these risks are identified and outlined in position papers produced by an alliance of over 40 civil society organisations prior to the decision on the CRM Act, in 2023[44].

Building a common understanding of the challenges related to raw materials will create a good foundation to increase the social sustainability of projects.

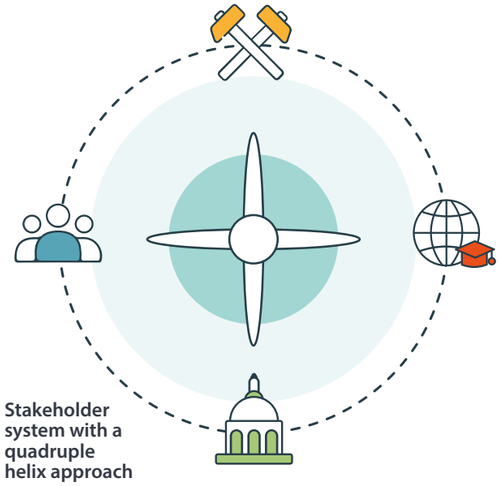
As stated through the statistics of the Business & Human Rights Resource Centre[45], mining is a high-risk sector for human rights violations, emphasizing the need to develop tools and methods that prevent further issues. Important aspects for the SRIA and the Partnership in this context are, for example, increased public participation, communication and transparency, impact assessment, data collection, monitoring and remediation.

Increased mining activities, developing stronger recycling systems and adopting new ways to reuse and keep operational products for as long as possible enhancing circular economy will impact both local communities and the public. Building awareness, acceptance and trust towards the transition can be accomplished through the Partnership-funded projects and the consortium, stakeholders and other actors working together, communicating results and impacts in an easily accessible, transparent and adaptable language tailored to the target groups outside of the RM R&I community.

Awareness in particular will be important for every initiative within the Partnership to target. While there has been a great deal of attention paid to RM and how to access them might jeopardize the green transition as of late, the EU is still losing ground compared to other continents/countries in regard to securing a resilient and strong supply of RM. Building a common understanding of the challenges related to RM will create a good foundation to increase the social sustainability of projects.

Strengthening social sustainability is of key importance. The Partnership aims to build a strong foundation for actors within the R&I community, including public and private sectors as well as civil society members to come together and work towards common goals for a sustainable and just RM sector. Key objectives within this pillar aim to:

- Include the entire stakeholder system taking a quadruple-helix approach, in which actors within industry, academia, government and civil society all influence the Partnership and contribute to its impact goals.



Stakeholder system with a quadruple helix approach

- Increase the awareness of raw material issues in society by working on public outreach and stakeholder engagement for a just transition.
- Increase efforts in social innovation as well as technical R&I to engage with and create more positive impacts on society.

3.3 Complimentary Actions and Initiatives

The Partnership is a tool to achieve the objectives of the European Green Deal, the benchmarks of the CRM Act, to overcome the existing economic, environmental, and social challenges, in order to reach the desired green and digital transition, the net-zero emissions of greenhouse gases, and the zero-waste, zero-energy economy.

The Partnership, with the SRIA as its guideline, is a co-funding scheme between the EC and national/regional RFOs that implement funding programmes on RM, and it is complementary to both the Horizon Europe Calls and the EIT RawMaterials Calls. The selected projects' duration is up to 36 months and the requesting funding usually does not exceed €1.5M, with a focus on needs-driven (basic and applied) research starting at lower to medium TRL. These conditions are based on the ERA-MIN 3 experience (Fig. 5).

Figure 5. Complementarity between the Partnership, Horizon Europe and EIT RawMaterials

Although the Partnership addresses the whole RM value chain, it is complementary to actions addressed by other initiatives in the RM domain. The Partnership alone is not enough to fully achieve the objectives of the different regulations mentioned above, which is the reason why it is vital to work closely and implement activities and actions, in some cases even calls for proposals, with other co-funded or co-programmed partnerships.

During the creation of this SRIA, meetings were held with the aim to foster future synergies and collaborations with other EU partnerships with different levels of involvement in the RM value chain, such as BATT4EU – Batteries European Partnership[e], Made in Europe Partnership[f], P4Planet Partnership[g], the envisaged Partnership IAM4EU (implemented by AMI2030 - Advanced Materials Initiative[h]), and the ERA-NET cofund action M-ERA-NET.

[e] Co-programmed Partnership that aims to achieve a competitive and sustainable European industrial value-chain for e-mobility and stationary applications.
[f] Made in Europe: platform for national and regional manufacturing technology initiatives.
[g] Processes4Planet Partnership aim is to transform the European process industries to achieve circularity and overall climate neutrality at the EU level by 2050 while enhancing their global competitiveness.
[h] Multi-sectoral accelerator for the design, development, and uptake of safe and sustainable advanced materials towards a circular economy.

Further collaborations are also envisaged with other initiatives such as Chips JU, Quantum Flagship or Clean Energy Transition Partnership.

The SRIA also benefited from the input of the European Technology Platform on Sustainable Mineral Resources (ETP SMR) whose Mission is to develop long-term European Minerals Industries R&I agendas and roadmaps for action at EU and national level and whose Vision is to modernise and reshaping the European Minerals Industries, fundamental pillar of the European economy. The Partnership is in line with ETP SMR which aims at "*strategic alliances between Member State policy-makers in terms of decision making and concerted actions, policies on new financial incentives on emerging technologies and stakeholder engagement*".

The new SRIA of ETP-SMR will contribute to support the planning of evidenced-based RM calls in Horizon Europe 2025- 2027. Moreover, the industry they represent claims for "a long-term and concerted commitment to *i) funding research and innovation, ii) supporting collaboration and cross-sectoral knowledge sharing, and iii) to building a supportive industrial framework while engaging broadly with stakeholders." The ETP-SMR, representing the industry view, fully supports the Partnership in "connecting regional research funding initiatives, to reinforce the research and innovation community while improving strategic CRMs resilience".*

The Partnership will connect with the Raw Materials Academy and foster possible collaborations to ensure the strengthening of the RM sector by educating the lifecycle of innovators, through the calls for proposals or the additional activities.

The Partnership consortium is in contact with EuroGeoSurveys (EGS), the not-for-profit organisation representing the Geological Surveys of Europe, discussing collaboration possibilities under the Partnership additional activities, including activities that will aid the Member States with the National Exploration Programmes requested by the CRM Act. GSEU has RM as one area of expertise and focuses on strengthening the CRM data and the mineral resources sustainable management, and on increasing the sourcing of CRM from primary and secondary sources in Europe, which are goals that align with the Partnership mission.

Currently, two ways to collaborate are possible: EGS becomes a Partnership consortium partner and actively joins the organisation and implementation of the additional activities, or EGS becomes an advisor of the Partnership by aiding to tune the Joint Calls topics, and by making new data available for researchers through sharing the results from the project GSEU – A Geological Survey for Europe, that aims to compile consistent geological maps and models of the EU subsurface.

The Partnership has its roots on more than a decade of experience from the ERA-MIN network, the knowledge fostered and gathered throughout these years is available online on ERA-MIN's website, meaning that a two-ways knowledge sharing is another type of collaboration or cooperation with EGS and GSEU.

On another level, both the SRIA and the Partnership take into consideration the Strategic Implementation Plan (SIP) on RM, its objectives and targets, priority areas and actions, when

The Partnership alone is not enough to fully achieve the objectives of the different regulations, which is the reason why it is vital to work closely and implement activities and actions, with other co-funded or co-programmed partnerships.

creating the implementation plan and the set of key performance indicators (KPIs).

It is foreseen that the combined actions of the Partnership with the above-named initiatives, independent of their structure and implementation of activities and actions, will foster EU's transition towards a green, digital and circular economy, and at the same time, bolster Europe's resilience and open strategic autonomy in key technologies needed for such transition.

3.4 Partnership Key Performance Indicators

As mentioned previously, the Partnership addresses its objectives in different ways, mainly through increased efforts in promoting and funding R&I. The Partnership aims to strengthen the RM value chain, secure future resilient supply of RM, and ensure high levels of environmental protection through funding of high-quality external peer-reviewed projects in a specific thematic scope (further explained in chapter 5).

Furthermore, by opening the consortium to RFOs from non-EU countries, the Partnership is building a global network of knowledge exchange, that in turn will work to reduce the strategic dependencies in the long run. Significant emphasis will also be placed in involving EU regions in the project funding and activities of the Partnership to strengthen R&I and regional stakeholder engagement, as well as policy development and social sustainability.

The achievements of the Partnership will be measured through a list of overarching KPIs as listed below:

KPI	Background	Target value 2032	Justification of target value
0.1 Number of projects funded by the Partnership.	International R&I projects are the main instrument among the activities implemented under the Partnership umbrella. Projects will be selected for funding through two-step EU co-funded calls that include an independent expert assessment.	140	Estimation of approximately 20 projects to be selected for funding per annual open call, with seven calls to be launched in total (see KPI0.5).
0.2 Annual conferences organized.	Dissemination of R&I results is crucial and enables the discussion of new research questions, projects, and consortia, as well as upscaling and implementation of other strategic decisions based on the results.	6	Annual R&I conferences with focus on project results, networking and matchmaking will be held from year 2 until and including year 7 of the Partnership.
03 Number of regional administrative stakeholders collaborating with the Partnership.	The EU member states combined contain 242 regions with varying degrees of self-governance[16]. Since mining operations are bound to the location of economically viable ore deposits, these operations will, in many cases, have an impact on regions and their local communities	10	This is an ambitious estimate, based on the experiences of the ERA-MIN network, on the number of regional funding bodies that may join calls for projects.
0.4 Number of funding organizations participating in at least one co-funded call.	Extensive international collaboration is needed to achieve the Partnership Mission of sustainable supply and use of RM for the green and digital transition	30	This is an estimation based on the experience of the ERA-MIN network, as well as preliminary discussions with RFO from countries and regions that will potentially join the Partnership and/or the calls for proposals. Recruitment of new partners will be pursued throughout the Partnership lifetime.
0.5 Number of EU co-funded calls.	Annual and open EU co-funded calls for R&I proposals with consortia spanning over the countries with RFOs that have join the calls, are the basis of a strong innovation system and network under the umbrella of the Partnership	7	The estimation is to hold one EU co-funded call per year for a Partnership with a proposed lifetime of seven years. A major portion of the Partnership budget will be dedicated to the implementation of these joint calls
0,6 Number of prototypes developed by projects.	The development of a competitive and needs-driven R&I idea will evolve through TRL stages, involving the development and testing of prototypes[32]. Therefore, the research and creation of prototypes is an appropriate quality measure that a portion of all R&I projects funded reach mature TRL levels.	28	An estimation of 20% of all R&I projects (see KPI 0.1) funded are envisaged to achieve the successful development of a prototype. This is a conservative estimate since there is a focus on low-to medium TRL levels for R&I projects. In addition, the projects on social innovation and transversal themes may lead to results that are not directly compatible with the TRL scale.
0.7 Number of projects that contribute to standardization processes.	Standardization is widely regarded as positive for industrial sectors, resulting in improved cost efficiency, flexibility and scalability of production, which are integral parts of the Partnership mission.	14	An estimate of 10% of all projects (see KPI 0.1) funded are envisaged to have standardization practices and/or processes in their scope.
0.8 Number of projects that lead to upscaling activities.	One appropriate measure of competitiveness is the number of R&I projects that developed towards upscaling, implementation and commercialization through other initiatives (e.g. EIT RawMaterials or Innovation Fund calls).	70	An estimation of 50% of the total projects can be upscaled by applying to other funding schemes or to the Partnership itself. These developments will be closely monitored.
0.9 Number of public-private consortia in funded projects.	The focus on needs and challenges of the industry is crucial in order to make an impact on the innovation system and the Partnership mission, in combination with the involvement of other private stakeholders such as SME's or consultancies to keep R&I ideas competitive and focused on market needs.	120	An estimate of 80% of the projects (see KPI 0.1) will have at least one enterprise as a partner from the private sector.

04

Partnership Implementation Plan

The present SRIA outlines the scope and sets the foundation for the thematic approach of the Partnership, as previously explained; the implementation of the Partnership is described in a different document. The separation of both documents and processes improves the focus on thematic scope, the general challenges, and the needs within the SRIA, while aligning these strategies with more practical details and implementation actions of the Implementation plan. This modus operandi is in line with the guidelines for SRIA development published by the ERA-LEARN network, therein also called Annual Work plans/programmes[46], and will ensure a hierarchy between them and facilitate readability, flexibility and updatability.

To achieve the goals and mission of both the SRIA and the Partnership, the approach to the RM value chain is sub-divided into six thematic areas, with each thematic area structured from a vision and impact goals towards two outcomes monitored through a list of KPIs.

4.1 Intervention logic and the impact of the Partnership

The *intervention logic*[i] *or theory of change* of the Partnership follows a certain structure to increase readability and facilitate the monitoring of results and impact (Fig. 6). To achieve the goals and mission of both the SRIA and the Partnership, the approach to the RM value chain is sub-divided into six thematic areas (see chapter 5), with each thematic area structured from a vision and impact goals towards two outcomes monitored through a list of KPIs. This structure covers a timeline from 2025 up to 2040 with KPIs, outcomes and impacts having different time horizons. The structure is constructively aligned to guide the desired outcomes and impacts towards the achievement of the Partnership goals and mission.

The *impact goals* summarize the desired vision for the future – in which the Partnership, together with other initiatives, will lead to a more resilient society with higher living standards. Therefore, the impact goals are the combined effect of the impacts and results from the Partnership activities and the funded projects aligned with several other initiatives, as well as the market and society development in general. The impact goals are formulated to reflect a vision beyond 2040 and were subsequently divided into and aligned with each of the thematic areas (see chapter 5).

The intervention logic is built with the belief that, if we are to reach the ambitious visions and impact goals beyond 2040, intermediate goals, or *outcomes*, need to be defined. These outcomes are closer to the present state-of-the-art, but nonetheless rely on large resources and efforts put towards the impact goals to be achieved. The outcomes should be largely impacted by the outputs of the Partnership, but also influenced by external effects and efforts (other partnerships, initiatives, international and national programmes), as the Partnership alone is not an isolated driving force within the broader innovation system and the RM community.

The outcomes and outputs of the Partnership are monitored through KPIs. These are a set of quantifiable measurements used to gauge the Partnership overall medium- and long-term performance and are closely linked with the activities and actions of the Partnership, as well as the R&I community and relevant stakeholders through the co-creation process of the SRIA. The intervention logic is built in a way that, if the KPI target values are achieved or even surpassed, the Partnership will be able to positively influence the outcomes and, in turn, the impact goals in the long term.

[i] Intervention or programme logic model helps to identify and set out the relationship between the socio-economic needs to be addressed by the intervention/programme, and its vision, impact goals, outcomes, objectives and goals (more details see glossary).

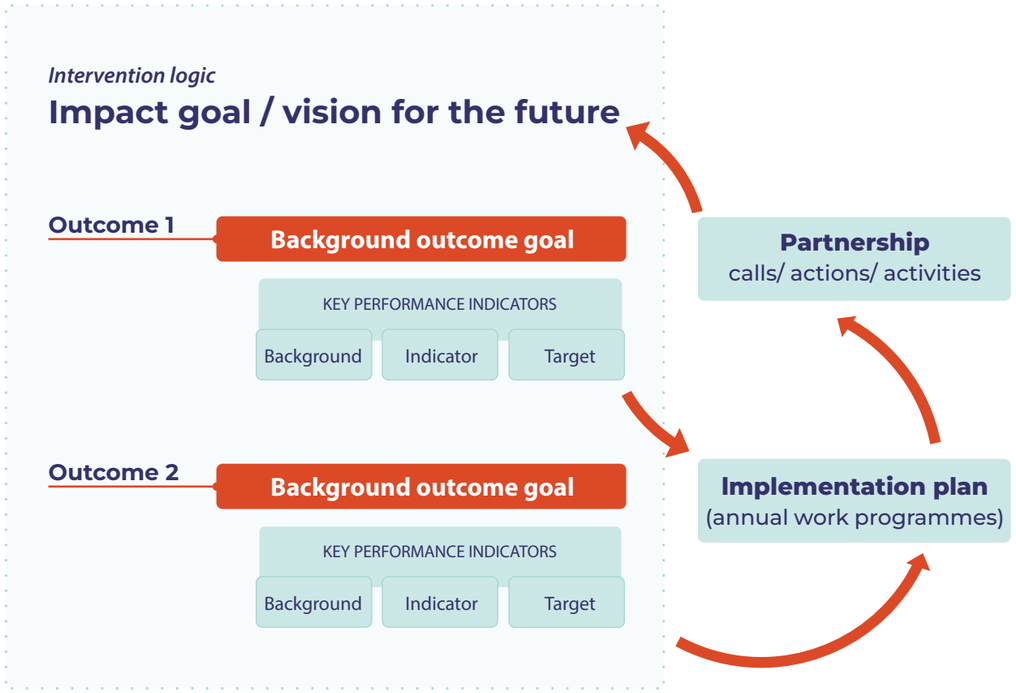


Figure 6. Intervention logic structure applied to the Thematic Scope

4.2
Implementation plan

While the SRIA summarises the general challenge areas and defines the vision, outcomes and impact goals, and lists the KPIs for the Partnership as a whole, it does not detail the implementation plan of the Partnership that includes collaboration among consortium partners, structure of the calls, communication plan, monitoring plan, and any other practical actions or activities.

