

The role of research and innovation in ensuring a safe and sustainable supply of critical raw materials in the EU

Critical and strategic raw materials are essential for the European Union economy, for satisfying societal needs and achieving policy objectives. At the same time, their supply is at risk today and will be for the foreseeable future. Raw material supply has become a more salient issue since the introduction of the EU raw materials initiative, culminating in the recent adoption of the Critical Raw Materials Act. Research and innovation (R&I) are instrumental in strengthening the EU's global position. The policy options identified here and in the accompanying study can all help to increase EU strategic autonomy, but carry the risks inherent to R&I. Investment in technological capacities is needed to develop and sustain a leading position for the EU as a technology provider along raw material value chains. Social science research can help identify concerns and find pathways for increasing domestic raw material supply to strengthen the EU economy, secure societal wellbeing and benefit local communities.

1. Summary

Critical raw materials (CRM) are necessary for a robust EU economy but are also diverse in their nature and the challenges they pose. Methodologies are in place to assess and monitor risks and possible impacts of supply disruption. Despite challenges regarding access to timely, high-quality data, these methodologies address both the status quo (CRM) and future developments (strategic raw materials, SRM) regarding supply and demand for raw materials. The outcome of CRM assessments has changed over time due to changing supply and demand realities. This will also continue to be the case in the assessment of SRM. These assessments and the accompanying background work provide a view of the entire supply chain for critical raw materials, allowing the development of options to minimise supply risks and increase resilience.

The EU has tackled the issue of raw material criticality with a variety of actions, including strong engagement in R&I for CRM. The role of R&I is stressed in policy documents, from the 2008 raw materials initiative to the recent Critical Raw Materials Act. In parallel with this political focus, funding has increased significantly in EU programmes, including past Framework Programmes and the current Horizon Europe, as well as EIT RawMaterials, now reaching the end of its funding period. The EU is an important actor in patenting, especially regarding mining/processing and recycling, with strong international ties (especially to the USA). Continued funding and policy support will be key to maintaining and profiting from this position.

Overarching themes in R&I and sustainability challenges for CRM are:

- Reducing costs and impacts of mining, processing and recycling;
- Managing complexity (from mining and processing complex ores to recycling complex products);
- Understanding and engaging with stakeholders, securing public acceptance;
- Covering the entire chain, from exploration to recycling, including circularity strategies;
- Ensuring access to data and creating transparency along supply chains.



2. Policy options

In the coming years, the European Union will face several policy challenges related to R&I in CRM. Overall, these follow logically from three central concerns, which are the focus of European policy makers' attention in recent years: (1) open strategic autonomy, (2) international competitiveness, and (3) sustainability and values.

First, the EU aspires to sustain a strategically independent position and, in view of certain weaknesses, avoid becoming unilaterally dependent on other nations. Other than raw material extraction with its geological constraints, there is no fundamental reason for the EU to suffer from such a dependency in R&I, in which it already harbours great strengths. Second, if the EU wants to uphold its ambition to remain an important provider of advanced technological solutions to mining and processing operations (including urban mining and substitution) worldwide, it will have to invest in improving its businesses' position in global value chains, by both upgrading their technological capacity and also supporting their global operations, responsibly, by political means. Moreover, the EU is still capable of developing a leading position in some areas, such as environmentally sustainable and socially acceptable extraction and processing of raw materials, as well as recycling and substitution. For this to happen, specific investments will be required.

In addition to these first two aspects which are primarily aimed at retaining the basis for societal well-being – i.e., value creation – in Europe, the EU also promotes a third and broader normative agenda. The EU has committed to developing European CRM value chains with sustainability and moral values as the main guiding principles. Research and innovation policies in CRM do not relate to engineering and technological development alone. To strengthen Europe's autonomy and sovereignty, large-scale projects on home soil must remain feasible and large-scale overseas operations must be ethically defensible. To achieve this, social science and humanities must be key contributors to R&I.

The first essential step in achieving the EU goals is to further improve its **intelligence, analysis and monitoring capacity**. In this respect, this study builds a clearer understanding of Europe's own capacities in an area of profound strategic importance.

Furthermore, Europe will have to **invest in improving capacities in research and innovation**, both in areas of current weakness (to ensure autonomy) and in areas of strength (to reinforce sovereignty). Diverse means can be leveraged to achieve this, and the EU should consider strategic, large-scale investments equal to those in other key enabling technologies.

Public outreach and citizen engagement are also key to public policy decision making. In the EU, experience has shown that the (re-)opening of additional extraction and processing sites can create controversy if not appropriately managed. An option to consider is embedding public consultation and conflict resolution at the local level (beyond what is legally mandated) into raw material development projects (mining, processing, recycling) in the EU.

