



D3.3 Nexus of policy decisions and drivers of change



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Executive summary

This report presents the methodological implementation of foresight-adapted tools to make sense of, and understand, the linkage between drivers of change and policy formulation affecting the future of Critical Raw Materials (CRM) value chains.

To achieve this goal, several steps were taken with the design and implementation of future looking methods, including Horizon Scanning, Delphi Survey, Scenarios planning and development, What-if analyses with gaming elements and DPSIR-focused frameworks on topics relevant to the world of CRMs. The focus was on tying together policy decisions with elements from the political, economic, social, technological, environmental and legal spheres. Many of the methodological steps involved the interaction with stakeholders that were engaged with on-site and on-line exercises.

Each method allowed for the exploration of different relevant factors. The Horizon Scanning led to the identification of several Drivers of Change organised under different clusters and aligned with a PESTEL framework. The Delphi Survey, built in two rounds, provided the opinions and visions of stakeholders on the future of Critical Raw Materials and mining-related activities in environmentally protected areas. Four CIRAN scenarios for 2035 were developed, highlighting potential ways the world of mineral raw materials – and the EU's place in that world – could evolve. A What-if analysis framework for assessing how mining-related projects could be seen, understood and implemented in environmentally protected areas was designed and aims at being realised in upcoming stakeholder meetings. Several drivers of change were explored under a DPSIR-framework.

The results from these exercises were brought together into the design of the four CIRAN Scenarios for the year 2035. They describe four potential views for the future under two main scopes: globalisation vs de-globalisation and technology development vs technology stagnation. The Scenario narratives incorporate several descriptions following the PESTEL framework and the drivers of change, and how these influence policy-formulation to address future challenges and needs, particularly through foresight exercises to facilitate the prevention of potentially damaging consequences. As such, the CIRAN 2035 scenarios can be an important tool to better frame policy decisions and their implementation, depending on the state of the world in the near-to-mid future.

Drivers of change, such as technological advancements, geopolitical shifts, and societal priorities, play a pivotal role in shaping the policy decisions that govern CRMs' management. For instance, the push for electrification and green energy transitions drives an increased demand for CRMs such as lithium, cobalt, and rare earth elements, necessitating policies that ensure supply security through diversified sourcing, domestic production, and recycling. Geopolitical shifts can influence trade policies and strategic partnerships, directly impacting CRM availability and costs. At the same time, technological innovation can accelerate materials' efficiency and productivity, substitution, and recycling capabilities, prompting investments in research and development. Policymakers must navigate these interconnected drivers by crafting frameworks that balance supply chain resilience, environmental stewardship, and societal acceptance. The interplay between these drivers and policy decisions is crucial to addressing vulnerabilities, such as supply concentration and import dependency, while advancing long-term goals such as sustainability and strategic autonomy.

The developed lines of work led to results that are both objective and subjective in nature, influenced by expert opinions and views. Furthermore, the results provide a future outlook onto an always changing and adapting landscape. Due to these aspects, it is then recommended that this work is looked at from a critical

angle – it is impossible to predict the future – and that information is carefully considered. It is also recommended that steps of the methodological approach, including the CIRAN 2035 scenarios themselves, are reviewed in three to five years, due to the overall changing conditions of the world’s governance, and, of the mineral raw materials’ landscape, in particular. This will ensure that CIRAN outputs are up-to-date and still relevant.

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List of acronyms

CRMs	Critical Raw Materials
DPSIR	Driver-Pressure-State-Impact-Response
EC	European Commission
EPA	Environmentally Protected Areas
ESG	Environmental Social Governance
EU	European Union
ICTs	Information and Communication Technologies
PESTEL	Political, Economic, Social, Technological, Environmental, Legal
SDGs	Sustainable Development Goals
UN	United Nations
WP	Work Package

1 Introduction

1.1 Background to CIRAN

With the need to cater for decarbonisation of the EU's economy as envisaged under the European Green Deal (EC, 2024c), and to ensure security of supply by strengthening value chains, there is an increasing demand for certain raw materials that are deemed critical. These materials, which are collectively known as Critical Raw Materials (CRM), are crucial for the economy and have an important role to play in the achievement of overarching policy objectives. Some CRM resources are currently known to occur at only a few locations around the world, while commercial recovery of these resources is dominated by a single or small number of countries. Geopolitical tensions threaten supply chains and fragmented regulatory regimes can affect the sustainable extraction of these key resources.

Concomitantly, the EU has wide-ranging objectives in relation to protection of the environment through the application of the principles of precaution, prevention and rectifying pollution, which is done through a series of environmental assessments of plans and projects at different life cycle stages. A key element of the environmental policy is to ensure the protection of habitats, species and ecological networks under the Biodiversity Strategy 2030 (EC, 2020). This will be further reinforced by the Nature Restoration Law (EC, 2024b).

Balancing these policy objectives can be achieved through a coordinated and strengthened policy framework that will ensure the delivery of CRMs and promote the protection of the environment. Streamlining more efficient, effective and transparent permitting procedures throughout the mineral extraction life cycle in environmentally protected areas, would contribute to securing sustainable access to primary raw materials, whilst considering and reconciling requirements in environmentally protected areas (EPAs). CIRAN's Deliverable 3.2 *"Sensitivity maps of potential conflicts over natural resources usage"* (Ovaskainen et al., 2024), found that more than 80% of the known CRM occurrences are inside or less than 5 km away from EPAs, thus explaining the almost certain inevitable exploration and exploitation of CRMs in these areas to guarantee the access to primary raw materials.

The project will contribute to the exchange of best practices in permitting extraction activities that may affect EPAs. There is a need to review these permitting procedures, particularly in relation to legal requirements under the Birds Directive (Directive 2009/147/EC) and the Habitats Directive (Council Directive 92/43/EEC), and the emerging objectives of the EU's Biodiversity Strategy 2030 (EC, 2024a). A cross-sectoral policy approach is required to analyse the regulatory and policy frameworks for economic development (extraction of CRMs), and environmental protection (provisions relating to EPAs). A key element in this approach is considering social aspects (societal acceptability), critical to securing the policy objectives.