Such decisions need to come from the partners and stakeholders and be derived from common goals outlined in the SRIA, while still being flexible enough for regular updates to keep up with the evolution of the research and innovation system.

While the SRIA sets the stage for the Partnership in a theoretical sense, the Implementation plan describes its actions in more practical terms.

The preliminary content of the Implementation plan is listed below and outlined further in coming sections. It should include, but is not limited to:

- A description of the partners committed to the Partnership.
- A flexible long-term action plan stretching over the 7-year period of the Partnership.
- A detailed short-term action plan comprising of the initial three years of the Partnership.
- A monitoring plan.
- A communication and dissemination plan.

4.2.1 Partners committed to implementing the Partnership

Partnerships evolve over their duration, not only due to the impact of their activities and the results of the funded projects, but also due to the consortium committed to implementing the Partnership changes, RFOs might suffer internal changes, new RFOs might join. In addition, we welcome other organisations whose main role is not funding, such as research organizations, partnerships, associations, NGO's and other public authorities or ministries, to join the Partnership and contribute to its additional activities.

The Implementation Plan lists the initial consortium partners and should outline how each partner chooses to implement the Partnership according to their national research agendas, strategies and priorities, as well as certain vital conditions needed (for example related to monitoring goals or keeping the funding to specific thematic areas or TRLs). The implementation Plan is the consensus work plan for the Partnership, so all partners can be aligned with its mission and goals but also align the Partnership with their national priorities. This work plan includes the preliminary commitments (financial and human resources) to be expected from each partner throughout the active years of the Partnership.

4.2.2 Long-term action plan

To achieve the mission and the goals set by the SRIA, as well as for the Partnership, a long-term action plan is needed as a guideline for the partners. This plan should include a general overview of all important actions that require preparation efforts by all partners, such as: calls outline and implementation, annual meetings and conferences organised by the Partnership, stakeholder engagement, etc.

A rough timeline of such activities will help the partners adhere to the goals and should, in general, require little modification as the Partnership progresses.

4.2.3 Short-term action plan

The short-term action plan will set a pattern for the long-term action plan, and ultimately for the achievement of the objectives and KPIs of the Partnership. It should include more detailed goals and activities within a period of three years. These activities should reflect the combined efforts by all partners, such as: call preparation, administration and external review, workshops

The implementation Plan is the consensus work plan for the Partnership, so all partners can be aligned with its mission and goals but also align the Partnership with their national priorities.

and conferences organisation and attendance, consortium meetings, and collaborative actions with other initiatives. The short-term action plan should be reviewed and updated every year for a future period of three years to consistently provide a guideline and facilitate the planning of not only the Partnership activities but also and the national commitments for the consortium partners.

For the Partnership, the action plans will include funding and organization of activities that are in line with and work towards the intervention logic outlined for each thematic area. These may include:

- EU co-funded R&I projects
- Building collaboration and matchmaking with stakeholders in third countries
- Matchmaking events for international consortium building
- Conferences, workshops, and seminars for dissemination and cross-disciplinary outreach for system innovation
- Policy labs
- Communication arenas and platforms for regional stakeholders, local communities, and the wider society
- Networks to facilitate life-long learning
- Mobilization grants for visiting researchers and knowledge exchange

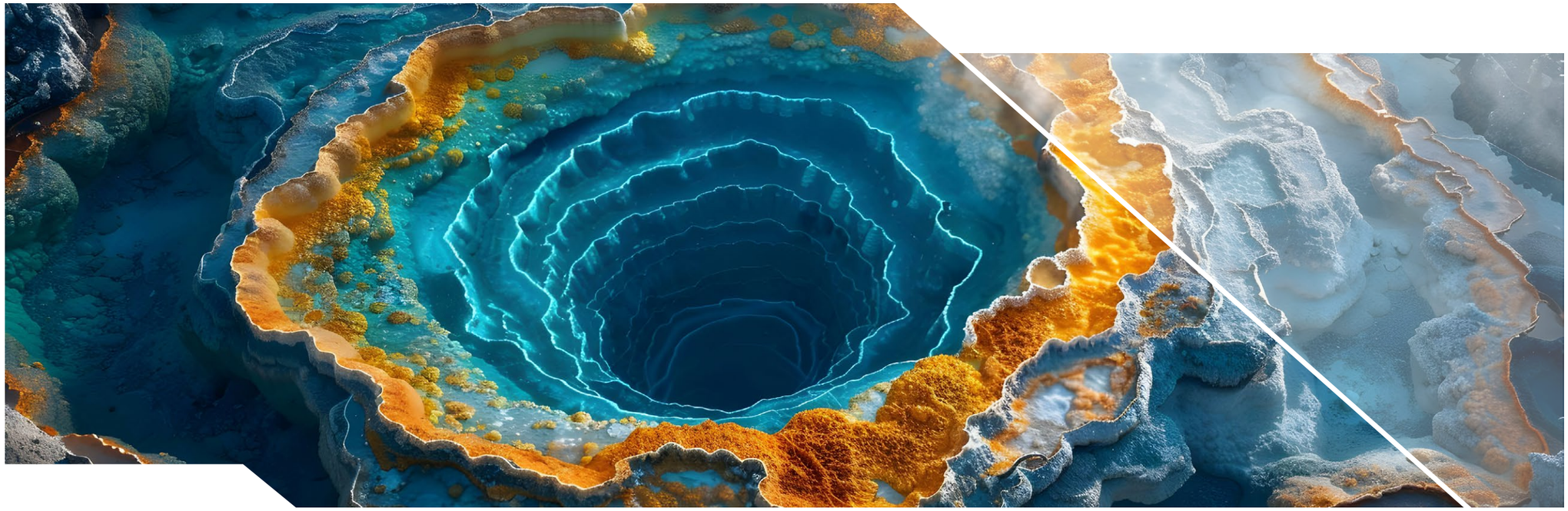
4.2.4 Monitoring plan

While the intervention logic, impact goals, outcomes and KPIs described in the present SRIA provide the premise for calls and other activities of the Partnership, a separate plan needs to be developed to follow up and monitor the progress towards the achievement of these goals and KPIs. The monitoring plan should provide the context to each KPI, as well as a plan to collect and analyse data to describe how each indicator is achieved.

While KPI target values are always quantitative, the monitoring and collection of data includes both quantitative and qualitative information, for example from statistics and surveys regarding projects and calls, or interviews and workshops related to the calls and the Partnership structure. In addition, monitoring systems for assessment and statistical analysis of innovation potential, scientific excellence and upscaling feasibility will be developed.

4.2.5 Communication and dissemination plan

Effective communication and outreach are important factors for the success of the Partnership. Calls, workshops, and conferences will not be limited to EU member states and regions, but instead designed to include more relevant stakeholders from non-EU countries, EU associated countries, and third countries. The communication plan will set the guidelines for the visual identity and public presence of the Partnership, as well as for the several outreach activities aiming to a larger number of stakeholders and the wider society; it will also include the internal Partnership communication paths.



05

Thematic Scope

More than ten years have passed since the publication of the ERA-MIN Research and Innovation Agenda[47] and the RM landscape has considerably changed since then. As the world, and in particular the EU, transitions from a fossil-based economy to a near-zero waste and emission economy, the:

Demand for many RM skyrockets. Expert predictions indicate up to 20 times the current demand by 2040 for some raw materials.

Geopolitical risks are higher than anticipated a couple of decades ago, thus threatening the sustainable and resilient RM supply to European industries and straining the RM value chain.

Recycling of RM will only meet a fraction of the exponentially growing demand for materials, and there is a need to act on both short- and long-term strategies to increase European Union resilience.

With new R&I endeavours, as well as actions under the framework of Horizon Europe, the Partnership, together with other RM-related initiatives and a growing network of stakeholders, can continue the journey that began with ERA-MIN in 2011, towards achieving the common mission of *Sustainable Raw Materials Supply and Use for the Green and Digital Transition*.

This SRIA outlines a set of themes for the Partnership with the aim to build up the R&I system and establish leadership towards environmental and social sustainability goals, while at the same time ensuring economic sustainability and global market competitiveness of the European RM industry. These themes have been selected carefully to be in line with the challenges and objectives detailed in relevant policy documents such as the CRM Act[4], the European Technology Platform on Sustainable Mineral Resources (ETP SMR) SRIA[48] and the ERA-MIN research agenda[48]. The themes are not only linked with EU policies and regulations, but also strongly intertwined with the Sustainable Development Goals (SDGs; Fig. 7).

Figure 7. Relation between the six themes and the SDGs

Due to the rapid progress of modern technology and societal development, the increased demands as well as old and new challenges, the intention is to create a SRIA that is a dynamic and flexible document with a broad mission approach as well as thematic scope and intervention logic that can be implemented during the Partnership. The SRIA considers the dynamics and regular updates of the EU CRM list [49, 50, 51, 52, 3] but does not have an exclusive focus on CRM[4]. R&I on non-fuel, non-food RM (with priority on metals and minerals) currently not considered critical are explicitly included in the scope of this SRIA, since it is an equally crucial challenge to prevent non-critical RM from becoming critical in the future.

The SRIA comprises six themes, three of which are technical, business-focused addressing economic activity (so-called core themes) and will tackle the main research and innovation challenges in the field:

- **Core Theme 1:** Resilient primary and secondary raw materials supply
- **Core Theme 2:** Efficient use of raw materials in design and production
- **Core Theme 3:** Sustainable use and reuse of products

The remaining three themes have a focus on policy development, social and environmental sustainability, as well as international cooperation and skills (so-called transversal themes), and will enable the development of a strong innovation system:

- **Transversal Theme 1:** Effective policy development and governance
- **Transversal Theme 2:** Maximizing societal benefits
- **Transversal Theme 3:** World-class innovation capacity

The alignment of these themes with the circular economy value chain of RM, as well as the interfaces between them are illustrated in Fig. 8.

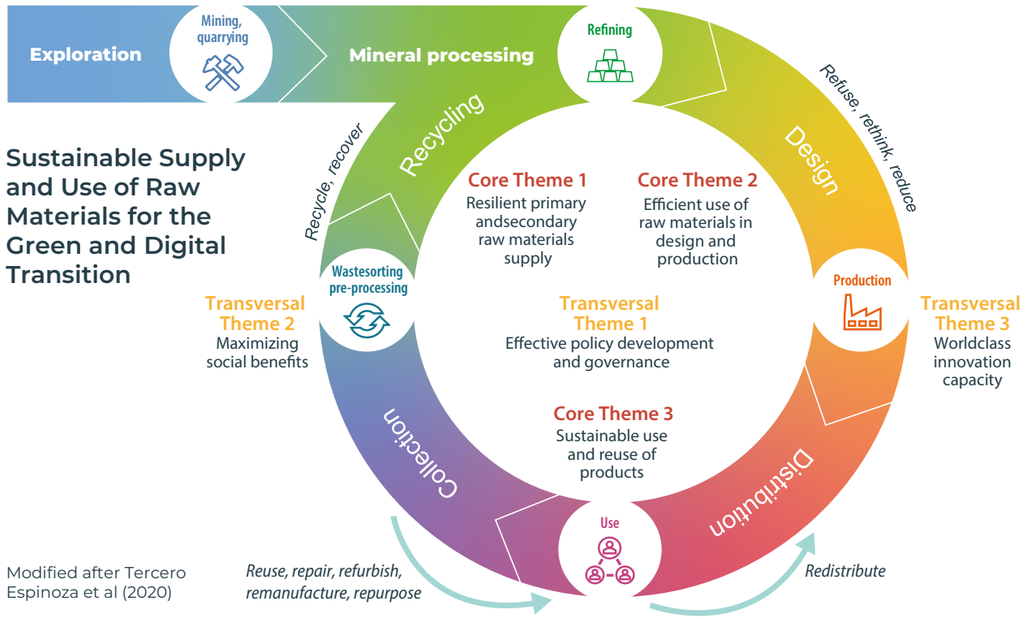


Figure 8. Relation between the six themes and the circular economy of raw materials

Figure based on[53].

The SRIA comprises six themes, three of which are technical, business-focused addressing economic activity (so-called core themes) and will tackle the main research and innovation challenges in the field.

Below is a description of each theme including sub-sections based on the intervention logic (Fig. 6):

Vision and Impact Goal 2040. This section represents the desired vision and impact of the Partnership for each theme. While the Partnership actions will be aligned to produce impacts towards the vision, these are also heavily influenced by external effects. The visions and impact goals are ambitious, as many synergies within and outside of the Partnership will contribute to them.

Outcomes. The outcomes represent the implementation of results from the Partnership, its projects and activities in live environments, combined with influences from external effects and synergies with other initiatives. The outcomes are often qualitative rather than quantitative, and are envisaged to be achieved within a timeframe of 5 years after the end of the Partnership. Each outcome is aligned with the vision and impact goals of the specific theme.

Key performance indicators (KPIs). The objectives of the Partnership, including the funded projects and additional actions/activities, are monitored using a selection of measurable and quantitative KPIs. The background of each KPI, its quantitative target value and justification are outlined.

Since the KPIs monitor the implementation and achievement of actions and activities within the Partnership, they do not consider external effects. However, they depend in many cases on effects and results within the wider innovation system and stakeholder community, which the Partnership can stimulate but ultimately not control through its actions. Each KPI detailed below is aligned with a specific Outcome and, in turn, with a Vision and Impact Goal 2040 for a specific theme.

5.1
Core Theme 1
Resilient Primary and Secondary Raw Materials Supply

RM are needed to produce virtually everything in use in society, and it is possible to identify the role of metals and minerals within the life cycle of virtually every product needed for modern life[54]. Essentially all industrial value chains, such as the ones for batteries, permanent magnets, wind and solar power, electric engine, advanced material, semiconductor and quantum technology production, rely on a resilient and sustainable supply of RM, with special emphasis on the risky and drastic supply shortage of CRM[4]. As countries' economies and populations grow, societies develop, and the need for a twin transition to new green and digital technology increases, the demand for RM is expected to skyrocket towards the middle of the 21st century[9, 55].

Building resilient value chains begins with increasing the supply of RM from both primary (mining) and secondary (recycling) sources. In the SRIA, primary and secondary RM supply are addressed in the same theme to reflect the increasing industrial practice of metallurgical activity accommodating material streams from both these sources in the same operation, as is the case at, for example, the Rönnskär smelter, the third largest and most efficient base and precious metal metallurgical facility in Europe[56]).

While being crucial as an enabler of the green and digital transition [57], the environmental and social sustainability of RM supply operations, in particular mining operations, remains an issue and will need to be addressed in concert with the upscaling of the

production. Environmental hazards and risks may be encountered and need to be addressed throughout the RM value chain from exploration through mining, mineral processing and metallurgical activity to the final stages of closure and rehabilitation [58]. These hazards include, but are not limited to, water use, emissions to air and water, land use and climate change[59]. While social effects include benefits such as job creation and income, drawbacks include, but are not limited to, land use-related conflicts as well as environmental impacts on human health and human rights, especially affecting the existence of local and/or indigenous communities[60].