In these times of transition, stakeholders hold that justified public concern in Europe must be taken seriously and be reflected in governmental intervention. At the same time, both the EU and Member States are challenged by the fact that Europe is losing ground globally and – in the interests of the very same constituencies that are wary of change – cannot stand by idly and avoid taking decisions that might be challenging for some.

The table below provides an overview of R&I options to boost Europe's global competitiveness and (re)assert its autonomy, while at the same time remaining conscious of the societal cost that any expansion of mining and processing activities (including recycling) necessarily entails – in the EU and elsewhere.

Table 1 – Summary of policy options considered in the study and their evaluation

Assessment dimension → Option ↓		Costs	Benefits	Feasibility	Effectiveness	Sustainability	Risks and uncertainties	Coherence with EU objectives	Regulatory impacts	Social and ethical impacts
Institutional and R&I capacities	Strengthening and bundling of expertise in European institutions	□	≡	≡	≡	≡	□	≡		
	Improve use of existing EU research ecosystem capacity	≡	≡	≡	≡	≡	□	≡		
	Increase funding allocated to CRM topics in EU framework programmes	□	≡	≡	≡	≡ □	□	≡		
	Continue funding for bringing research results to the market	□	≡	≡	≡	≡ □	□	≡		≡
International collaboration	Strengthen R&I on CRM demand reduction	□	≡	≡	≡	≡	—	≡		≡
	Strengthen incentives for research collaboration with non-EU partners	≡	≡	≡	□	≡ □	—	≡	□	≡
	Use international projects to generate data on opaque supply chains	≡	≡	□	≡	≡	□	≡	□	≡
Legitimacy & regulation	Ensure funding for R&I in strategic partnerships on raw materials	≡	≡	≡	≡	≡	≡	≡		≡
	Support demo-cases and living labs around exploration, mining and processing sites	□	≡	≡	≡	≡	□	≡		≡
	Integrate social sciences and humanities into technical CRM projects	≡ □	≡	≡	□	≡	□	≡		≡
	Research solutions to regulatory barriers and strengthen drivers to achieve the goals of the CRM Act	□	≡	≡	≡	≡	□	≡	≡	

Legend: ≡ positive / low cost / low risk; □ neutral, uncertain or depends largely on implementation; — negative / high cost / high risk; more than one colored block indicates range, empty indicates no impact expected.

Source: Compiled by the authors.

The first set of options is about strengthening Europe's institutional R&I competencies, aiming to **develop, retain and reinforce its own capacities**. The EU institutions tasked with the implementation of the CRM Act will require additional resources for assessment and monitoring of CRM supply chains in the EU. Furthermore, EU mining and processing firms (including those in recycling), as well as equipment and technology providers, require support in their effort to offer competitive solutions to global markets. Under existing State aid rules, this will primarily relate to reinforced investment in research and development efforts, in collaboration with research institutions. The background research indicates that granular support for single projects does not tackle the breadth and complexity of CRM

supply chains effectively and that CRM R&I deserves attention as a key area of 'common European interest'. This means supporting smaller, innovative entities such as SMEs and citizen initiatives to encourage significant, disruptive innovation and avoid consolidation of the status quo.

The second set of options focuses on international collaboration. **Collaborating with the best is necessary to learn faster – regardless of whether Europe leads or has to catch-up.** Intensified collaboration with the US, Japan, but increasingly also with China, appear advisable – as are more intense joint intra-European efforts. Furthermore, while many nations with a focus on extraction may not count among the scientific leaders, they have specific knowledge of site conditions and the practical experience essential to make European solutions technologically and commercially viable at home and abroad. International collaboration should also help make data available for alignment with European environmental footprint requirements in global value chains.

A final set of options aims at **strengthening legitimacy by investigating sources of local conflict and co-creating acceptable solutions.** Problems need to be identified precisely to be acknowledged, ideally by neutral unbiased third parties. The political task is neither to avoid conflict nor seek to talk stakeholders into compliance. Instead, means should be found – and agreed – that allow for action to secure Europe's CRM sovereignty. This extends to operations overseas, where the reach of the EU political process is limited. Research can help develop a sound, evidence-based foundation for standards in future international partnership agreements and contribute to defining what European corporations must and must not do, and what they must ask from local governments. Research can also allow for better diagnostics of current economic and regulatory barriers to achieving sustainable strategic autonomy in CRM, as well as increasing knowledge of potential solutions.

These options are described in more detail in the main report. An additional list of specific action, addressing CRM supply chain challenges is provided in Annex B of the main report.

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