Table 1. CIRAN Key Strategic Objectives (KSOs).

KSO1	Define systemic and integrated permitting procedures in environmentally protected areas.
KSO2	Define a modern policy and social contract framework to reconcile vulnerabilities.
KSO3	Develop a community of practice that remains active after the project is completed.

2 Methodology and data collection and processing

2.1 Introduction and overview

The methodology line implemented involves a series of foresight-oriented exercises, supported with other complementary methods, with the goal of collecting baseline information and understanding how experts and stakeholders see the near and long-term future of CRMs, environmental protected areas and their connections to political, environmental, societal, technological, economic and legal aspects. These are linked to shed light into the connection between drivers of change and policy decisions and their formulation.

The following selection of methods was considered and implemented: Horizon Scanning, Delphi Survey, Scenarios planning and building, What-If case studies, Gaming methodologies and DPSIR framework. The central point in the methodology was the development and creation of the four CIRAN 2035 scenarios.

The methodological approach started with the design and implementation of Horizon Scanning. Results from the analysis contributed to the creation of the Delphi Survey. Then, results from both exercises led to the design and creation of the four CIRAN Scenarios for 2035 (Figure 1).

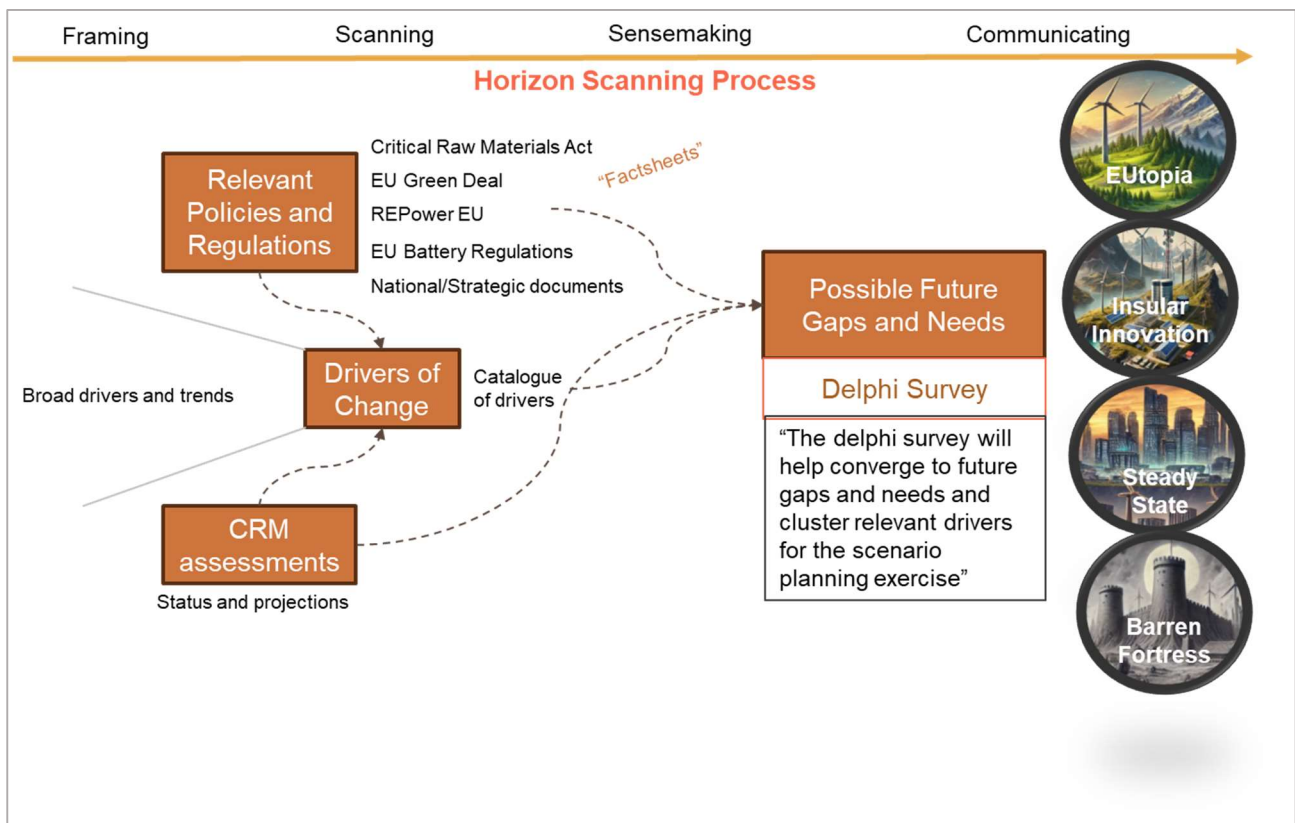


Figure 1. Methodological overview of the first phase of the scenarios-building process: Horizon Scanning, Delphi survey, and scenarios.

The methodological approach was concluded by a scheme for the future implementation of "What-If" Case Studies coupled with gaming elements, and the development of a DPSIR framework for the identified drivers of change, both based on the CIRAN 2035 scenarios.

The following sections within Chapter 2 detail the methodologies, data collection, and processing steps. Results for each stage are then presented in Chapter 3. These are brought together in Chapter 4, where the nexus of policy decision and drivers of change is analysed. To conclude, closing remarks outline the future lines of action arising from the project's work as outlined in this Deliverable.

2.2 Drivers of change (Horizon Scanning)

The Horizon Scanning foresight-focused process is classified as a way to “develop and maintain a broad and externally focused forward view to anticipate and align decisions with both emerging (near-term) and long-term futures” (Hines et al., 2018). The main objective of running this type of foresight method is to discover early signs of potential change and it is commonly used as a tool to make systematic use of emerging information to support decision making. Examples include identifying investment opportunities and supporting policy decision, development and implementation (Palomino et al., 2012).