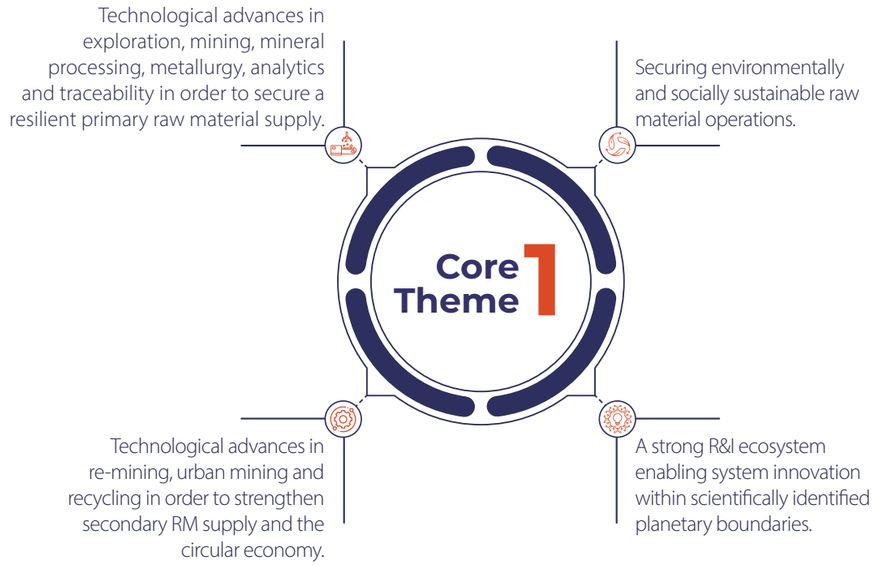
The implementation of sustainable practices throughout the RM value chain will be crucial and requires a vast increase in R&I funding to build an efficient innovation system. It is vital to orient R&I investment and efforts to enable the rapid and economically sustainable upscaling of the RM industry to meet the many-fold demand for twin-transition technologies in the coming decades, all the while not losing sight of the need to avoid and/or mitigate the negative environmental and social impacts, thus avoiding generating new sustainability problems.

Public and private financing have a crucial role in delivering sustainable value-chains for CRM. To get acceptance for the projected global expansion of mining in countries with significant CRM deposits, a considerable improvement will be required in the environmental and social governance (ESG) performance of the mining industry. International R&I collaboration and partnerships will be crucial to build a global innovation system for exchange of knowledge and best practices.

Due to the key role of resilient primary and secondary RM to enable the green and digital transition, and the importance to increase its sustainable and resilient supply to meet the CRM Act benchmarks, Core Theme 1, as the main and most important theme, addresses the beginning of the RM value chain and aligns with most of the funded activities.

Core Theme 1 includes:

- Technological advances in exploration, mining, mineral processing, metallurgy, analytics and traceability in order to secure a resilient primary raw material supply.
- Technological advances in re-mining, urban mining and recycling in order to strengthen secondary RM supply and the circular economy.
- Securing environmentally and socially sustainable raw material operations.
- A strong R&I ecosystem enabling system innovation within scientifically identified planetary boundaries.



5.1.1 Vision and Impact Goal 2040

By 2040, RM used in Europe are sustainably sourced through resilient value chains. New techniques and exploitation of a variety of deposit types and other sources allow high yields and recovery of every raw material needed. Supply chains are resilient and as short as possible, enabled by a RM industry (both primary and secondary) scaled appropriately and within our planetary boundaries. The European RM sector is seen as a vital pre-requisite and instrumental in achieving European climate targets and securing a reliable and sustainable supply of minerals and metals required by European industries in environmentally, socially, and economically ways, not only by policy makers but also by local communities and society as a whole.

The RM industry has a widely recognized role in the industrial value chains of products and, thereby, forms the backbone of the EU's industrial ecosystem. A large part of the mined minerals and metals remain in the technosphere indefinitely and are recycled with high efficiency. There is a wide knowledge and awareness of Europe's primary and secondary raw material resource potential, and the ability to extract and refine more metals, including but not limited to CRM, with higher yield as well as cost and resource efficiency has increased significantly. The number of RM considered critical has decreased significantly.

In accordance with the CRM Act[4] and the SRIA presented by ETP SMR[49], the funding of R&I projects under the Partnership is in line with key quantitative objectives and benchmarks closely linked to the KPIs under this Core Theme:

- At least 10% of the EU's annual strategic raw material consumption domestically produced by 2030
- At least 25% of the EU's annual consumption from secondary sources by 2030
- Mineral processing capacity of at least 40% of the EU's annual consumption of strategic RM
- Net-zero GHG emissions in mining by 2035 and processing by 2045
- Net-positive biodiversity impact of mineral and metal production by 2030

Technological advances in exploration, mining, mineral processing, metallurgy, analytics and traceability.

By 2040, knowledge of Europe's mineral potential is significantly improved attracting exploration investment. The integration of different sets of geodata in mineral system models on all scales is improved and new target areas are accurately identified through the utilization of predictive mineral potential maps and common-earth models. Improved exploration technologies lead to new discoveries of deep (land-based) deposits, while technologically separate fields such as deep-sea and extra-terrestrial exploration are under development at low to medium TRL levels.

Improved drilling technologies increase efficiency and reduce costs. Easy public availability of results and data from geoscientific research and national exploration programmes in national and European databases has led to reworking, reprocessing and reuse of existing data including digital data standards, which faciliate sharing and development of digital tools for exploration, as well as new studies, policy decisions, and investments.

Systems along the entire mining value chain are highly digitalized and carbon neutral. Accurate and detailed digital twins (IoT) of mining operations as well as mining technology, including autonomous mining machinery, result in interoperability and system integration as well as improved ore recovery and minimized waste. New solutions in data management and integration, connectivity, cyber security, autonomous solutions as well as sensors for automation and machine vision are utilized and exported globally.

Through the implementation of ground-breaking R&I results, Europe's metal extraction, processing and smelting capacities, including but not limited to CRM, have increased, making EU less sensitive to trade disturbances and global geopolitical risks. Novel, sustainable and resource efficient technologies, including mining machinery, to increase process yield from ores have been scaled up for industrial implementation, also enabling the extraction of a wider range of valuable by-products from material streams.

Resource and energy efficiency are significantly improved, contributing to minimized environmental footprint and significantly reduced emissions to air, land, and water. Processing residues are valorised in the construction material industry. Raw material flows within the industry as a whole are largely circular and waste is minimized towards near-zero. RM operations are adapted to and withstand climate-change-related impacts and disturbances through innovative solutions improving e.g. land stability and water management. Accurate analytical and tracking technologies are adopted throughout the RM value chain to support the sustainable sourcing of CRM, governed by certification and standards related to the due diligence of CRM.

Technological advances in re-mining, urban mining and recycling.

By 2040, sustainable, resource-efficient, carbon-neutral technologies have been implemented to extract additional elements from mine waste and tailings of operating, closed and abandoned mine sites. Consequently, the demand for primary mining for many RM is reduced, supply chains gain stronger resilience, waste is minimized and remediation efforts of legacy or abandoned mine sites is reinforced. Accurate monitoring, prevention and mitigation technology is in place to minimize the risk of new releases of contaminants from waste piles and legacy tailings into air and water. Through proactive and continuous stakeholder engagement in re-mining projects, social performance is ensured through preventing the continuation or recreation of possible environmental injustices encountered by local communities impacted by past mining.

Through the implementation of ground-breaking R&I results, Europe's metal extraction, processing and smelting capacities, including but not limited to CRM, have increased, making EU less sensitive to trade disturbances and global geopolitical risks.

Novel monitoring and tracking technology, using Artificial Intelligence (AI) and IoT[j] solutions, enable accurate mapping and quantification of dormant and accessible metals accumulated in urban sediments and out-of-service infrastructure such as buildings, technical systems, appliances, and fortifications, making urban mining a significant source of secondary RM.

Efficient monitoring has resulted in accurate waste inventories of depositories and dumps (municipal landfills, domestic waste streams), improvement of waste use (redirection of waste streams). Technological advances have led to resource-efficient recycling of a large range of valuable RM, including CRM, from a variety of secondary resources in the technosphere (mine waste, urban mining sources, waste streams from other industries, electronic scrap), with high recovery rates, thereby strengthening the circular economy.

Securing environmentally and socially sustainable raw material operations.

By 2040, the RM industry has achieved a drastic decrease of negative environmental and climate impact throughout the value chain. Exploration, extraction, and recycling operations are largely decarbonized, climate-neutral, and contribute to a net gain in local biodiversity. The amount of waste from mining is minimized due to system-wide and accurate environmental monitoring and closed-loop systems. RM operations use accurate methods, technologies, and tools for assessment, and ensure the mitigation of any negative effects on local water and air quality, land and water use as well as other harmful emissions. Innovative and scientifically proven practices and methods are in place to remediate closed mine sites, experiencing a renewal of biodiversity, or to co-design recreational areas with the local community.

Both the primary and secondary RM industry are widely accepted as key enablers of the green and digital transition towards a climate-neutral society and circular economy. Systems and arenas are in place to proactively engage and involve all stakeholders affected by RM operations in strategic decisions with potential impact on local communities, leading to a Social License to Operate. Through the widespread affinity of industrial stakeholders for novel and ground-breaking technology in pursuit of ambitious sustainability goals, RM operations as well as the R&I system are regarded as attractive workplaces. The RM industry contributes positively to local economic growth, education, training, and employment.

A strong R&I ecosystem enabling system innovation within scientifically identified planetary boundaries.

Through established strategic R&I consortia between industry, deep tech companies, academia, research organizations, civil society and other relevant stakeholders, the European RM industry leads the development and implementation of green technology, digitalization and automation. Exploration and deposit evaluation are widely recognized as essential requirements for economic sustainability. These factors enable system innovation and efficient implementation in exploration, extraction, processing and metallurgy in a resource-efficient and economically viable way, with the lowest negative environmental and social footprints in the world. European technology for all aspects of the

[j] See Glossary

The Partnership and complementary initiatives are deeply aligned with and contribute to and monitor the legislative implementation of the CRM Act, such as the achievement of its benchmarks and implementation of other programmes based on the Act such as the national exploration programmes at EU member state level.

RM value chain is in global demand, contributing to resource (including water and energy) efficiency, increased mine safety, and reduced emissions from RM operations around the world.

R&I for a sustainable RM supply is practiced across downstream industrial value chains, integrating the challenges and needs of production systems for resource-intensive green technology such as the battery, permanent magnet, wind and solar power, electric engine as well as advanced material, semiconductor and quantum technology value chains. Through the establishment of efficient innovation systems and platforms, stakeholders from a variety of industries communicate and collaborate towards common R&I and sustainability goals. The RM industry operates within the limits set by scientifically proven planetary boundaries and enables the green and digital transition through system innovation in close collaboration with downstream industries.

5.1.2 Outcome: Technological advances to increase raw materials exploration, extraction, recovery and resilience

Five years after the end of the Partnership, collaboration between industry and the research community across Europe has enabled important, cost-effective, and economically viable technological advances to increase sustainable RM extraction and recovery, ranging from exploration to recycling. Through dedicated R&I efforts, there is a deep understanding of the factors influencing the vulnerability of value chains and the mechanism that need to be in place for securing resilience.

The Partnership and complementary initiatives are deeply aligned with and contribute to and monitor the legislative implementation of the CRM Act, such as the achievement of its benchmarks and implementation of other programmes based on the Act such as the national exploration programmes at EU member state level. System innovation consortia across traditional boundaries between different sets of stakeholders and segments of the RM value chain have been established, resulting in ground-breaking R&I in exploration, extraction, and recovery that is scaled up and implemented together with the industry. Novelty and value is demonstrated through patents held by European stakeholders, based on the results of various R&I projects.

Through further development, upscaling and implementation initiatives by the industry and complementary funding bodies, a large part of the Partnership project results and prototypes lead to novel industrial technologies as well as products and services on the market, increasing the overall economic sustainability and resource efficiency of the RM sector. System innovation, collaboration between stakeholders and needs-driven R&I are strengthened by a well-integrated and large network of cutting-edge and easily accessible research infrastructure including demonstrators, test beds and pilot facilities.

This outcome is assessed by monitoring the following KPIs:

KPI	Background	Target value 2032	Justification of target value
C1.1 Number of EU Member States exploration programmes impacted by project results.	Through the CRM Act, EU member states are required to establish national exploration programmes. The Partnership will contribute to the R&I dimension of these programmes through collaboration with projects that aim to improve the quality of available information on mineral resources, through the regular updating of data and the harmonisation of information.	20	The aim is to collaborate with the respective exploration programmes of each EU member state that has joined the Partnership.
C1.2 Number of funded projects in exploration, extraction, recovery and value chain vulnerability.	R&I projects focused on improving the resilience of RM supply is the core of the Partnership mission.	70	This is the main project category for the Partnership and should be addressed by at least 10 projects per annual call (i.e. 50% of all projects, see KPI 0.1). Even though projects on primary and secondary RM supply are integrated into the same KPI, the Partnership will strive for a balanced project distribution between both supply categories.
C1.3 Number of patent applications related to RM exploration, extraction and recovery resulting from projects.	The Partnership seeks to fund R&I projects providing novel and excellent ideas, as well as industrially applicable solutions, for which patent applications are widely regarded as reliable indicators.	7	The aim is for at least 10% of the total number of projects addressing this theme to apply for one or more patents during the timeframe of the Partnership (see KPI C1.2).
C1.4 Number of new system prototype demonstrations in operational environment by projects related to RM exploration, extraction and recovery.	Even though the supported R&I is focused on lower to medium TRL, it is considered vital for a certain number of projects to reach TRL 7 to demonstrate their potential for upscaling and implementation.	14	It is envisaged that at least 20% of all projects addressing this theme can achieve TRL7 (see KPI C1.2).
C1.5 Number of new demonstrators, test beds or pilot facilities in an industry-specific context, or new utilization of current research infrastructure in an industry context.	The development and industrial utilization of quality research infrastructure tailored to industrial needs is crucial for successful, implementable, and scalable R&I conducted within the Partnership.	14	At least 20% of projects addressing this theme should contribute to or use large research infrastructure (see KPI C1.2).

5.1.3 Outcome: Sustainability of exploration, extraction and recovery processes

Within five years after the end of the Partnership, extraction and recovery of RM are increasingly sustainable, for example adopting principles such as full electrification and automation, CO_2-neutrality, zero accidents, closed-loop systems, no-enter mines, etc.

Industrial implementation of project results in exploration, extraction, and recovery have led to a measurable improvement of the ecological and societal footprint as well as resource efficiency of the RM sector. Interlinked digital and automated process solutions with efficient monitoring, implemented in Europe and worldwide, have its basis in R&I projects of the Partnership. This contributes to the economic viability and sustainability of RM operations with positive impacts on resource, water, and energy efficiency, environmental footprint, process monitoring, workplace safety and health as well as social performance. The identification of bottlenecks and decision making for sustainable practicing are guided by established accurate databases (e.g. LCI) and concepts such as Save and Sustainable by Design (SSbD).

Despite numerous novel technologies that improve the environmental, social, and economic sustainability of the sector, there is a sufficient level of standardization, and awareness of the need thereof, across the RM value chain, resulting in improved cost efficiency, flexibility, and scalability of production. Robust monitoring, reporting, and verification mechanisms are established to promote transparency and accountability in the RM sector, thus enhancing trust among stakeholders and ensuring compliance with environmental and social standards.

Proactive communication by projects and stakeholders towards the public has increased knowledge and awareness of the necessity for a sustainable RM supply and increase of circular economy processes. This communication strategy highlights the tangible benefits of sustainability initiatives, showcasing successes within the EU. Efforts are made to engage the public in a dialogue that fosters a deeper understanding of the RM sector's challenges and opportunities, enhancing public support and trust in the industry's sustainability efforts. The participation of local and regional stakeholders affected by raw material operations in strategic R&I projects, activities, and decisions ensures a broad system involvement, acceptance, and social sustainability.

This outcome is assessed by monitoring the following KPIs:

KPI	Background	Target value 2032	Justification of target value
C1.6 Number of projects on minimizing the ecological and/or societal footprint of exploration, extraction, and recycling operations.	Reducing negative environmental impact of RM operations is a key requirement for a sustainable supply.	35	At least 50% of projects in this theme should have an environmental and/or social sustainability focus (see KPI C1.2).
C1.7 Number of projects on resource-efficient technologies in exploration, extraction, and recycling.	Optimizing resource efficiency (e.g., energy and water saving, reduction of waste) of RM operations is a key requirement for a sustainable supply.	35	At least 50% of projects in this theme should have a resource efficiency focus (see KPI C1.2).
C1.8 Number of projects that contribute to standardization processes of sustainable practices relevant for RM extraction and recovery.	Standardization of sustainable practices in the industry is generally seen as an important enabler to improve cost efficiency, flexibility as well as scalability of production.	7	At least 10% of projects in this theme should contribute to standardization of sustainable practices (see KPI C1.2).
C1.9 Number of successful communication activities by projects for the broader public to raise awareness of the need of exploration and mining activities to ensure a resilient and sustainable raw material supply.	While there is a vast amount of popular scientific literature promoting the circular economy for the broader public, there is a lack of communication on the need for sustainable RM supply as an essential requirement for the establishment of circular material flows in the technosphere.	100	Approximately three successful activities per project are envisaged. Success will be measured through the participation satisfaction rate, measured through activity-specific surveys
C1.10 Number of projects addressing digitalization and automation of the RM industry.	Digital and automated solutions, including data management and integration, connectivity, cyber security, autonomous solutions, sensors in automation and machine vision and the connectivity between synergistic digital infrastructures (e.g., Green Deal Data Space) are needed to improve numerous aspects of sustainability in the RM value chain.	14	Approximately 20% of projects addressing this theme (see KPI C1.2) should contribute to digitalisation and automation.