In CIRAN, Horizon Scanning was selected as the first step in the methodology, and as stated in Cuhls (2019), “scanning is viewed as a search for ‘signals’ and is generally found at the beginning of any forward-looking activity”. The Horizon Scanning aspect within CIRAN was dedicated to mapping and understanding potential Drivers of Change. For CIRAN, the Drivers of Change are seen as trends and influencing forces that might dictate the development of the CRM fields in one way or another, depending on how they evolve. At the same time, relevant factors, trends and issues, and ultimately important but uncertain areas, were also mapped with the vision of contributing to the following steps in the methodology.

For the Horizon Scanning process, several documents and reports were reviewed. These included existing CRMs assessments, EU and National policies related to raw materials and energy, and forward-looking reports, among others. The documents reviewed are divided between broader areas of relevance to CIRAN, including:

- International and EU policy (e.g. UN SDGs, EU Green Deal),
- Directives and laws (e.g. CRM Act, Nature Restoration Law),
- Reports (e.g. foresight reports, policy background reports),
- Studies and projects (e.g. MinLand, SCRREEN2),
- Data and fact sheets (e.g. demographic change, CRM factsheets).

Results from the outlined Horizon Scanning process are described in section 3.1.

2.3 Delphi survey

Using the data collected through the Horizon Scanning process, and especially considering the identified Drivers of Change potentially connected to and/or affecting the world of raw materials, the next methodological step was the implementation of a Delphi Survey with internal and external experts.

The Delphi Survey was originally developed as a technological forecasting technique, which aimed at reaching consensus over relevant technological developments. This technique is anonymous and conducted in several rounds, building on group communication, so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem or question (Linstone and Turoff, 2002).

In a Delphi process, experts (the participants) are asked to consider and classify a number of statements and/or questions. The Delphi process is different from other types of surveys and questionnaires. First, a list of relevant interested experts is pre-compiled, and those experts invited to participate. Second, there is a possibility for experts to comment and explain their opinion on any of the statements. Third, answers are analysed, statistics built and fed back to the experts for further comments, resulting in new rounds of statements and questions. Finally, the objective of a Delphi survey is to reach a consensus among the expert pool (Shariff, 2015).

In CIRAN, the Delphi Survey method was developed to invite and engage raw materials, policy, environmental, and social sciences' experts with the aim to collect their views and opinions on topics of potential interest for the development and implementation of CIRAN, for both the near- and long-term future. The CIRAN Delphi Survey was implemented in two rounds of statements and questions, derived from the results of the Horizon Scanning process. Statements and questions were designed to be provocative to prompt comments and discussion among experts.

The Delphi Survey was implemented using the EU Survey platform (<https://ec.europa.eu/eusurvey/>) (Figure 2). Basic statistics and answers were collected by the platform and later treated, with further statistical analysis of the results undertaken in Microsoft Excel and with the help of online tools. This method provided qualitative and quantitative analyses of the results.

CIRAN

CIRAN project Delphi Survey Round 1

Pages
[Introduction](#) [Objectives and participation in the Delphi Survey](#) [Disclaimer and Reminder](#) [Personal data](#)
[Delphi statements](#) [Thank you for participating!](#)

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5
Delphi statements

The rate of improvement by the industry in terms of mining practices towards more sustainability is sufficient to make mining broadly accepted by stakeholders within the next 10 years.

Disagree Neutral Agree No opinion

[Save](#)

[Return to start page](#) [Go to next question](#)

The Critical Raw Materials Act will not produce any meaningful outcomes and it will not lead to a unified, streamlined permitting process for all Critical Raw Materials.

Disagree Neutral Agree No opinion

[Save](#)

[Return to start page](#) [Go to next question](#)

Most of environmentally protected areas should be automatically no-go zone for mining projects.

Disagree Neutral Agree No opinion

[Save](#)

[Return to start page](#) [Go to next question](#)

Figure 2. Screenshot of the CIRAN Delphi Survey Round 1 from the respondent's view.

Figure 3 summarises the CIRAN Delphi process and its main characteristics.

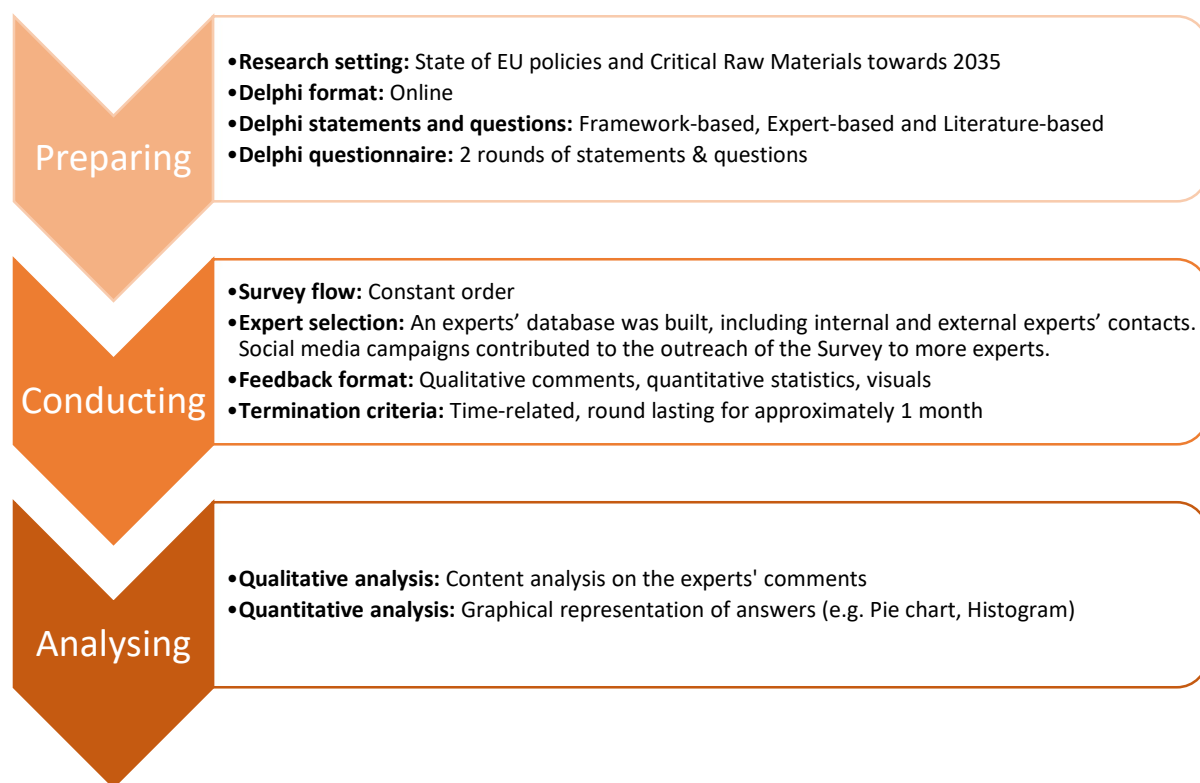


Figure 3. Outline of the CIRAN Delphi Survey main steps and the elements defining each step.

2.3.1 CIRAN Delphi Survey Round 1

Round 1 included ten statements posed to the experts on raw materials related topics derived from the Drivers of Change catalogue and the Horizon Scanning process. Statements spanned the PESTEL categories and aimed at gathering information across several important topics. Participants could Disagree, be Neutral, Agree or have No opinion on a statement and were asked to freely comment and explain the reason for their selection. This round ran between October and December 2023. The presented statements, questions, and an overall analysis of the responses can be found in section 3.2.

2.3.2 CIRAN Delphi Survey Round 2

The statements and questions presented in Round 2 of the CIRAN Delphi Survey built directly on the results from the first round and considered both, quantitative (trying to reach consensus) and qualitative (comments and reasoning for choices) aspects in their design. Similar to Round 1, participants could Disagree, be Neutral, Agree, or have No opinion on a statement and were asked to freely comment and explain the reason for their selection. For the questions, participants were asked to select how several identified aspects would behave in the future and to comment on considerations needed to open a mine in Europe. This round ran between

March and April 2024. The presented statements, questions, and an analysis of the responses are detailed in section 3.2.

2.4 Scenarios planning and development

The scenario planning method is commonly used in organisations for the creation of long-term plans, developed to influence action on the present. This technique is used to address complex and uncertain problems and involves creating hypothetical situations to explore different outcomes, and plan accordingly, serving as a valuable tool in problem-solving and decision-making processes (Amer et al., 2013; Konno et al., 2014).

Furthermore, scenarios' building should adhere to the following principles:

1. Scenario-building should be participatory: Scenarios should be created with stakeholder input, either during the creation of the initial narrative, defining focus/scope, or in checking plausibility and potential outcomes (McGowan et al., 2019).
2. An appropriate time frame should be adopted: this may vary depending on the nature of driving forces. This should be at least five years where change happens quickly, but up to 50 years where change may be more slow or uncertain; at least ten years is typical (Pinnegar et al., 2006).
3. Plurality is required: two to four scenarios are considered to be the optimal number for exploring a range of potential futures (Dean, 2019).
4. The scenarios developed should have plausibility: whilst scenarios are not intended to be accurate forecasts of the future, they should be constructed in such a way that users can see the scenarios as possible futures.
5. Scenarios should have internal consistency: the building blocks (or drivers) that are used to create each scenario should be joined together in an explainable and logical manner (Van Hoof et al., 2014).

Using the results from the Horizon Scanning and Delphi Survey exercises, especially considering future gaps and needs mapped through these processes, the next step was to design and create four different scenarios for the future of raw materials in general and for CIRAN in particular, focusing on several aspects (based on PESTEL), but with CRM needs at the core. These scenarios were built with the timeline of 2035 in mind, and they aim at providing linkages between policy implementation and a range of future states, to adapt to or influence possible futures with dedicated actions, depending on how the world is evolving. The CIRAN 2035 scenarios are narratives of possible futures, not predictions.

In addition to the above-mentioned use of Drivers of Change and the results of the Delphi Survey, the development of the four CIRAN 2035 scenarios encompassed the outputs from the discussions with the diverse group of consulted experts in two Scenario workshops. The first of these workshops took place in January 2024 in Lisbon, Portugal (Figure 4). The second one was held in June 2024 in Turku, Finland (Figure 5). Both internal and external experts were involved in discussions that led to the creation and tailoring of the CIRAN scenarios, where the main aspects defining possible scenarios, narratives, and outcomes were discussed.

The final goal of this process was the creation of the defined framework for the four CIRAN 2035 scenarios, each with its own set of specificities, in an effort to help stakeholders to make strategic decisions considering potential future developments and their possible outcomes. The CIRAN 2035 scenarios were developed to

include visuals and descriptions that are fit for the general public to understand, allowing hence their use by a wide range of stakeholders and for further dissemination, among others, in community engagement events.

While the scenarios provide insights into potential future developments in several realms, it is worth acknowledging that they are not expected to fully materialise within the projected timeframe or even after. Instead, scenarios serve as illustrative models, offering strong signposts that signal key trends and the potential direction of evolution or change. These indicators can help guide strategic decision-making by highlighting areas where certain actions can be adopted to prevent and mitigate evolving circumstances over time.



Figure 4. Group exercises during the 1st Scenarios' Workshop (January 2024, Lisbon, Portugal).



Figure 5. Group discussions during the 2nd Scenarios' Workshop (June 2024, Turku, Finland).