5.2
Core Theme 2
Efficient use of raw materials in design and production

Using a systemic approach, the SRIA focuses on the entire RM value chain and not only on the supply (covered by Core Theme 1). Therefore, Core Theme 2 addresses the production industry and covers all segments of the value chain where RM from both primary and secondary sources are converted into new materials and products, including product design. Hence, the production industries strongly rely on a resilient supply of primary and secondary RM (see Core Theme 1). On the other hand, design and production affect the sustainable use of products by determining most of their environmental impact (see Core Theme 3).

The European production industries contribute to the independence from imported products and resilience of society to unexpected events or crises as they guarantee access to essential products and services to European citizens. A recent study investigated the supply chain from RM to the last step of the chain including processed materials, components assemblies, and super assemblies[13]. The data show the criticality of the upstream steps and highlight the challenges to guarantee an affordable and secure supply not only of RM but also of materials, components, and products.

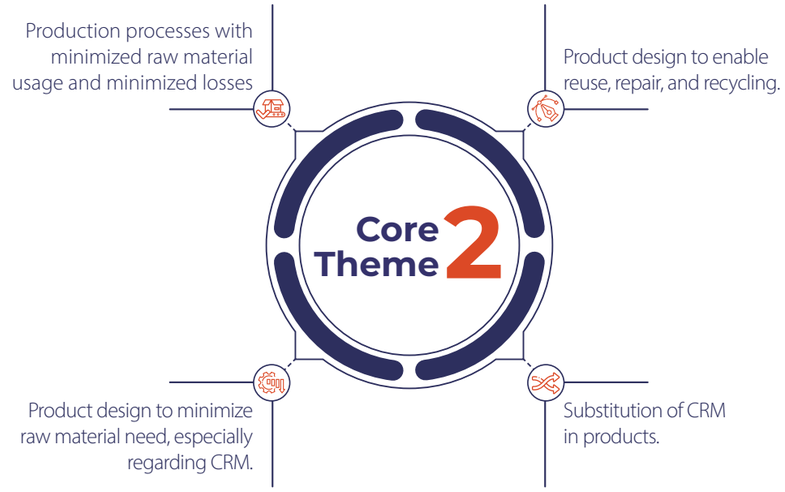
Although the vulnerability of supply chains tends to diminish along the value chain, there are still cases where Europe has a high dependency on foreign imports up to the final product (e.g., batteries, solar photovoltaic (PV), data storage and servers, smartphones, tablets and laptops, and drones). In the value chain for solar PV, Europe has only a share of global production volumes of 2% of the RM, but the share of global production volumes increases for processed materials (12%). However, further in the value chain the share of global production volumes decreases showing a value of 11% for components and only 2% for assemblies.

With this background, the Partnership aims to decrease the vulnerability of the entire value chain including the upstream steps up to the final products. Therefore, it will contribute to the CRM Act[4] which emphasizes to build a full value chain and prevent any bottlenecks at intermediate stages. In line with this, the CRM Act aims to increase the EU's processing capacity along the value chain and to be able to domestically supply strategic RM by at least 40% of the annual consumption for processing.

Currently, the European production industry is facing a great transformation to become climate-neutral and economically circular by 2050 while at the same time enhancing its global competitiveness. This transition also includes a materials transition since a climate-neutral industry is far more minerals- and metals-intensive than the current fossil fuel-based industry. A recent study underlines that a massive increase in wind power plants and solar PV installation, hydrogen, and batteries to store electricity and to power vehicles stimulates new demands for CRM[13].

Since the success of the transformation of the European production industry depends on the availability of RM, in particular the critical ones, all efforts need to be made to reduce RM consumption during production processes and to adopt circular economy principles to increase the resilience of the domestic supply of essential products for the EU citizens. Currently, secondary resources contribute 12% to the total material demand within the EU with very small progress during the last years; the latest corresponding figures from 2022 for metal ores and non-metallic minerals are 24% and 14%, respectively, showing a stagnation as compared to 2010[61]. As the proportion of secondary RM needs to increase to meet growing demand, production lines need to adapt to feedstocks with a wider range of properties.

In order to ensure the sustainability of production value chains, all aspects of sustainability should be addressed as outlined in the *EU principles for sustainable raw materials*[62]; these aspects could include the elimination of hazardous materials from the recycling loop or the reduction of water consumption. Furthermore, the efficient use of RM in product design and its production plays an essential role in strengthening the European industry. Innovative product design and production processes address a clear market opportunity and have the potential to improve the global competitiveness of the European production industry.



For ensuring a sustainable supply of products for a future climate neutrality, it is necessary to direct R&I investment and efforts to the minimization of RM use in production value chains. Emphasis should be put on supply chains with a high importance for strategic areas such as renewable energy or e-mobility. In addition, R&I are also needed in industries with high raw material input, such as metal and steel production or construction, as in these sectors a major leverage effect can be achieved. R&I activities should always include the sustainability of the whole value chain to avoid the nullification of the benefits of resource efficiency by new negative impacts on environment and society.

To secure Europe's supply with RM essential for climate neutrality and the digital transformation, and to ensure the achievement of CRM Act benchmarks, Core Theme 2 is an important part of the SRIA and will be addressed by and in line with the Partnership funding activities. The activities will complement other partnerships and initiatives that address the challenges for specific production value chains, but do not have a specific focus on RM-related issues. The most important complimentary actions and initiatives are described above in chapter 1.2. It is important to establish cooperations with these actions and initiatives to support effective collaborations between all actors of the value chain.

Core Theme 2 includes:

- Production processes with minimized raw material usage and minimized losses.
- Product design to minimize raw material need, especially regarding CRM.
- Product design to enable reuse, repair, and recycling.
- Substitution of CRM in products.

5.2.1 Vision and Impact Goal 2040

By 2040 the European production industry embraced a circular economy approach to RM use, integrating it from the initial design phase to the technical development of the production processes phase. Through extensive R&I, significant reductions in raw material consumption are achieved while simultaneously maintaining or enhancing product quality. Domestic production increased to contribute to Europe's autonomy for strategic technologies. At the same time, the European industry made big steps towards climate neutrality and circular economy which will be fully achieved by 2050. Emerging technologies, e.g. additive manufacturing, artificial intelligence and block chain will be major drivers for innovative approaches in product design and production, and support the transformation from a linear to a circular economy.

Circular economy principles are adopted throughout the entire production value chain so that RM consumption is reduced to a minimum. Knowledge about different approaches to increase resource efficiency increased and provides a sound basis for designing resource-efficient production value chains in an environmentally, socially, and economically sustainable way. Tools for assessment of resource-efficient production value chains are established, providing guidance for process development and product design. A holistic approach considers LCA perspectives and the recommendations given by the *Safe and Sustainable by Design* (SSbD) framework[63].

Technological advances in circular design

An integral part of the production phase is the design of products since most of the environmental impact and costs over the entire life cycle of a product are determined during this phase. Therefore, this phase has particularly great potential to increase the efficiency of RM use. By 2040, innovative approaches for product design improve recyclability and make products less resource-intensive during their life cycle. The reuse of products and components is prioritized over RM recycling.

Interfaces of digital systems enable the monitoring of product and material flows, and facilitate re-use, repair and recycling. Machine learning methods support the adaption of production processes to varying feedstock qualities from secondary RM. An extended knowledge and easy-to-use measurement and evaluation methods support the uptake of circular design, and the development of new business models leading to the full integration of circular design into norms and standards. Technological innovations overcome barriers for circular economy, e.g., exchange of data between different actors along the value chain.

Advanced materials play a key role in circular design by enabling the substitution of CRM with less critical RM. This will reduce Europe's dependence on CRM while ensuring resilient supply chains. A holistic approach will ensure that advanced materials promote the circularity of products, thereby improving their overall environmental footprint over their entire lifecycle.

To support this goal, R&I activities will address, but not be limited to:

Emerging technologies, e.g. additive manufacturing, artificial intelligence and block chain will be major drivers for innovative approaches in product design and production, and support the transformation from a linear to a circular economy.

- Increase of re-useability and recyclability (e.g., using easily separable material composites and substitution of materials which inhibit recycling).
- Extension of the lifetime of products (e.g., through optimized reliability, reparability, and upgradeability).
- Substitution of CRM.
- Integration of recycled materials in new design solutions.
- Integration of interfaces to digital systems for controlling product and material cycles.
- Developing tools, which assess impacts on the entire life cycle to compare different options for product design.

Technological advances in production processes

By 2040, the European production industries have re-designed their operations to a large extent to achieve climate neutrality and circularity. Tailor-made solutions for different industries are widely adopted which are more effective and efficient for specific applications. These solutions include: the reduction of RM use, (near)-zero waste production, closing cycles by using waste as input material for other processes or an increase of RM efficiency. A sound knowledge of the options available to improve resource efficiency in production enables decisions to be made on the best option, taking into account the impact on the entire value chain. Through RM savings, the European industry increases its competitiveness and reduces its environmental impact.

Technological advances cover the whole value chain and take into consideration impacts from both downstream and upstream processes. The ongoing digital transition is a key enabler for more intelligent operation of installations and enables cross-sectorial collaboration by tracking data (e.g., for by-products) and sharing information in an effective and secure manner (e.g., to open the loop to industries using by-products as raw material). Circularity is greatly improved by digital tracking and tracing of products and materials.

Research activities facilitated the transition to a circular economy in the production industries by addressing the following topics:

- Increasing RM efficiency in the production value chain.
- Closing loops for waste streams and valorisation of by-products.
- Substitution of CRM in production processes.
- Establishing new cross-sectoral collaborations (e.g., between production and waste management industry thus leveraging industrial symbiosis models).
- Exploiting the full potential of digital technologies (e.g., for the monitoring of material cycles or cross-sectoral data exchange and collaboration).
- Providing easy-to-use tools to evaluate production processes in terms of environmental impact for the entire life cycle of a product.

Securing environmentally and socially sustainable production value chains

By 2040, production industries have made a great step toward climate neutrality and environmentally sustainable operations. Awareness has increased for a responsible sourcing of CRM, its use has therefore decreased, or alternative, non-critical solutions have been widely adopted. The transformation to a circular economy is almost completed so that waste from production value chains is, to a large extent, minimised and usually used as input for other processes within industrial symbiosis. Innovative technologies are adopted by industry, which enable to use RM according to highest standards for efficiency and environmental performance. As part of an inclusive approach innovative value chains in the production industry demonstrate high resource efficiency, including the efficient use of energy, water and all other resources.

The green and digital transition increases the domestic production capacity for many products in Europe, thus decreasing Europe's dependence on essential import of products such as batteries, permanent magnets, wind and solar power or electric engines. European industries become world leaders for climate neutrality and circular production technologies therefore increasing their global competitiveness. The production industry remains a strong pillar of the European economy and contributes to the creation of jobs.

Achieving the green and digital transition while maintaining highest environmental standards has required a rethinking of value chains in the processing and production industries. Strategies have been established to focus the use of CRM to sectors, which are of strategic importance for Europe. At the same time research efforts have been made to substitute CRM or to reduce the consumption of RM. The processing and production industries are fully aware of the benefits of different strategies in order to avoid potential conflicts. For example, miniaturization might support the reduction of raw material demand. On the other hand, low amounts of raw materials in complex miniaturized components may provide a challenge for recycling.

Studies on environmental and social impacts of entire value chains provide a sound basis to define priorities in product design and production. New methods and tools provide reliable data to evaluate the impact of production processes on resource use, energy consumption, GHG emissions, etc., taking into consideration impacts in up- and downstream processes of the value chain, and providing evidence of whether a new approach is preferable to conventional technology. Barriers, e.g. provided by differing regulatory frameworks for waste and products have been overcome.

5.2.2 Outcome: Efficient use of raw materials in production through technological innovations

Within five years after the end of the Partnership, technological advances in production and design processes have made the industry take steps towards more resource-efficient practices. This includes the reduction of RM use especially of those considered critical, the closing of material loops, and the increase of resource-efficiency through the optimisation of production processes.

The Partnership during its lifetime and in parallel and/or consequent complementary initiatives supports the green and digital transformation of the European processing and production industries. R&I activities contribute to an increase of the TRL for technologies addressing circular design, the substitution of CRM, and resource efficient production. Several prototypes and patents resulting from the Partnership's funded projects demonstrate the potential for upscaling and market uptake. For new emerged technologies, such as e-mobility, the product circular design is already integrated in an early stage of development to realize a great potential for closed-loop systems.

Activities implemented within the Partnership will support the objectives of the CRM Act[4] by highlighting the criticality of upstream processes and securing Europe's autonomy for strategic technologies. The reduction of RM consumption will be a pivotal part of the transformation of the European industry and economy to climate neutrality and circularity within the European Green Deal[8]. There is a strong link to other initiatives addressing the production value chain, e.g., Processes4Planet[64] which aims at closing the energy and feedstock loops in process industries, Made in Europe[65], which aims at ultra-efficient, low energy, circular and carbon-neutral manufacturing or BATT4EU[66] which aims to support local and circular supply chains for batteries.

Because of the complexity of production value chains, it is expected that funded projects addressing Core Theme 2 largely cover two or three approaches for an efficient use of RM in production (design for circularity, resource efficient and circular production, substitution of CRM). Considering that 25% (circa 40 projects) of the funded projects have their focus on Core Theme 2, separate KPIs are set for circular design, resource efficient, and circular production, and substitution of CRM to ensure that all these approaches are covered in an appropriate way by funded projects.

This outcome is assessed by monitoring the following KPIs:

KPI	Background	Target value 2032	Justification of target value
C2.1 Number of projects on design for circularity (e.g., durability, repair, re-use, and recyclability).	Since product design has a great impact on circularity over the entire life cycle, R&I efforts need to address circular design (e.g., by increasing durability, reparability, or recyclability).	20	t is expected that approximately 50% of the funded projects addressing Core Theme 2 will contribute to circular product design approaches.
C2.2 Number of projects addressing resource-efficient and circular production processes.	To use RM in a sustainable way in future climate neutrality and circular production processes R&I efforts are necessary to increase resource efficiency and to close materials loops.	20	It is expected that approximately 50% of the funded projects addressing Core Theme 2 (see KPI C2.1) will contribute to innovation of resource-efficient and circular production processes.
C2.3 Number of projects on substitution of CRM for a sustainable production.	In order to decrease criticality of production processes using CRM, R&I efforts need to address substitution of CRM by less critical ones.	10	It is expected that approximately 25% of the funded projects addressing Core Theme 2 (see KPI C2.1) will contribute to the substitution of CRM.
C2.4 Number of new system prototype demonstrations in operational environment by projects related to circular design and resource efficient production.	Even though the Partnership will support R&I across the entire TRL scale with a focus on low to medium TRL, it is considered vital for a certain number of projects to reach TRL 7 in order to demonstrate their potential for upscaling.	5	It is envisaged that at least 10% of all projects funded under Core Theme 2 (see KPI C2.1) can achieve TRL 7.
C2.5 Number of patent applications for technical innovations in resource-efficient design and production.	Only if innovation can provide clear evidence that it is novel, involves an inventive step, and has an industry application, it can be considered mature enough for a patent application.	7	It is expected that one project per call addressing Core Theme 2 can submit a patent application for newly developed technologies and/or products.

5.2.3 Outcome: Enabling an efficient use of raw materials in the production industry.

Within 5 years after the end of the Partnership awareness of RM importance has increased in the production industry, particularly for CRM, leading to greater emphasis on responsible sourcing, diversification, and adoption of alternative (non-critical) or secondary RM, design for circularity or technologies for resilient and sustainable value chains.

The Partnership during its lifetime contributes to the cooperation of all relevant players in production value chains. Collaboration between stakeholders from the RM value chain, from the processing and manufacturing value chains, and from end-users of products ensure a responsible use of RM throughout the entire value chain. It is therefore expected that funded projects share their results within the processing and manufacturing industry including upstream and downstream processes (e.g. linking the collection of waste and its integration into a new production cycle).

Key actors from industrial value chains should be included in projects in an appropriate way to provide their views on the technological and economic viability of the developed solutions. The Partnership plans to support the dissemination within production value chains through organising dedicated events. Cooperation with other initiatives (see 5.2.2) will be of utmost importance to establish a network which includes all relevant stakeholders from the value chain.

The R&I activities involve participation of partners from science background, industry sector, and potential end-users to pave the way for scaling up for new concepts and technologies validated in the lab and future uptake by the market. This guarantees that new product designs and production processes are implemented with the lowest negative environmental impacts and social footprint in the world.

Awareness of the production industry's role in achieving climate neutrality in Europe and commitment to the highest environmental and social standards are key to improving the public image of production industries and paving the way for a Social License to Operate. Within this context funded projects will be obliged to communicate their results to the broader public. This will facilitate the acceptance of new technologies and products by consumers and other public stakeholders. This outcome is assessed by monitoring the following KPIs:

KPI	Background	Target value 2032	Justification of target value
C2.6 Number of publications in media relevant to the manufacturing industry addressing design for circularity or technologies for resilient and sustainable value chains in projects.	To increase awareness of RM importance in the production industry it is necessary to cross boundaries between the scientific community and non-scientific actors of the production value chain.	35	The aim is that each project addressing production design and production publishes its project results in media relevant to industry in the production value chain, e.g., an industry magazine.
C2.7 Number of projects including a partner operating in manufacturing industry or product design.	In order to increase awareness of RM importance in the production industry, it is necessary that partners from the production value chain are involved in R&I projects at an early stage of a new development.	100	Topics related to the production value chain and including a partner operating in manufacturing industry or product design should be addressed at least by 25% of all projects funded through the Partnership.
C2.8 Number of successful events on topics relevant to the manufacturing industry organized by the Partnership.	To increase awareness of RM importance in the production industry it is necessary to establish a network, which includes industry representatives from the production value chain.	6	The Partnership aims at organizing annual seminars (beginning of year 2) with specific sessions for stakeholders in the production value chain. Success will be measured through the participation satisfaction rate, measured through activity-specific surveys.
C2.9 Number of projects involving a business-to-consumer supplier or an Original Equipment Manufacturing (OEM).	For the success of innovative products and technologies it is necessary to involve all relevant actors along the production value chain especially OEMs as pivotal actors of the value chain.	10	The Partnership has the ambition that approximately in 1/3 of the funded projects addressing Core Theme 2 (see KPI C2.1) have OEMs involved as consortium partners.
C2.10 Number of communication activities by projects to the broader public (society) to promote circular economy in production processes (events, website publications, social media channels, webinars, training).	For the smooth adoption of new technologies and products it is necessary to involve the broader public to increase their acceptance among potential customers and raise awareness for the role of the production industry in relation to the needed transformation of European society towards climate neutrality.	10	It will be expected that each project addressing resource-efficient design and production implements at least three activities to communicate its results to the broader public (e.g. websites, social media, events). If applicable, success will be measured through the participation satisfaction rate, measured through activity-specific surveys.

5.3
Core Theme 3
Sustainable use and reuse of products

Introduction

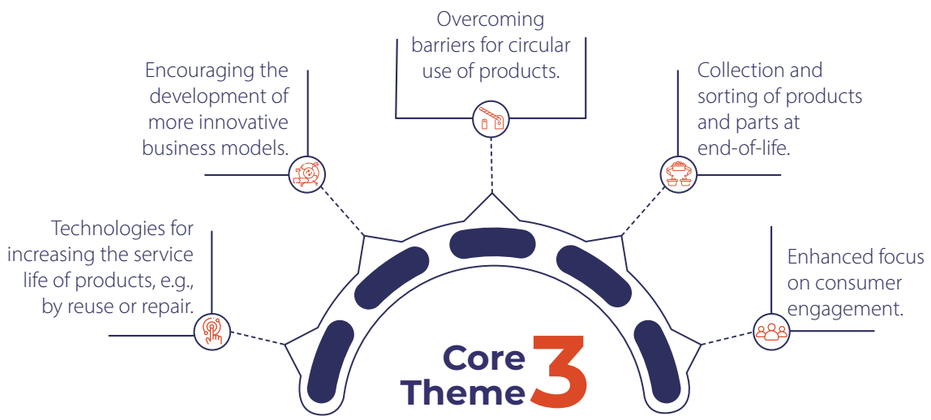
Whereas Core Themes 1 and 2 address the supply of RM and the conversion into products or immovable assets, Core Theme 3 complements the RM value chain by looking at the use of products containing RM with strong links to Core Themes 1 and 2. With an approach covering the entire value chain, increasing the service life of products is an essential element of a sustainable use of RM. Therefore, the focus will shift from industry to the consumer. During production (Core Theme 2) the service life of a product will already be largely determined. The supply of RM (Core Theme 1) strongly relies on secondary sources including end-of-life products as resource to be used again.

Sustainable use and reuse of products are not a core concern of the CRM Act. However, the Act sets a clear and ambitious benchmark to increase the EU recycling capacity to at least 25% of the Union's annual consumption of strategic RM. End-of-life products are an important source of strategic RM, hence it will be essential to establish a strong link between the use of products and the supply of RM to close the loop and thus return RM from end-of-life products to the supply chain as secondary RM.

The EC has addressed the importance of sustainable use of products towards a sustainable use of RM[67] in the Circular economy action plan (CEAP[68]) and as a main element of the European Green Deal. Together, the CRM Act and the CEAP cover all phases of material loops involving CRM as well as products and components containing CRM.

With a comprehensive and holistic approach, the Partnership looks at the entire RM value chain; it aims at reducing the loss of RM during use by supporting the shift from a linear to a circular economy where end-of-life products are considered as resources to be used again within a *closing the loop* approach. To support this shift, Core Theme 3 addresses:

- Technologies for increasing the service life of products, e.g., by reuse or repair.
- Encouraging the development of more innovative business models that prioritize sustainability and circularity in product design and consumption patterns which could lead to significant advancements in achieving a circular economy.
- Overcoming barriers for circular use of products. Identifying and overcoming non-technological barriers, such as legal, regulatory, and psychological obstacles is critical for enabling a circular economy.
- Collection and sorting of products and parts at end-of-life.
- Enhanced focus on consumer engagement: Strengthening communication strategies to actively engage consumers in promoting circular economy practices, incl. consumption reduction and encouraging the return of products for repair, refurbishment, or recycling could further drive sustainable product use and reuse.



5.3.1 Vision and Impact Goal 2040

By 2040, RM are recognized for their significant value, prompting both industry and consumers to embrace new and sustainable norms regarding use, reuse, repair, refurbishing, remanufacturing, and repurposing of products and components. Through the adoption of innovative technologies and business models, circular economy becomes increasingly feasible. Progressively, actors and stakeholders from entrepreneurs to citizens, are involved in the transformation into Circular Society.

Circular economy is adopted by the whole society resulting in a decrease of consumption of RM. A strong knowledge base in combination with easy-to-use tools allow for the monitoring of products to support the necessary decisions for an environmentally, socially, and economically sustainable use of products and components. High-level approaches which increase the product service life are widely adopted and have led to the establishment of new businesses. However, if products further use is not feasible these are returned to the supply chain by closing the loop between end-of-life and supply of secondary RM through recycling.

Technological Advances for closing loops for products and components

Core Theme 3 mainly addresses technological advances aimed at an increase of the service life of products or components. In relation to the different options available, there is a need for a systemic approach which considers existing solutions and gaps in the knowledge of product life cycles. Measuring and safeguarding reliability also plays an important role in extending the service life of products, and consideration needs to be given to the integration of products into efficient recycling processes once the end of life is achieved.

Recycling is not the only answer for closing RM loops consequently the knowledge base for circular economy (e.g., material and energy flows, costs for collection and treatment of used products) must be expanded to support the decision for an optimized strategy. In several cases, the use of products and components (i.e. RM at their highest value) for as long as possible and reasonably has to be prioritized to reduce the increasing need for RM, as well as the impact on climate, environment, and society. However, if products achieve the end of their lifetime, the present RM need to return to the value chain through recycling (e.g., because a further increase of the lifetime is not economically or technologically feasible or if certain material flows must be channelled out).

Accordingly, there is a need for easy-to-use real time decision support for old products, or product information systems, to optimize disassembly processes. Digital tools to monitor products in order to optimize decisions for repair and remanufacturing or removal from the life cycle facilitate the circular economy and are a key enabler for extension of the service life and improving product reuse. Digital tools also enable data exchange between different actors of the value chain, so that products and components which are waste for one actor can be used as input materials by other actors.

Mast et al (2022)[69] described the available strategies for sustainable use of products as follows:

- Re-use: Re-use by other users, Use according to original function.
- Repair: Repair and maintenance of broken products, Use in original condition,
- Refurbish: Remanufacture, restore, and update old products,
- Remanufacture: Use parts of an old product in a new product with the same function,
- Repurpose: Use parts of an old product in a new product with a different function.

As shown in Fig. 9, the available strategies range from low-level strategies with a need for incremental innovation (e.g., repurpose) to high-level strategies which require more radical innovation (e.g., re-use).

An essential element to enable circular economy are logistical aspects. Innovative concepts for the cross-company organization of return logistics or "closed loop supply chains" are of considerable importance for the planning and control of product and component cycles. Rebound effects must be avoided. The availability of larger amounts of products or components will be key for a circular economy on an industrial scale. Only if there is a predictable and reliable return of products or components value chains for reusing, repairing, refurbishing etc, can these be established in an economically feasible way.

By 2040, tailor-made approaches are applied to increase the service life of products and/or components. An extended knowledge base and easy-to-use methods for monitoring products allow the application of the best available strategy for specific cases. High-level strategies where products are reused are prioritized over strategies where only components or RM are returned to the supply chain. Thus, raw material losses will be avoided.

R&I activities have supported the development of innovative technologies for a circular use of products and/or components by addressing:

- Innovative technologies for closing loops by re-use, repair, refurbishment, remanufacturing and repurposing.
- Monitoring product quality to assess options for increasing the service life.
- Closing the loop between end-of-life products and the supply chain for RM through recycling.
- Optimization of collection and disassembly of products.

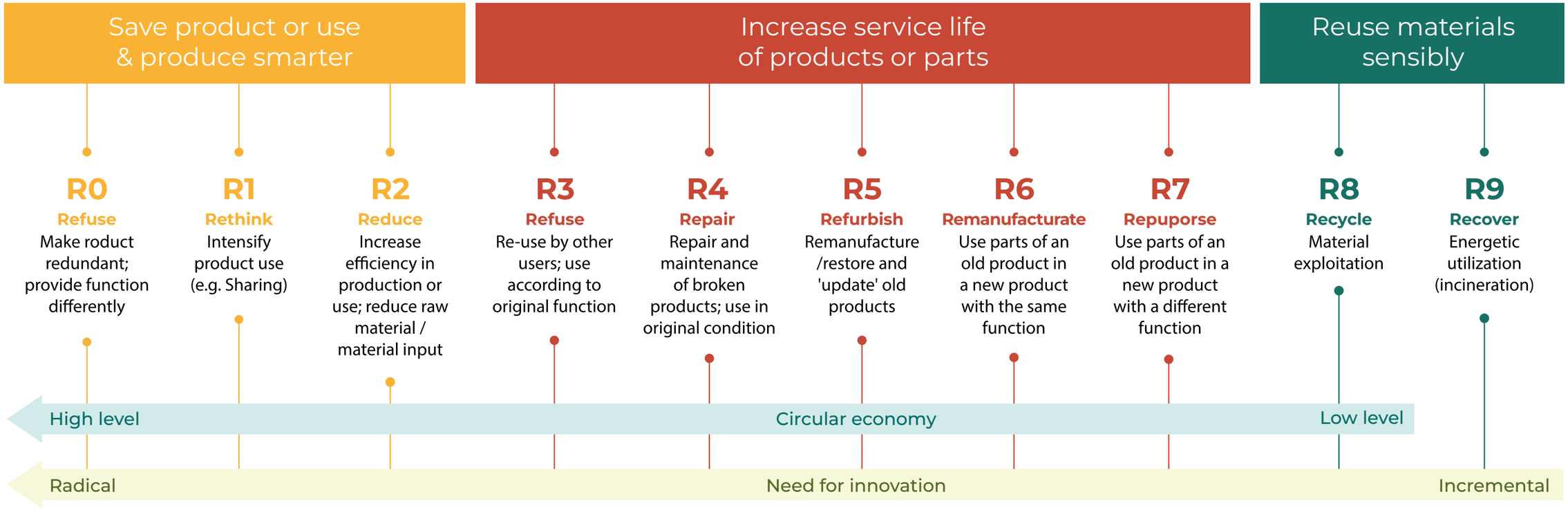


Figure 9. R-strategies as guidelines for the Circular Economy

According to[70]

Circular business models

As shown in Fig. 9, in addition to technological advances, new business models to save products are also important elements of the transformation from a linear to a circular economy on a high level. These business models provide an alternative to conventional business models which are based on selling virgin product. Innovative business models, services, and cooperation networks create economic incentives for companies to develop products with a long service life and cascading use, thus decreasing the number of new products needed. With their focus on economic sustainability, business models are key elements for the circular economy and to retain the value of RM at a high level. They also provide the framework for high-quality recycling if no further use at the end of the service life is economically viable.

An example is the shared use of products which reduces the demand for a specific product and thus the demand for RM. Other examples are Product-Service-Systems or "bottom-up" approaches similar to repair cafés which could play a role in the shift to a circular economy. Therefore, research addressing technological advances needs to be accompanied by evaluation of new circular business models.

Strategies to save products that allow a circular economy on a high level and require radical innovation, intensifying product use (rethink) or making a product completely redundant (refuse) are shown in Fig. 9. Such high-level strategies might affect the whole RM value chain. New business models, which have the purpose to save or (re-)use products must take into account that a circular economy needs to be economically sustainable.

To make circularity economically feasible R&I activities will address:

- New business models (e.g., Product-Service-Systems or shared use of products)
- New networks between stakeholders.
- Tools for exchange of product data.
- Market transparency for used products.

Barriers for circular economy

The transition to a circular economy also requires identifying and overcoming non-technological barriers, such as the availability of data necessary to repair products, their warranty or transparency-related issues for used products. Further development of standards and norms can play an important role to increase the acceptance of refurbished used products and to improve the tools for monitoring and testing old products.

Consumers play a central role for the use and re-use of products. Activities to increase acceptance on the consumer side are the nucleus of Core Theme 3. R&I into socio-psychological barriers could be therefore part of R&I topics as well as activities to communicate the importance of the sustainable use of products. There needs to be clear evidence provided that an increase of the service life of a product, an intensified product use, or a substitution of the product, actually decrease negative environmental impacts within the products life cycle.

Activities on overcoming barriers for a circular use of products could include, but are not limited to:

- Identification of barriers for a circular use of products.
- Integration of legal aspects.
- Development of reliable standards and norms for used products.
- Development of test procedures for used products.
- Psychological barriers.
- Communication with costumers.
- Evaluation of new business models regarding environmental and social impact.

5.3.2 Outcome: Research and innovation for a sustainable use and re-incorporation of by-products as secondary raw materials

R&I in business models, technologies, and methods propel the development of sustainable approaches for the utilization of products and components containing critical RM. Technological advances have been made to promote efficient use, reuse, repair, refurbishing, remanufacturing, and repurposing of products and components. Tools for product monitoring are established to optimise the strategies for increasing the service life of products and components. Improved technological solutions for collection and sorting of products and components enable these to be returned to the RM supply chain at the end of their life, thereby reducing secondary RM losses to a minimum. Digital tools enable an exchange of data between different actors in the RM value chain including producers, consumers, and the recycling industry.

This outcome is assessed by monitoring the following KPIs:

KPI	Background	Target value 2032	Justification of target value
C3.1 Number of projects addressing the sustainable use of RM in products and components by increasing their service life (e.g., through re-use, repair, refurbishing, remanufacturing, repurposing products, and returning them to the supply chain for recycling).	This KPI addresses the challenge to increase the service life of products and/or components and thus contributing to the implementation of the CEAP as binding legislation on EU level, which requires EU member states to establish national programmes on use and reuse of products and components containing CRM.	35	It is expected that 25 % of all funded projects will contribute to a sustainable use of products by increasing their service life (see KPI 0.1).
C3.2 Number of prototypes for technologies and methods to increase the life of products, and components by addressing sustainable use of RM (e.g., through repair, refurbishing, remanufacturing, and repurposing).	Even though the Partnership will support R&I focused on lower to medium TRL, it is considered vital for a certain number of projects to reach TRL 7 in order to demonstrate their potential for upscaling and/or implementation.	7	It is expected that one project per call addressing Core Theme 3 could reach TRL 7.
C3.3 Number of projects addressing new business models for sustainable use and re-use of products and components (e.g., Product-Service-Systems or shared use).	Circular business models are vital for the economic feasibility of the transition to a sustainable circular economy.	10	Although the focus of R&I projects will be on technological advances it is expected that 1 or 2 projects per call will have circular business models as main topic.