2.4.1 First Scenarios' Workshop

The first Scenarios' workshop was organised back-to-back with a CIRAN Consortium Meeting in January 2024 in Lisbon (Portugal). This ensured an efficient use of available internal and external expertise (i.e., invited experts) to collect data for the first possible CIRAN 2035 scenarios' ideation. The workshop was structured to bring into discussion the Drivers of Change catalogue and the results from Delphi Survey Round 1, and took the first version of the "Future Mining Scenarios for 2050" developed by INTRAW in collaboration with SAFE as a baseline to foster discussion. The first iteration of these INTRAW Scenarios had been developed in 2017, where three scenarios were created as part of the Horizon 2020 INTRAW project for the Future of Raw Materials targeting the year of 2050. Given the limited literature available on the topic, the use of this research as a baseline for CIRAN's 2035 Scenarios was motivated by the convergence of the project's coordinator and the previous participation in the process of the researchers involved in this Task.

Nevertheless, it is worth noting that the use of the INTRAW Scenarios for 2050 was aimed at spurring discussion, whilst the timeline and, therefore, the leading drivers and forces in each of the envisioned realities would differ from the ones outlined in CIRAN's. These scenarios focused on narratives deriving from six main clustering themes: (1) applied research and innovation; (2) joint educational and skills programmes; (3) trade; (4) exploration; (5) exploitation, and (6) processing, recycling, and substitution. The INTRAW scenarios that were used during the first CIRAN Scenarios' workshop in Lisbon were a draft version made available internally at that time. In 2024, these 2050 Scenarios were updated and transformed into four new scenarios, that have been published by the time of submission of the present Deliverable (Correia et al., 2024)¹.

Previous to the workshop session, all relevant materials were sent, as a documents' package, to the participating experts, to ensure informed and fruitful discussions during the allocated time. This workshop entailed the following steps (Table 2), visualised in Figure 6.

Table 2. Structure of the first CIRAN Scenarios' workshop (Lisbon, 2024).

Introduction • Welcome and round of introductions. • Summary of findings of the CIRAN T3.3 Horizon Scanning process (Drivers of Change catalogue summary) and overview of Delphi Survey Round 1 results. • Introduction to the INTRAW 2050 reference scenarios.
World Café exercise (Part 1) • Introduction to the main exercise – setup and instructions.

¹ The new *Future Mining Scenarios* (Correia et al., 2024), developed by INTRAW in collaboration with SAFE, were officially presented to the wider audience at the MINEX Forum, which took place in Prague (Czech Republic) on the 22nd of October 2024. The full report can be accessed through the INTRAW website: <https://intraw.eu/2050-scenarios/>. The authors of this Deliverable, to structure the first CIRAN Scenarios' workshop, had access to the first version available at the time of the workshop, with the permission of the project's coordinator, INTRAW's Secretary General and author of the report, and for research purposes only. No further use or interference with the aforementioned scenarios took place after that.

- Division into four predefined groups with a mix of expertise, one for each reference scenario. The facilitator explained the dynamics of the exercise: 1) Moderator posing questions relevant for CIRAN under that specific scenario, illustrated by the findings of the Drivers and trends/Delphi review, and host taking notes; 2) After 40 minutes, groups rotating and host presenting the questions and briefs on the last group round; 3) Participants invited to build on the comments from the previous group.

This exercise was carried out using one canvas per Scenario, listing the drafted questions and collecting post its with inputs from the experts.

World Café exercise (Part 2)

- For each group: discussion of a specific scenario input identified from the list generated in Part 1 of the exercise, that contributes to or threatens the implementation of controversial raw materials' exploration and/or extraction projects, identifying gaps and vulnerabilities for policymaking using the methodology of a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis.

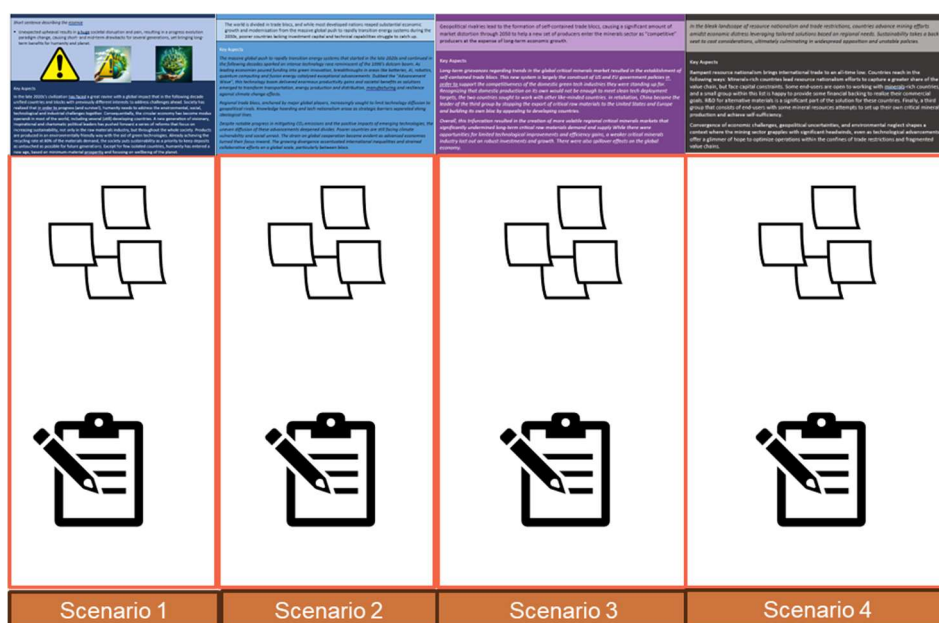


Figure 6. Representation of the first CIRAN Scenarios' workshop structure, involving reading, flipchart-based discussions, and note-taking tasks, for each of the four scenarios presented.

Building on all the elements outlined above, combining the previous CIRAN Task 3.3 work together with the outputs of the first Scenarios' workshop, the first iteration of the CIRAN 2035 scenarios was developed. Results are documented in section 3.3.2.