5.3.3 Outcome: Effective communication of the importance of a sustainable use and re-use of products.

Projects and activities of the Partnership must effectively communicate the circular economy's significance and increase the perceived value of RM in society. This in turn influences both industry and consumers to embrace more sustainable practices. Communication activities must take into consideration that consumers play a key role when it comes to the sustainable use of products and for returning RM from products to the supply chain through recycling. The projects funded and activities implemented under the Partnership umbrella address the two primary stakeholder roles that are defined in the literature[70]:

- connecting businesses and other actors in multiple coalitions;
- influencing the development of and experimentation with novel business practices related to the circular economy.
- This outcome is assessed by monitoring the following KPIs:

KPI	Background	Target value 2032	Justification of target value
C3.4 Number of successful communication activities towards consumers to promote projects on circular economy including on reducing demand of (critical) RM (in collaboration with other stakeholders).	Communication with consumers is key for the shift to a circular economy to overcome existing social barriers when it comes to the re-use of products and to facilitate cooperation regarding returning products for repair, refurbishment or recycling.	35	It is considered essential that each project addressing Core Theme 3 must communicate its results to consumers as important stakeholders in the value chain for use and re-use of products (see KPI C3.1). Success will be measured through the participation satisfaction rate, measured through activity-specific surveys.
C3.5 Number of successful communication activities to promote circular economy per funded project (e.g., events, website publications, social media channels, webinars, training).	While there is a vast amount of popular scientific literature describing and promoting circular economy for the broader public, there is a lack of communication and scientific translations of the need to use and reuse products and components as an essential requirement for the establishment of circular material flows, thus leading to RM sustainability.	100	Approximately 3 successful activities per project are envisaged. Success will be measured through the participation satisfaction rate, measured through activity-specific surveys.
C3.6 Number of projects involving a business-to-consumer supplier or OEM.	OEMs link the production industry to the consumers and are therefore essential for providing products which are ready to be used by the market in a circular economy.	10	It is expected that approximately 1/3 of the projects addressing Core Theme 3 have OEMs involved as consortium partners.

5.4 Transversal Theme 1

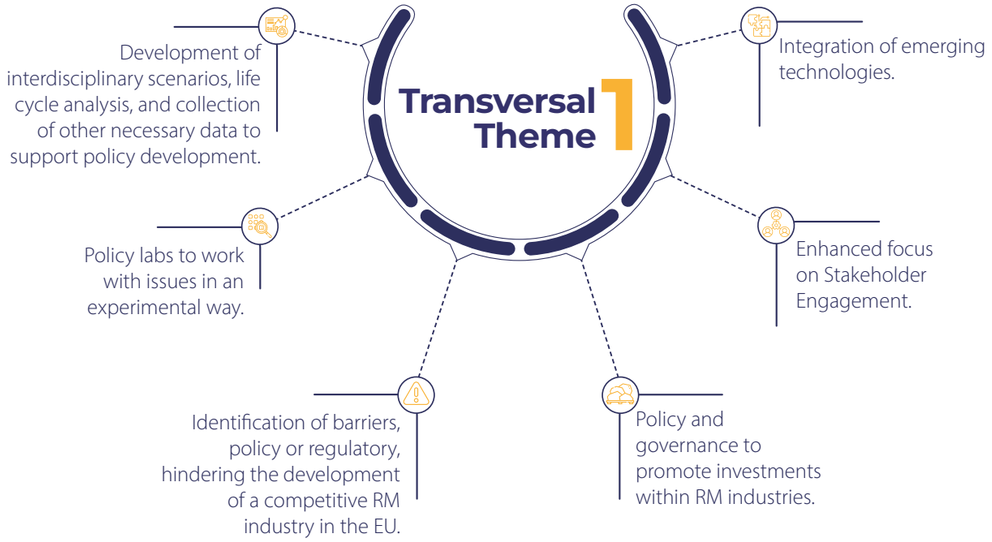
Effective policy development and governance

Globalization has increased economic interdependence among nations, leading to complex geopolitical dynamics that impact trade policies, international cooperation, and diplomatic relations. National laws and regulations provide the legal framework for policy development, implementation, and enforcement within a country. Policy development often involves aligning domestic laws with international obligations and commitments, including treaties, conventions, and agreements. Legal frameworks for natural resource management, including land tenure rights, property rights, and indigenous rights, influence policies related to resource extraction, energy development, and sustainable practices of land use. Environmental policies governing the raw materials industry in the EU are required to follow EU environmental legislation.

Overall, geopolitical and legal aspects significantly influence policy development by shaping national, EU and international agendas, defining legal frameworks and regulations, and addressing complex challenges such as security threats, trade disputes, and environmental degradation. Policymakers must carefully consider these factors and navigate geopolitical realities and legal constraints to develop effective and sustainable policies that promote peace, prosperity, and human well-being.

The EU policies regarding RM are supported by strong partnerships, contributing to the R&I objectives outlined in both the European CRM Act and the CRM Action Plan. Through the Partnership, national programmes are connected to address common goals under a circular economy umbrella by pooling national, regional, and EU funding to support transnational R&I projects, thus generating trustworthy data for science-based policies. Projects funded under the ERA-MIN funding scheme have led to the development of several analytical standards in different stages of certification and review, as well as contributions to the framework of ISO/TS 22451[k] and the ERMA Action Plan on Rare Earth Magnets and Motors[71, 72].

[k] ISO/TS 22451:2021 - Recycling of rare earth elements. Methods for the measurement of rare earth elements in industrial waste and end-of-life products.



To truly support more sustainable use and supply of RM within the EU, effective policy and governance must be developed. Several laws and regulations focused on RM have been proposed and discussed. The CRM Act approved in 2024 is a disruptive policy measure and is highly interconnected with other EU policy areas (land and subsurface use relating to surface- and groundwater, nature regulation, geo-energy, geological storage, agriculture, urban development, etc.).

However, EU industrial policy needs to be continuously developed and adapted to the changing global competition and regional funding schemes, particularly in the USA and China: maintaining fair competition on a level playing field is key to avoid conflict and allow optimal use and management prioritisation or even further development on the regulatory frameworks to achieve the green and digital transition. Interconnectedness of data/science-informed policy will be crucial as well as impact assessments that analyse new proposals.

Data collection and management for efficient policymaking are important requirements to support a sustainable development.

Each Member State shall draw up a National Exploration Programme that will include mineral mapping (including deep ore deposits). Resulting data must be made available on an open-access website maintained by the EC. Lack of transparency regarding this basic information could lead to market distortions and trade speculations impacting directly the single market, the international prices and ultimately the economy on different scales.

Transversal Theme 1 includes, but is not limited to:

- Development of interdisciplinary scenarios, life cycle analysis, and collection of other necessary data to support policy development.
- Policy labs to work with issues in an experimental way: develop tools to measure the results of innovative policy actions; review Member States mining laws as well as other internal environmental and sustainable policies; discuss strategies for fostering a cultural transformation that promotes sustainability and values resource stewardship.
- Identification of barriers, policy or regulatory, hindering the development of a competitive RM industry in the EU. Innovation in guidance and structure within governance for the public and private sectors.
- Policy and governance to promote investments within RM industries.
- Enhanced focus on Stakeholder Engagement: strengthening mechanisms for stakeholder engagement and collaboration in policy development processes to enhance the inclusivity and effectiveness of the policies formulated.
- Integration of emerging technologies: incorporating emerging technologies such as blockchain for traceability and transparency in RM supply chains to bolster the governance framework and ensure sustainable practices.

Effective policy and governance are not only technically feasible but also economically viable and socially acceptable to support sustainability in RM use and supply within the EU. This includes resource efficiency and the circular economy, sustainable supply chains, diversification and substitution, regulatory frameworks to incentivise circular practices and to address market failures by levelling the playing field for sustainable businesses, investment, and financing. It is important to adopt a systemic perspective and to engage stakeholders in the co-creation of innovative solutions to complex problems[73]. Transparency throughout the process is ensured through accountability mechanisms, reporting frameworks, and stakeholder engagement.

The inclusion of umbrella topics such as interdisciplinary scenarios, life cycle analysis, and stakeholder engagement highlights the need for a holistic approach to policymaking that considers the environmental, social, and economic dimensions.

5.4.1 Vision and Impact Goal 2040

By 2040, new and effective policy and governance models are developed and facilitated by data-driven insights and expert networks within the research community. Through innovative, interdisciplinary processes and analysis, trust in policy formulation and adoption has increased among all stakeholders.

Effective policies across Europe and worldwide are developed by fostering continuous novel collaborations and platforms for generating data. Strategic partner countries with relevant experiences and expertise are involved in policy for raw-materials-related issues. Policy decisions are informed by robust evidence and responsive to the needs and priorities of stakeholders and society.

A holistic system approach to policy development and governance is adopted, recognizing the interconnectedness of social, economic, environmental, and technological factors. Cross-sectoral collaboration, policy coherence, and integrated decision-making is promoted to address complex challenges such as renewable energy, e-mobility and digital transformation. Policymakers develop informed, evidence-based policies that account for the interconnected nature of societal challenges, promote sustainable development, and improve the well-being of citizens. Workshops and collaborative sessions are facilitated to brainstorm and develop plausible future scenarios considering different socio-economic, technological, and environmental factors.

Life Cycle Assessment (LCA) and Life Cycle Inventory (LCI) data play a critical role in evidence-based policymaking for sustainability, providing policymakers with the necessary information to develop and implement effective strategies for reducing environmental impact across various sectors, promoting resource efficiency, and fostering a transi-

tion towards a more sustainable economy. It can also identify important sustainability bottlenecks throughout the entire RM value chain. Overall, the combination of data-driven insights and expert networks enhances the quality, effectiveness, and legitimacy of policy and governance models.

Policymakers make use of innovative solutions provided by the research community and the industry to address complex challenges, build trust among stakeholders, and promote sustainable development and societal well-being. Collected data and insights from different disciplines and sectors are integrated and analysed following an interdisciplinary approach. Comprehensive datasets are developed involving collaboration with experts in environmental science, social science, economics, public health, and other fields that capture the multidimensional nature of sustainability.

Capacity among policymakers, researchers, civil society organizations, and local communities in interdisciplinary analysis, scenario planning, LCA methodologies, and data-driven policy development is built through training, workshops, webinars, and knowledge-sharing platforms.

Data collection efforts are aligned with policy objectives and priorities. The effectiveness of data collection efforts and policy interventions are continuously monitored and evaluated to be prepared to adapt and refine strategies based on new evidence and feedback to better achieve desired goals and outcomes. Policymakers and authorities regularly review and update data collection efforts to ensure that they remain relevant, timely, and responsive to evolving challenges and priorities, emerging issues, and new information needs over time. This may include disaggregating data at the regional, national, and local levels to understand disparities and inequalities and monitor changes over time to assess progress and identify emerging issues.

By integrating interdisciplinary scenarios, life cycle analyses, and other relevant data, policymakers can develop informed policies and strategies to navigate the complexities of the green and digital transition, contribute to the sustainable development, and address emerging challenges in a holistic and integrated manner. To reach such integration, it is important to effectively connect the EU-envisaged Green Deal Data Space (including the open access European Geological Data Infrastructure - EGDI) with policymakers before and during policy development, thus fostering cross-sectoral collaboration and policy coherence.

Collaborative platforms and multi-stakeholder partnerships that bring together government agencies, businesses, civil society organizations, academia, and community representatives are established to co-create, implement, and monitor policies and programs. Digital technologies and online platforms facilitate virtual collaboration, data sharing, and participatory decision-making processes, enabling greater transparency, inclusivity, and accountability in governance.

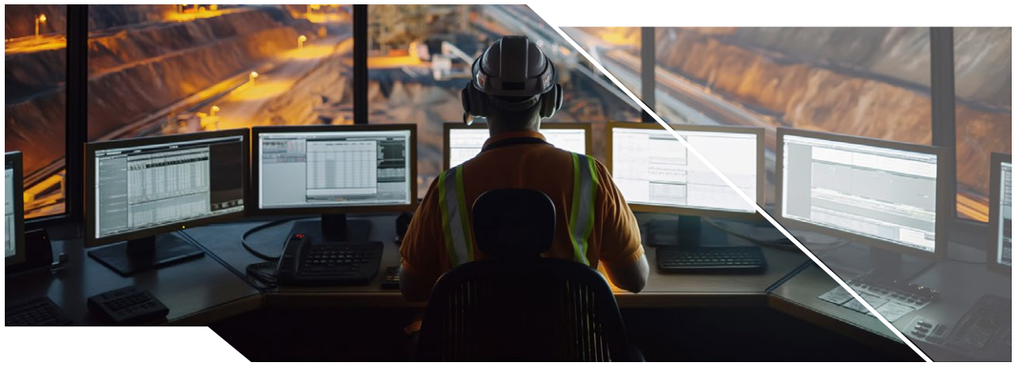
Policy labs offer a collaborative, experimental, and dynamic approach to addressing complex societal challenges, fostering innovation, and driving systemic change towards a more sustainable, inclusive, and resilient future. By harnessing the collective intelligence and creativity of stakeholders, policy labs catalyse transformative policy action and accelerate progress towards the green and digital transition. These labs serve as collaborative spaces where policymakers, researchers, industry stakeholders, and citizens can come together to co-create, prototype, and test innovative policy solutions.

In addition to expert networks, participatory processes engage stakeholders (policymakers, researchers, academics, practitioners, think tanks, industries, other experts and affected local communities) in the policy development process thus ensuring that their perspectives are well represented. Through community-based monitoring programs, and citizen science initiatives, policymakers ensure that policies reflect the needs, values, and preferences of the people they serve. with regular assessment of the effectiveness of said policies and continuous stakeholder feedback loops and adaptive management.

Flexible regulatory frameworks are implemented that enable adaptive governance, allowing rules and regulations to be adjusted based on changing circumstances, emerging trends, and stakeholder feedback.

Data-driven decision-making is supported by big data analytics, predictive modelling, and artificial intelligence to analyse complex datasets, identify trends, and forecast future scenarios. Investment in research and evaluation generate evidence on the effectiveness, impact, and unintended consequences of policies and programs, thus informing evidence-based policy formulation and implementation.

Innovation hubs are established to support experimentation, promoting innovation, and facilitating collaboration between various stakeholders in regulatory frameworks. A robust policy and governance framework that balances economic development with environmental sustainability, social responsibility, and resource efficiency contributes to promote investments within RM industries, and policymakers can work towards a more sustainable and resilient future for RM management. A favourable investment for RM industries is created when regulatory stability, predictability, environmental and social standards and transparency dominate. Long-term commitments are encouraged, investment risks are minimized with streamlined permitting processes and reduced bureaucracy.



Comprehensive datasets are developed involving collaboration with experts in environmental science, social science, economics, public health, and other fields that capture the multidimensional nature of sustainability.

5.4.2 Outcome: Generating data for the development of effective policies and new regulations

Within five years after the end of the Partnership, continuous novel collaborations with collection of data and platforms that host such data for future use contribute to the development of effective policies and new regulations and laws across Europe and worldwide.

By establishing an open science database for policy development, stakeholders leverage scientific knowledge and evidence to inform decision and policy makers, foster collaboration and knowledge sharing across disciplinary boundaries, and promote transparency and accountability in the policy process. Data sharing, reuse, and redistribution is promoted, encouraging researchers to contribute with their findings to the database and thus allowing policymakers to freely access and use the information for policy development purposes. Database content is accessible to all users free of charge and without restrictions, adhering to open access principles.

The Raw Materials Information System (RMIS)[74] developed by the EC provides a comprehensive database and information platform to support evidence-based decision-making in the RM sector by providing access to reliable and updated data and information, reports, and other resources, which help policymakers, industry stakeholders, and researchers to address challenges related to RM supply, demand, and sustainability in the EU. The RMIS database has a link to the Partnership dashboard that showcases all funded projects and its main results since the implementation of ERA-MIN in 2011 up to and including the Partnership.

This outcome is assessed by monitoring the following KPIs:

KPI	Background	Target value 2032	Justification of target value
T1.1 Number of projects on generation of data for policy development	Data collection is crucial to support sustainable development by providing the information to understand environmental, social, and economic dynamics, track progress towards sustainability goals, and inform evidence-based decision-making.	35	An estimate of 5 funded transnational R&I projects per call (see KPI 0.5) will contribute with data.
T1.2 Number of citations of generated data in EU policy documents	Policymakers need to develop effective, evidence-based policies that address pressing societal challenges and contribute to sustainable development; R&I project findings can contribute to these policies	7	Generated data from R&I funded projects under the Partnership will be cited in at least one policy document per call (see KPI 0.5).
T1.3 Number of projects contributing to the RMIS	The RMIS is continuously updated with new information to support evidence-based decision making. The Partnership will contribute to the database through a direct weblink from the Partnership project dashboard to the RMIS. The Partnership call texts will encourage contribution to RMIS.	45	6–7 funded transnational R&I projects per call are expected to contribute to RMIS.