2.4.2 Second Scenario Workshop

The second CIRAN Scenarios' workshop was organised within the context of the 2024 Futures Conference (<https://futuresconference2024.com/>, 13–14 June 2024, Turku, Finland), dedicated to the Futures of Natural Resources. For this workshop, the above-mentioned first iteration of the CIRAN 2035 scenarios was presented to external experts, mainly professionals in or connected to the Future Studies' domain, with the view of collecting their feedback and therefore tailoring the final iteration of the CIRAN 2035 scenarios.

The workshop comprised the following steps, outlined in Table 3 below.

Table 3. Structure of the second CIRAN Scenarios' workshop (Turku, 2024).

Introduction • Welcome and round of introductions, mapping participants' connections with or previous knowledge about raw materials. • Overview of the CIRAN project and of Task 3.3 objectives and results by the time of the workshop.
Roundtable discussion exercise (Part 1) • Presentation of the selected list of Drivers of change, adapted from the longer list provided in the first Scenarios' workshop. Work in two small groups to review the list and prioritise the Drivers to be developed within the scenarios, according to their relevance by the experts' views.
Stand-up discussion exercise (Part 2) • Mapping the collected inputs and priority elements into a canvas showing the four preliminary CIRAN 2035 scenarios. • Group discussion on the leverage of the CIRAN 2035 scenarios: improvement, dissemination to the general public, and relevance for EU/policymaking stakeholders.
Conclusion • Participants' final suggestions on amending the CIRAN 2035 scenarios. • Final round of feedback on the exercise structure and methodology implemented.

Acknowledging the great value of the inputs collected from the diversity of experts in the second Scenarios' workshop, a renewed iteration of the CIRAN 2035 scenarios was performed. These four updated scenarios went through a major rework, resulting in a document with a full description of each of the CIRAN 2035 scenarios, which can be consulted in section 3.3.3 and, in detail, in Annex 1. After a complex process, the final result reflects the convergence of opinions of several experts consulted at different stages of the project, influenced by the policy and governance aspects characterising the respective contexts of the discussions held (e.g., entry into force of the EU CRM Act, ongoing geopolitical conflicts, etc.). Ultimately, these outputs will be used for future CIRAN work throughout 2025 and are expected to be further disseminated after the project funded period.

2.5 What-if case studies and gaming methodology

After being developed, the CIRAN 2035 scenarios were used as a basis for performing the next step of the methodology, dedicated to the creation of a framework that relies on the use of gaming techniques to explore What-if mining-related situations with stakeholders. The framework is intended to be replicated in the activities of WP5 with stakeholders, especially targeting their use during Public Discussions in the selected case studies in several EU countries.

A What-If methodology is commonly used during the risk assessment step of planning a project. At its core, the What-If approach is a structured risk assessment method to map potential consequences of failures that could occur and measuring the likelihood of their consequences. This technique uses information related to processes, operations, operating procedures, and operating conditions to frame several What-if questions, intended to be worked with stakeholders (Tejaswi and Samuel, 2017).

CIRAN uses a slightly adapted approach to the What-If analysis, where the focus is on the uncertainty of the future, through the use of a combination of illustrative case studies (real world) with modelled scenarios and comparative cases. In conjunction, these simulate how current uncertainties, depending on the way they are resolved, can impact policymaking and permitting. In this methodology, the What-if scenario questions are developed and presented to stakeholders to collect their views and opinions on the consequences of implementing mining projects in protected areas.

The development of the “What-If” Case Studies approach is coupled with a gaming technique component. “Gamification” is about inducing people to engage in a defined activity or process in a game-like way (Ingvarsson et al., 2023). CIRAN uses this gamification approach to bring stakeholders potentially impacted in (possible) future exploration and exploitation projects that can be involved in fruitful discussions on the possibility of having such projects in protected areas.

2.5.1 The CIRAN 2035 scenarios "What If" Case Studies Framework for Community Engagement

The development of the "What If" Case Studies approach is a key output of the project's exploration of future scenarios for CRM extraction in environmentally protected areas across Europe. Within the CIRAN project, this framework is designed to facilitate meaningful engagement with local communities through the application of speculative but plausible scenarios in a non-technical approach. The process builds upon the work presented in the previous section regarding the design and development of four future scenarios for 2035, each reflecting distinct socio-economic, technological, and environmental conditions that shape the supply and demand dynamics for CRMs and are influenced by multiple drivers of change.

The proposed “What-If’s” framework is intended to be applied during the last year of the project, and, particularly, during the first half of 2025, through a series of local community events, involving local stakeholders such as various societal groups and municipalities. For this, preliminary work on the Scenarios was presented and introduced into the discussions in some communities, particularly in the Public Discussions held in late 2024 in Portugal (Idanha-a-Nova) and the Czech Republic (Veselí nad Moravou).

Lastly, given that the final version of the Scenarios and the “What-If’s” framework resulting from these are presented in this Deliverable, it is expected that at least one “What-If” scenario will be tested in each of the four local communities where WP5 events are to be organised for 2025. As such, each community will engage with a tailored “What-If” Case Study corresponding to one of the scenarios, which includes key questions to be resolved within the community discussion. Furthermore, to align with Task 3.3 objectives and with the objective of making such discussion topics much more engaging and understandable by the general public, the “What-If” Case Studies’ framework has been coupled with a role-playing gaming framework, which can be found in Annex 2.

The “What If” Case Studies framework based on CIRAN 2035 scenarios is summarised in Table 4 below.

Table 4. Outline of the “What If” Case Studies framework based on the CIRAN 2035 scenarios.