Database content is accessible to all users free of charge and without restrictions, adhering to open access principles.

5.4.3 Outcome: Evidence-based insights and solutions from R&I projects

Within five years after the end of the Partnership, R&I projects play a crucial role in the formulation of effective and forward-thinking policies and governance frameworks, by providing evidence-based insights and solutions. Policy decisions are based on robust evidence and policymakers may require evidence that is directly applicable to their decision-making processes and policy goals, which may not always be available from R&I projects.

Establishing mechanisms for ongoing dialogue, knowledge exchange, and feedback help to bridge the gap between research and policy, and facilitate the integration of evidence into policy development processes. Policymakers must remain flexible and responsive to evolving circumstances, updating data sources, methodologies, and analyses as needed. Policymakers use workshop discussions to gather insights, perspectives, and evidence that inform the development of policy proposals, strategies, and action plans. Workshops offer stakeholders a chance to engage directly in the policy development process, fostering collaboration, transparency, and inclusivity in the policymaking process.

This outcome is assessed by monitoring the following KPIs:

KPI	Background	Target value 2032	Justification of target value
T1.4 Number of project contributions to policy development.	Effective policy decisions are based on the best available evidence. Results from R&I projects can contribute in different ways to support the development of policy documents and consequently have a strong impact on policy making.	10	From ERA-MIN network experience, some projects had results contributing to policy documents, so the estimation is 1–2 contributions per Call.
T1.5 Number of Partnership participations in workshops organised by policy makers.	The ERA-MIN network has been participating in policy events and workshops every year since its start in 2016, the Partnership consortium will continue to do so.	10	The Partnership and its consortium partners will continue to participate in workshops organised by EU and other partners' policy organisations.
T1.6 Number of Partnership participations in policy documents development.	The ERA-MIN Research Agenda developed in 2013[48] was a background document of the Strategic Implementation Plan (SIP) of the European Innovation Partnership on Raw Materials (EIP RM) published in 2013[75].	3	The Partnership and its SRIA are expected to influence other EU policy documents, for example the foreseen update of the SIP of EIP RM among others.

5.5
Transversal Theme 2
Maximizing societal benefits

The sustainable development of our society depends on how the current challenges arising from climate change and fundamental value chain disruptions are addressed while not creating new challenges that endanger the aim of reaching a green and digital transition.

Transversal Theme 2 focuses on the social dimension of the sustainable development framework, and for the purposes of this SRIA it is important to define social concepts and principles. In 2021, the EU defined two social principles for sustainable RM:

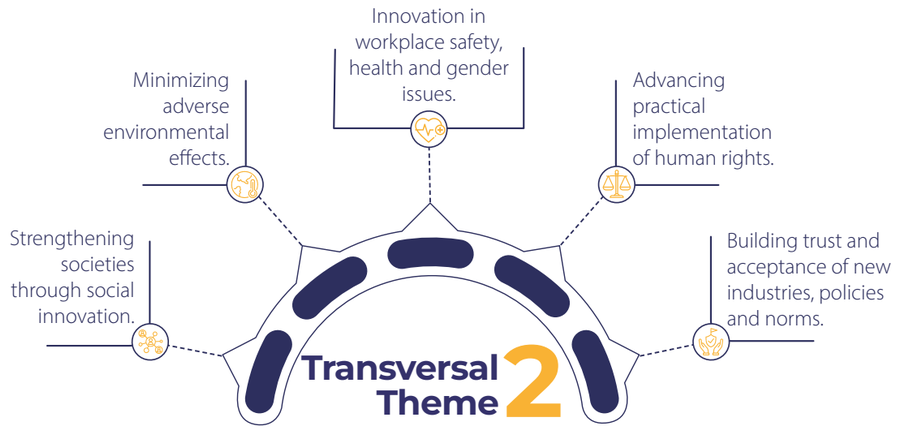
1. Extraction and processing support human rights, communities, and sound governance, and
2. Extraction and processing support decent work for the workforce[63].

Both align with the concept of social sustainability as a pre-condition for environmental and economic sustainability[76], which is the aim of a RM value chain with a strong focal point on circular economy. Social sustainability depends on environmental and economic pillars while sustainable development should be considered as a process of reconciling competing social equity, economic development, and environmental protection priorities[77].

While exploration and mining are complex and high-risk activities that need support on many fronts for the RM sector to flourish in a competitive and sustainable manner, risk reduction through the existence of adequate financing instruments that facilitate the green transition for the ore extraction and processing sectors is paramount; there is a need for responsible mining practices that will secure the minerals required to make the energy transition work with minimized adverse environmental and social impacts to local communities.

Two of the major constraints for domestic mining in Europe are the low public acceptance and the low awareness of the society's dependence on mineral resources in many sectors and electronics that enable a modern life. Projects fostering interdisciplinary teams that focus on social acceptance of domestic mining and social perception of the RM value chain will be encouraged.

Concerning the rest of the RM value chain, it is important to focus social sustainability and social innovation on processing and (re)designing new and old products, as well as acceptance of the need for human behaviour changes regarding the consumption of reused, repaired, and refurbished products.



However, the path to social sustainability must be paved in a way that is just and equitable towards both the people and the planet. To build a well-being economy across the EU, there is the need to take a systemic, holistic approach and realise transformational shifts. The vision is a system built around five interconnected core values: participation, fairness, purpose, nature, and dignity[77].

By focusing R&I on maximizing societal benefits, the aim is to ensure that the world left behind to the newer generations is a more sustainable one in terms of social, economic, and environmental aspects. Transversal Theme 2 includes:

- Strengthening societies through social innovation
- Minimizing adverse environmental effects
- Innovation in workplace safety, health and gender issues
- Advancing practical implementation of human rights
- Building trust and acceptance of new industries, policies and norms

5.5.1 Vision and Impact Goal 2040

Industry and society need to collaborate to maximize value from new investments, balancing economic development and social progress. Local communities impacted by the RM industry receive equitable opportunities to influence and benefit, while research and innovation foster robust civil engagement. It is key to reach a balance between a sustainable RM value chain that includes green mining and social sustainability that involves all types of communities that are directly and indirectly affected by the changes needed to achieve the green and digital transition.

Strengthening societies through social innovation

Social innovation is defined as a dynamic process of strategically developing and implementing inventive ideas, strategies, or interventions aimed at proactively addressing prevalent social issues and instigating positive, transformative change. While the Partnership is focused on R&I of all the RM value chain, translation of results and of activities is needed to popular language, thus there is a need to engage with thriving and inclusively organised civil society movements that encourage active citizenship at all levels. The main focus of social perception improvement activities are: mining processes and environmental impacts, community added value, the RM value chain, importance of RM for all industrial sectors, and consumption habits and how these are associated with the green, digital and energy transition.

Minimizing adverse environmental effects

Overall, while investment in sustainable mining is essential to create supply, jobs, and economic progress, it must also ensure socio-economic and environmental improvements based on corporate social responsibility. The key concern is how to reach a balance between promoting sustainable mining in Europe and ensuring public acceptance[78].

New exploration and mining projects need to demonstrate how the environmental impacts are minimized and/or mitigated while maximizing local profit and value, mainly through the creation of jobs. New and recycled business models need to take social and environmental purposes and challenges seriously and implement processes in line with the above-mentioned social principles for sustainable RM and for social sustainability.

Creating local value is not limited to employment – it is about minimizing nature/environmental impact and maximizing local value creation, the type of which is important to understand and define, in order to obtain a societal license to operate.

Environmental impacts, although localised and largely regulated (e.g. through the EC Habitats Directive)[40], might have a greater impact in the whole European ecosystem revealing the importance of the process of policy and decision making to take into account the already existing negative and positive environmental impacts from not only policies but also RM-related industries as well as mining and extraction processes (e.g., the 75% loss of flying insect biomass in Germany, France and other countries, place an even greater importance on regions that are a hub for biodiversity but also a potential location for a CRM mine[79]).

Innovation in workplace safety, health and gender issues

By investing in R&I, it is possible to find substitutes to the most problematic minerals, whether the underlying issues are geopolitical constraints, toxicity, or human rights abuses[80]. However, this needs to be addressed considering workplace safety and health conditions through employment that commits to economic democracy with purpose focused on decent livelihood. It is, therefore, important to engage with thriving and inclusively organised trade unions that oversee the needs, wants and conditions of employees.

The impacts of mining are not gender-neutral; women often experience the negative impacts of mining more than men, and rarely receive the benefits that men do[81]. The mine as a workplace also needs to be equally attractive to women and men. It is fundamental that gender justice becomes a central issue in global mining sector reform efforts and that women's rights are more progressively realised; the Partnership addresses this by ensuring that equal opportunities are given to all researchers independent of their gender (see Transversal Theme 3 KPIs).

However, gender justice does not apply only to the mining industry, but to the whole RM value chain. Gender equality and human rights need to be address by the Partnership but mostly by stakeholders, companies and trade unions, and civil society organisations.

Advancing practical implementation of human rights

It is imperative that the fundamental human rights are respected, not only in EU countries, but also in the countries with which the EU is creates bonds through strategic partnerships; it is mandatory to respect and adapt to the distinctive cultures, their social organisation, practices and rituals, as well as their geographic and natural resources conditions that ultimately influence the local communities' perspectives when it comes to the RM value chain, in particular mining and extracting.

While industries might need to be expanded or developed in new areas, it is important to prioritize local communities. This can be achieved by making them part of the process through communication activities and the right to participate in public consultations.

Building trust and acceptance of new industries, policies and norms

Over the years, incremental policy changes and market-based incentives have gained political support. However, one way to achieve the green and digital transition is to focus on the supply-side measures instead of a sole focus on the demand-side policies. Getting the EU on track with the imminent CRM Act benchmarks is about addressing both the challenges regarding EU RM suppliers' diversity and its ultimate consumption.

To build trust it is important to not underestimate the power of the public and local communities, thus it is vital to avoid disinformation and lack of public involvement when actions are centred on extracting and mining CRM. Instead, companies need to implement a fair and transparent process with a clear and understandable language involving all stakeholders and the public.

Market-based solutions have had a disproportionately negative impact on low-income earners and communities without the resources to adapt[82]. The Partnership through its consortium partners, can champion the transition and demonstrate the commitment to ensuring that the changes needed to the RM value chain, as well as the green and digital transition require equity and a just distribution of cost and benefits by building trust on communities. Also, the Partnership can contribute to the prioritisation of human wellbeing when in pursuit of new policy design, implementation, and evaluation.

5.5.2 Outcome: Outreach & Community Engagement

Through proactive outreach and community engagement, the Partnership raises awareness among the public by promoting a better understanding of sustainable practices. Furthermore, by placing a strong emphasis on transparency and open communication, the funded projects and activities foster trust-based relationships with local and/or indigenous communities, thus creating a mutually beneficial environment for sustainable development. It is important to create opportunities for capacity building and skilled workforce that will help finding solutions to tackle the previously defined challenges.

Under the Partnership, a social assessment plan will be developed and implemented to follow up on the activities focused on civil society, local and/or indigenous communities' engagement. This plan will allow to assess the impact of the Partnership activities that are aimed to change and/or increase social knowledge of the whole value chain, social engagement, social acceptance of new mines in Europe, and social benefits of changes in consumer habits.

The best way to ensure that the public, stakeholders, partners, etc have access to trustworthy information is by promoting the obtained R&I results and the Partnership activities in a language that simplifies and explains the science to the target public.

Although the target of the EU co-funded calls are the academia and the industry, the funded projects' results might be of interest to stakeholders connected with the RM field, but also a wider public for critical thinking and to better understand the RM value-chain. The main goal of the newsletter and social media accounts is to disseminate and promote projects results and Partnership activities. However, an emphasis will be on how R&I can improve the circular economy and diminish the negative impacts of the RM value chain.

The Partnership will create a network and/or establish close contacts with policy stakeholders and invited partners, with the aim of knowledge sharing and positively impacting the future RM-related policies and regulations.

This outcome is assessed by monitoring the following KPIs:

KPI	Background	Target value 2032	Justification of target value
T2.1 Number of Partnership newsletter subscribers not affiliated with academia and industry.	The Partnership consortium makes all efforts to promote the Partnership activities and the projects' results in different events with different types of attendees (from highly involved stakeholders to the lay person).	50	For the target value, only the invited partners, other policy stakeholders (Ministries, regional agencies, networks of policymakers, municipalities, etc), and anyone interested in the RM field are considered.
T2.2 Number of successful awareness actions for local communities organised by funded projects (e.g., events at schools, social media channels, websites, newsletters).	Making any EU-funded or co-funded project visible is crucial to reach out to relevant stakeholders and build new collaborations, but even more important is communication to a lay audience that has little to no contact with the existing R&I in the RM field.	280	Funding of a total of 140 projects throughout the 7 EU co-funded joint call with each project implementing two or more dissemination actions. If applicable, success will be measured through the participation satisfaction rate, measured through activity-specific surveys.
T2.3 Number of views of social media videos and posts by the Partnership.	Social media is an effective and engaging tool that allows to instantly communicate and disseminate to any audience at a low-cost, the Partnership will be using already existing accounts, thus building on the experience from ERA-MIN.	20,000	Currently, there are 69 subscribers on the ERA-MIN3 You tube channel which has 62 uploaded videos with a total of 8,634 visualisations.
T2.4 Number of successful stakeholder engagement actions aimed at local and regional communities.	To reach social sustainability there is a need to involve all stakeholders in all stages of the value chain, but also in the communication of funded projects results. Actions aiming at stakeholder engagement will be organised by both the Partnership and the projects themselves, translating science and policy to local and regional communities.	14	At least two successful events per year are envisaged. Success will be measured through the participation satisfaction rate, measured through activity-specific surveys.
T2.5 Number of participants outside projects in communication and dissemination events organised by the Partnership.	As KPI T2.1, the Partnership consortium makes all efforts to communicate and promote the Partnership activities and the projects' results to stakeholders, policy and decision makers, and enthusiasts in RM. Promotion of all events organised or co-organised by the Partnership will be promoted on social media and through relevant partners/ channels to reach external participants and entice them to attend.	700	100 external participants per year.
T2.6 Number of successful workshops/conferences for exchange of experiences on social sustainability organised by the Partnership.	Explaining and promoting sustainability of the value chain, in particular the mining and exploration of RM and circular economy, is of essence to ensure the public engagement and acceptance of the green and digital transition with its needs and challenges.	7	At least one successful event per year is envisaged. Success will be measured through the participation satisfaction rate, measured through activity-specific surveys.
T2.7 Number of views of social media videos and posts from projects.	As KPI T2.3, social media will be used to promote, communicate, and disseminate the results from the funded projects. In this way, it will also help to ensure public engagement on organised events and promote public acceptance.	28,000	Each funded project should aim at 200 views through their duration.

5.5.3 Outcome: Collaborations with Civil Society

Initiatives drive the development of improved and sustainable processes within the RM sector, for example within traceability and waste management, in active collaboration with civil society organizations by enhancing accessibility and public understanding of science.

KPI	Background	Target value 2032	Justification of target value
T2.8 Number of activities/ projects contributing to social sustainability.	Social sustainability as mentioned above includes different priorities depending on the ecosystem and context. For the purposes of this KPI, it includes gender equity, public and labour health, workplace, social acceptance. How to overcome lack of interest from civil society or how to increase public perception towards the RM value chain, its needs, obstacles, and challenges, with a more efficient communication and with activities and projects with results that contribute to social sustainability.	50	Aiming, at least, at an average of 2.5 projects per call plus all activities within Partnership.
T2.9 Number of civil society organisations involved in projects.	Civil society organisations have a better knowledge of the main issues and concerns that the public has in relation to RM, mainly when it comes to mining and exploring, to repurposing/reusing of equipment, and even to recycling of electronic equipment that can be used as secondary RM source. It is therefore important to connect with these organisations and have them take part in the R&I throughout the RM value chain.	35	25% of all projects funded under the 7 calls (see KPI 0.1).
T2.10 Number of successful stakeholder engagement actions aimed at civil society organisations and NGOs, organized by the Partnership.	The involvement of NGO's and other civil society entities is crucial to reach social sustainability and public acceptance of the changes needed in the RM value chain to achieve the green and digital transition, from green mining to the reuse of products and repairing instead of immediately recycling older products.	7	At least one successful action per year is envisaged (see KPI 0.5). Success will be measured through the participation satisfaction rate, measured through activity-specific surveys.

It is important to create opportunities for capacity building and skilled workforce that will help finding solutions to tackle the previously defined challenges.