SCENARIO 1 – EUtopia	SCENARIO 2 – Insular innovation
"What-If" Concept: <i>What if international cooperation eliminates the need for domestic mining?</i>	"What-If" Concept: <i>What if domestic mining became the only option for resource security?</i>
This case study will explore the implications of a world where strong global partnerships and circular economy practices make domestic mining in protected areas unnecessary. This may be brought to any of the communities, regardless of their connection with environmentally protected areas and environmental views, given that the scenario would not require mining there. Nevertheless, participants will have to consider the potential benefits and challenges of this paradigm, including whether it is realistic enough, and acknowledging consequent factors, such as the continued dependency on international supply chains, and the environmental impact in other external producing countries. They may also compare their current local economic development with the potential prospects for growth or negative impacts brought by this scenario.	This case study addresses a future where protectionist policies necessitate mining in environmentally protected areas. Community members will debate the trade-offs between resource independence and environmental preservation, focusing on the societal and ecological impacts of domestic resource extraction. Local communities’ responses to this case study may vary based on factors such as, but not limited to, their perspectives on the importance of environmental protection versus market development and economic growth, the technological and innovation potential of the region (which implies more use of CRMs), and the social and historical dynamics in relation to mining and other employment opportunities connected to the industry.

SCENARIO 3 – Steady state	SCENARIO 4 – Barren fortress
"What-If" Concept: <i>What if we maintained the status quo for the next 10+ years?</i>	"What-If" Concept: <i>What if resource scarcity necessitated mining in protected areas despite fragmented governance?</i>
Under this scenario, communities will examine the potential outcomes for their region (and, consequently, for Europe) of continued reliance on existing and somehow insecure CRM supply chains. Participants will be invited to consider whether limited technological innovation is a realistic framework for the future of their community. Discussions will address the risks of stagnation versus the benefits of predictable stability, with minimal pressure for new mining initiatives.	This case study explores a challenging future where protectionism, resource scarcity, and weak governance facilitate mining activities into protected areas with inadequate mitigation measures. Participants will evaluate how these pressures might affect environmental standards, community resilience, and regional autonomy. They will carefully consider whether this is a realistic scenario for them based on the level of environmental protection and occurrences of environmentally protected areas in their region, including surrounding areas. They will contrast these aspects against their perspectives on present and future needs of CRMs and mining/extraction activities in their area.

The “What-If” roleplay gaming framework will also foster inter-WP collaboration; namely, as a link between WP3 outcomes and WP7 objectives, contributing to the development of visual materials such as game instructions and characters’ cards for players that could be translated into the different languages to be used in the WP5 community events in 2025.

2.6 DPSIR framework

In 1999, the European Environment Agency created the DPSIR Framework to better understand Driving forces, Pressures, States, Impacts, and Responses of/to policy intervention in a causal relationship. The framework aims to describe the interactions between society and the environment: studying and assessing possible environmental problems resulting from societal actions. It serves to evaluate environmental changes in ecosystems, identify socio-economic pressures on a system, predict potential challenges and improve management practices.

In the application of the DPSIR framework, indicators are categorized into "drivers" which put "pressures" in the "state" of the system, which in turn results in certain "impacts" that will lead to various "responses" to maintain or recover the system under consideration. These elements are connected to one another, which depicts a basic relationship between the elements. The original purpose of the DPSIR framework is to serve as a systems analysis tool: (1) societal and economic developments exert Pressure on the environment and, as a consequence, (2) the State of the environment changes, such as the provision of adequate conditions for health, resources availability and biodiversity. Finally, this (3) leads to Impacts on human health, ecosystems and materials that may elicit a societal Response that feeds back (4) on the Driving forces, or (5) on the state or impacts directly, through adaptation or curative action (Smeets and Weterings, 1999).

Figure 7 presents the DPSIR framework as viewed from the CIRAN’s project perspective. The Drivers are policy decisions at the EU or national levels. These policies, for example the EU Green Deal, result in increased Pressure to extract primary mineral raw materials to address them. However, primary raw materials extraction, necessary to enable technology changes (e.g., chemical elements such as lithium or cobalt for batteries), primary extraction occurs mainly outside Europe, where the state of the societies and the environment are fragile and vulnerable. If raw materials continue to be obtained from outside of Europe, more impacts will be seen in these regions, also exposing EU societies to the risks of supply chain disruption. The response to this could be the domestic extraction of mineral resources to reduce vulnerabilities and impacts.

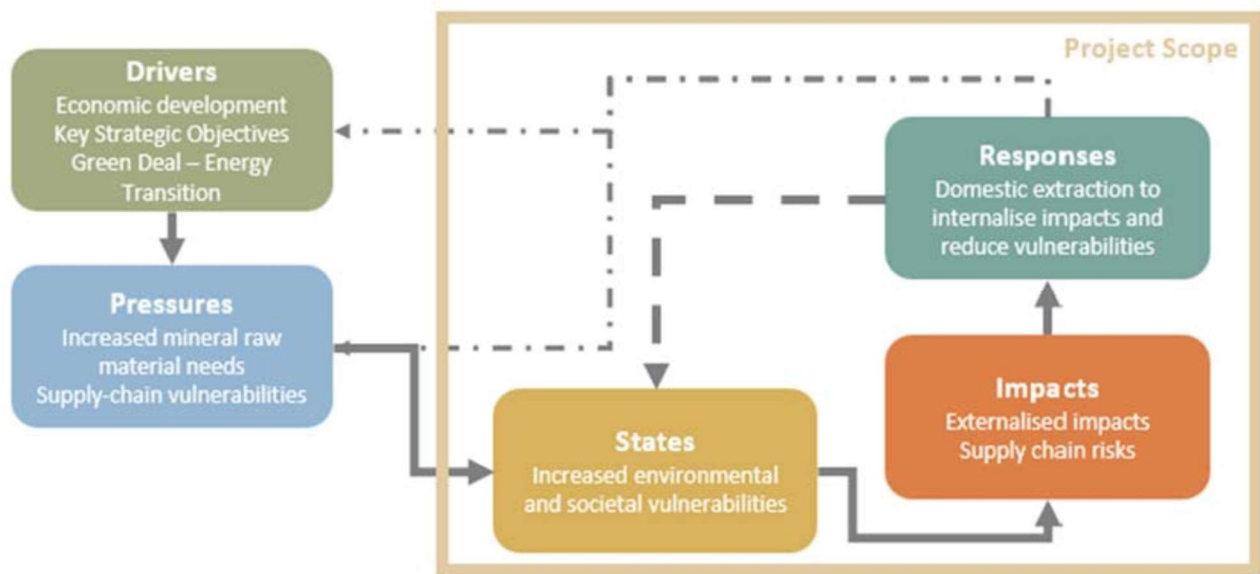


Figure 7. The DPSIR framework adjusted to CIRAN (adapted from Smeets and Weterings, 1999).