5.6
Transversal Theme 3
World-class innovation capacity

Historically, Europe has provided some of the greatest academic advances in the fields of extraction and processing of RM[83]. Continuing to be at the forefront of technological advances in all these fields is an asset Europe cannot afford to lose, thus a focus on expanding networks and collaboration across the world is key, and particularly with leading and friendly resource-rich countries in a mutually beneficial way. It is paramount that EU continues to be an exporter of good practices and sustainable sourcing, with the aim to bring the most efficient and environmentally friendly techniques to all places that are willing to provide and contribute to Europe's green and digital transition.

As mentioned previously, the EU has been engaging with several countries and regions with the aim of establishing strategic partnerships focusing on diversifying and securing the RM supply and knowledge sharing. In the same way, Europe cannot establish a world-class innovation capacity in RM on its own to consolidate the future leadership in R&I, and therefore must build a solid base by addressing the whole value chain from the beginning to the end. The Partnership will contribute to establish ecosystems that allow for a fluid knowledge valorisation and building solid bridges between academia and industry. However, it will also reinforce these bridges with a bottom-up perspective and establish a solid educational excellence and research mindset to inspire young talent.

This SRIA aims to address, in broad terms, all aspects that can contribute to improve Europe's stance with respect to the future R&I in RM. In particular, Transversal Theme 3 aims to identify the key areas through which the European R&I community can continue to grow and how the Partnership can help foster and nourish that vision. In this sense, this approach will involve continuing support across three main pillars:

- Support the EU's strategic partnerships on RM.
- Synergise national and regional funding bodies and other EU initiatives.
- Building the future talent to innovate, adapt and think globally.

5.6.1 Vision and Impact Goal 2040

It is the Partnership's goal to contribute to maintain Europe as a global hub for R&I on RM. Universities and research institutes should collaborate even more closely together with industry and civil society, driving investments to solve common challenges, develop world-class skills at national and international level, and inspire the next generation of experts in Europe and beyond.

By 2040, the vision is to position Europe at the centre of a world-class innovation ecosystem in RM, and this relies on adopting a strategic stance that balances open international collaboration with the preservation of Europe's economic and strategic interests.

Support the EU's strategic partnerships on raw materials

By 2040, the vision is to position Europe at the centre of a world-class innovation ecosystem in RM, and this relies on adopting a strategic stance that balances open international collaboration with the preservation of Europe's economic and strategic interests. Supporting EU's strategic partnerships on RM with non-EU countries remains crucial to continue to help Europe in promoting global networks and prioritise engagements that benefit its RM sector, ensuring that technology transfer, knowledge sharing, and collaborations enhance Europe's competitive edge and raw material security.

In a context that aligns Europe's values of sustainability, reciprocity, and fair trade, the Partnership will help to strengthen bonds with existing partner countries, supporting and promoting existing networks (such as EGS, PanAfGeo or ASGMI) and build new bridges with emerging regions where such collaborations will lead to mutually beneficial exchanges and contribute to improve the EU's strategic autonomy.

By means of scientific diplomacy, the activities designed to operate at the different levels of the RM value chain, will facilitate the dynamics of how R&I can influence the sector. Coordinated efforts will help to demonstrate that the different critical challenges can be solved more efficiently and effectively if concerted actions are taken and mimic across the world, maximising the impact of such improvements and building more resilient and responsible economies world-wide.

Synergise national and regional funding bodies and other EU initiatives

By 2040, the Partnership consolidates a framework that helps coordinate national and regional funding bodies to support international projects and collaborations that nourish the R&I ecosystems in Europe and its strategic partners. National and regional funding agencies across Europe are to continue playing a pivotal role in catalysing international collaborations that advance RM R&I, supporting projects along the whole value chain, from exploration to processing and beyond.

Following on from the relationships established under ERA-MIN, the Partnership will increase the allocation of resources to joint projects and international collaborations, facilitating the sharing of knowledge, technology, and best practices with partners across the world, enriching the ecosystem for all involved. Funding agencies will also be supporting more initiatives aimed at enhancing Europe's innovation capacity, including investments in education, social acceptance, training and infrastructure. This will develop a workforce ready for a more sustainable future development of extracting, processing, and recycling industries and that will be capable of exploiting the interconnectedness of the different stages in the value chain.

Through the funding of projects that align strategic European interests and global sustainability goals, the Partnership will contribute to a more balanced outlook that secures RM supply chains while fostering an environment of mutual benefit and respect among international

partners. The strategy of the Partnership will not only help Europe achieve its sustainability and strategic independence goals but further strengthen global partnerships for long-term resilience in the RM sector.

Furthermore, across strategic sectors for the EU, the Partnership will be able to help identify the resource needs, investments, as well as define and implement RM actions with third countries. From the Clean Energy Transition Partnership to the Chip Joint Undertaking, from quantum technologies to transport, all these initiatives and areas will be affected by Europe's weakening position in the supply of CRM. The Partnership will be the instrument that provides a common umbrella to coordinate and develop common and coordinated actions within Europe and beyond.

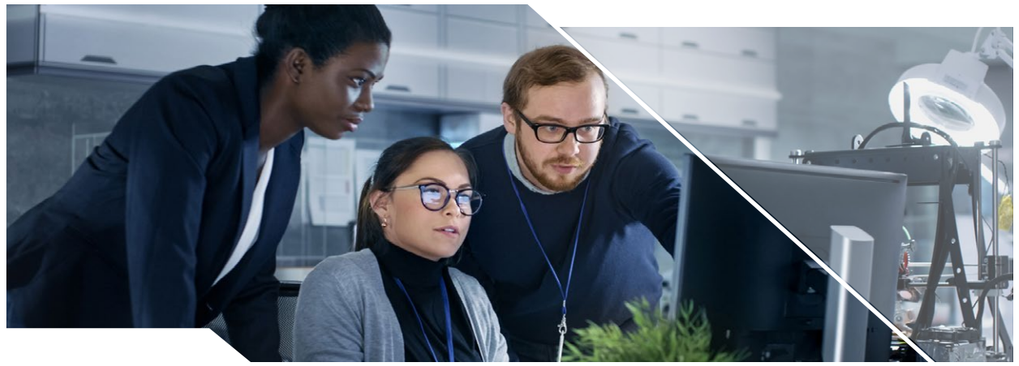
Building the future talent to innovate, adapt and think globally

By 2040, the vision is of a more dynamic workforce of researchers in the RM sector. Placing special attention to encouraging education and training programs that aim to create a versatile talent pool that can meet the sector's evolving needs. Emphasising on interdisciplinary approaches that combine engineering, environmental science, and socio-economic disciplines, will more likely ensure a well-equipped talent pool to tackle the complex challenges of sustainable RM extraction, processing, and recycling. Empowering young researchers, fostering vocational training and lifelong learning opportunities will transpire to a society with the adaptability needed in such a changing sector. If EU invests in human capital, promoting a culture of innovation and excellence, it will attract top talent from around the world.

The Partnership will also aim to facilitate a framework that promotes mobility and exchange of R&I across Europe and beyond, collaborating closely and in connection with other European initiatives such as INTERMIN, SCREEN or EIT Raw Materials.

Mobility within the RM sector offers unparalleled benefits for innovation, collaboration, and professional development. By 2040, robust programmes for mobility are established, enabling students, researchers, and professionals to easily move between member states and partner countries. This mobility will facilitate the exchange of ideas, best practices, and cutting-edge technologies, enriching Europe's knowledge base and fostering a dynamic and interconnected research community.

Moreover, mobility programs will support the formation of diverse and inclusive teams, driving creativity and problem-solving driving a more balanced workforce. The benefits of such mobility would extend beyond individual career growth, contributing to the development of a resilient, sustainable, and globally competitive European RM sector.



5.6.2 Outcome: R&I: the catalyst of a more sustainable raw materials sector world-wide.

Within five years after the end of the Partnership, the expectation is to have initiated and facilitated expert networks focused on RM, leveraging workshops and conferences to foster meaningful connections between Europe and third countries. These proactive collaborations will be geared towards collectively addressing future challenges in the RM sector.

For this reason, there is a plan to develop activities in line with the increasing engagements of those countries within and outside the EU; countries which are willing to contribute to the strengthening of R&I capacities in RM in Europe and beyond. The Partnership envisages different ways of collaboration with different countries and regions, which can range from full membership as partners (in the case of RFOs and other institutions contributing to implementing the Partnership's tasks), to all stakeholders along the RM value chain, which will be directly or indirectly affected by the Partnership's activities.

In this sense, the KPIs established aim to go beyond the involvement and increased participation of applicants from third countries but to also monitor and delve into deeper collaborations with the Partnership.

KPI	Background	Target value 2032	Justification of target value
T3.1 Number of third countries engaged with the Partnership.	Under ERA-MIN, collaborations with a broad number of entities from countries across the world have been established. The goal under the Partnership is to continue and strengthen the involvement of RFOs, funding R&I, but also other entities such as geological surveys that can contribute actively to the Partnership.	10	Aim to continuously involve the three existing third countries from the ERA-MIN3 consortium (South Africa, Canada, and Brazil), add additional partners from past ERA-MIN consortium (e.g., Argentina and Chile), and engage with additional entities from those countries and regions with or in negotiation of strategic partnerships with the EU (e.g., Norway, Namibia, Kazakhstan, Zambia, Democratic Republic of Congo, Australia, etc.).
T3.2 Number of third country stakeholders collaborating with EU entities.	Beyond targeting the collaborations with reference countries or regions, more importantly is to identify and establish relationships with the relevant entities with active investment in RM R&I. It will thus be a challenge to foster engagement between entities other than RFOs, such as geological surveys, research performing organisations or industry.	30	At least an average of 3 entities per third country, based on the third countries in the ERA-MIN consortium.
T3.3 Number of joint activities promoted by the Partnership including both European and third country industrial partners.	Establishing strong partnerships with a broad range of entities and monitoring the actual activities and outcomes of existing collaborations is crucial to assess their impact. A greater focus will be given to those interactions that involve industrial partners both in Europe and beyond.	35	Considering past calls, approximately 25% of the projects should have at least one partner from countries outside EU.

5.6.3 Outcome: Supporting the young talent in raw materials R&I

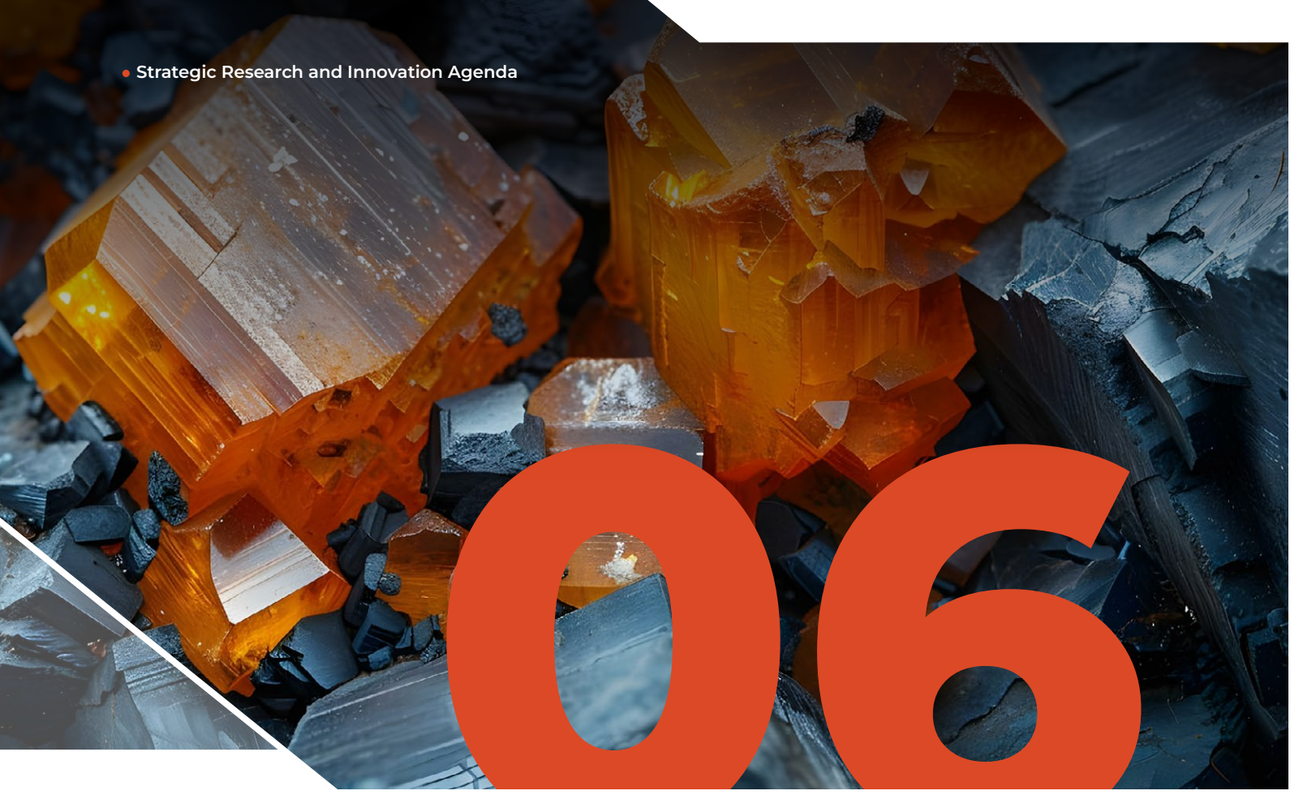
Within five years after the end of the Partnership, through innovation projects and collaborative networks involving higher education and industry, Europe has bolstered its position as a leader in RM R&I. Through job, professional education, and mobility opportunities as well as gender equality, the sector becomes more appealing to young talent, inspiring interest and participation.

It is the Partnership's goal to foster actions that influence the R&I ecosystem across all the RM value chain. Encouraging joint transnational R&I projects to give young researchers more responsibilities, training, specialisation and capacity building, as well as fostering exchanges between institutions at all levels (including outside Europe), will help build a solid community with a global approach.

Projects will also be geared to generate impacts that go beyond performing excellent science. It will be important that they consider other impacts on society, which include training and educational activities, and engagement of a broader range of stakeholders (including industry, society, and policymakers). One of the achievements will be to improve the societal perception of the RM sector and have the younger generations aspire to contribute.

This outcome is assessed by monitoring the following KPIs:

KPI	Background	Target value 2032	Justification of target value
T3.4 Number of PhD students and young researchers in funded projects.	Attract and engage a significant number of PhD students and young researchers to participate in proposals/ projects, ensuring the projects are appealing and accessible to emerging talents across diverse disciplines. Providing adequate support, mentoring, and resources to enable young researchers to assume leadership roles such as PI, which requires not only scientific expertise but also leadership and project management skills.	420	An average of > 2 PhD students per project and at least one young researcher as PI.
T3.5 Number of peer-reviewed publications with young researchers as co-authors.	Encourage and facilitate high-quality research that leads to peer-reviewed publications, especially in projects where young researchers are involved. This can be facilitated by fostering an environment that supports collaborative work between experienced researchers and young researchers and by giving opportunities for later to showcase their work (e.g., conferences, poster competitions, etc.).	280	At least 2 publications per funded projects (see KPI T3.4)
T3.6 Gender balance (percentage of female researchers) in projects.	Ensure that both male and female researchers have equitable access to opportunities to be involved in projects, leadership roles, and decision-making processes.	40-60%	A maximum majority of 60% of one gender (m/f) is considered gender-balanced in many countries of the ERA-MIN consortium. This does not consider the role taken within the research team hierarchy and power distribution.
T3.7 Number of jobs created within the funded projects.	Projects can generate both temporary and permanent jobs which directly contribute to the growth of the RM sector. It is important to ensure that the jobs created are of high quality and relevant to the needs of the projects, providing meaningful and enriching employment opportunities that attract skilled professionals and contribute to the project's success.	280	An average of two direct jobs per project (exclude PhD students). These can be temporary or permanent jobs.
T3.8 Number of successful actions for professional education (e.g., lifelong learning).	Professionalisation of several newer skills required by the RM sector is a challenge. It is thus important that lifelong learning activities are effectively integrated into the design and objectives of research projects from the outset, requiring projects to not only focus on immediate research outcomes but also on the broader impact of enhancing skills and competencies. These actions will be coordinated with complimentary activities such as the ICE-SRM and its contribution to UNFC.	14	Approximately two projects per call should contain such kind of actions. Success will be measured through the participation satisfaction rate, measured through activity-specific surveys.
T3.9 Number of mobility exchanges in funded projects (e.g., visiting researchers, student exchanges).	It is important to ensure that adequate funding and logistical support for mobility exchanges are in place in as many RFOs as possible. Coupled with good matching of researchers and students with host institutions these exchanges will provide meaningful learning experiences, networking opportunities, and collaboration potential.	420	At least three visits (of at least three weeks) per funded projects are to be expected.



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