In the CIRAN Task 3.3 work, the DPSIR framework was used against the backdrop of the four CIRAN 2035 scenarios, to highlight the main DPSIR elements affecting each of the considered scenarios, delivering key insights into each scenario’s dependencies, pressures, and potential responses (i.e., mitigation measures). Results of this comprehensive analysis can be found in section 3.5.

3 Results

3.1 Drivers of change (Horizon Scanning)

The Horizon Scanning process resulted in the identification of several potential Drivers of Change relevant for the sector of raw materials, in general, and for CIRAN implementation, in particular. The mapped drivers of change were collated into a Drivers of Change Catalogue. This catalogue lists the drivers of change in different clusters, with each driver of change being included in a cluster and having a unique rationale to support its inclusion. These drivers of change represent forces or signals of change (e.g. trends) that have the potential to shape the future, policy or strategy area. Drivers may have an immediate and direct effect or may have a more diffuse and indirect impact through a number of other drivers.

Understanding these drivers and themes is crucial for stakeholders in the CRM sector as they highlight the need for adaptive policymaking that can effectively reconcile the need for resources with conservation efforts. Through the review of documents and reports (mentioned in Section 2.2) 28 main drivers of change were identified and divided between six main thematic clusters deemed relevant for covering important yet uncertain topics. An iteration of this step resulted in 17 final drivers of change divided into six clusters.

The selection of clusters approximates the PESTEL framework for englobing the main drivers of change as it covers most of the relevant aspects of the work developed in CIRAN. The selection of Drivers of Change was limited to three drivers per cluster, to contain the work within certain limits. As identified from the first iteration of Drivers of Change, there were other possibilities, but they were considered to be less relevant than the selected ones. Table 5 shows the division of Drivers into their respective clusters together with the rationale for each selected Driver of Change.

Table 5. Selected Drivers of Change and their rationale in the CIRAN context, by cluster.

Cluster	Theme/Driver	Rationale
Environmental Policies and Regulations	Regulatory & Legislation developments	Emergence of environmental impact regulations, taxation, mining permits. Speeding up permitting for all critical raw material projects with a one-stop-shop contact.
	Global frameworks supporting policymakers	Objectives set at the global stage, especially the United Nations' Sustainable Development Goals (SDGs), also known as Agenda 2030. The global players set the stage for policy- and decision-making at lower levels of governance. In many instances, especially within the framework of the UN, these serve as a basis or recommendation but are non-legally binding instruments.
	EU and National Policy frameworks	Level of streamlined permitting, policy formulation, stakeholder involvement, access to mineral deposits, and frameworks such as the EU Green Deal and Energy Transition (i.e., speeding up permitting for critical raw material projects).
	Climate Change Potential	Industry decarbonisation targets set by the European Green Deal and Paris Agreements.

Cluster	Theme/Driver	Rationale
Public Perception and Social Factors	Public acceptance	Level of acceptance of CRM exploration and extraction, "not in my backyard" sentiment trends, and local community engagement levels (for instance, measured by degree of public participation in community-led initiatives, number of organisations dedicated to these topics, etc.).
	Consumption patterns and Social inequality	Societal trends regarding (sustainable) consumption and life-style behaviour. Perceived socio-economic inequalities explaining/influencing consumers' behaviour towards more/less sustainable practices and lifestyles.
	Demographics	Ageing European population and migration effects.
Cluster	Theme/Driver	Rationale
Sustainability Shifts	Recycling and Circular Economy	Developments in waste treatment, recycling technologies, and materials efficiency.
	Resource equity	Availability of water and environmental burdens on local populations.
Cluster	Theme/Driver	Rationale
Geopolitical and Economic Factors	Supply Chain Dependence & Trade	Global Competition for Raw Materials - EU's heavy dependence on China for some raw materials and processing capabilities. Climate crisis, pandemics, war can be identified as disrupting factors. Export-restricting measures affecting the supply of critical raw materials.
	Conflicts over land use and strategic resources	Competition for land resources is a major cause of conflict between and within nations and there can be significant impacts on land from violent conflicts.
	Safeguarding of mineral resources	Avoiding 'sterilisation' of (future) CRM needs, see Minatura 2000 and MinLand project results.
Cluster	Theme/Driver	Rationale
Technology and Innovation	Digitalisation/ Robotics/ Automation	Technology solutions to find, access, and process raw materials are becoming more important for the value chain.
	Substitution	Shifts in possible alternatives to avoid the use of CRMs. Identifying where CRM are currently in use and which substitutes (if any) may exist.
Cluster	Theme/Driver	Rationale
Industry and Resource Management Dynamics	Changes in Critical and Strategic Raw Materials lists	Projected demand for raw materials in strategic technological sectors (e.g., renewable energies, e-mobility, ICTs, energy-intensive industries, etc.), for emerging technologies, and updates of CRMs lists.
	Price vs. Production costs of CRMs	Profitability driving mining choices and access to capital/ finance. Level of vertical integration and concentration of raw materials producers and strategic positioning.
	Primary and Secondary sourcing	Level of diversification of supply across different stages of the supply chain within the Member States. Although mineral exploration is key to expanding or even maintaining current production levels, only limited exploration activities take place across the EU, with considerable differences among Member States. As for secondary raw materials, they will still have limited availability in the near to mid-term future, but will become a more relevant driver as the time goes by.

3.2 Delphi survey

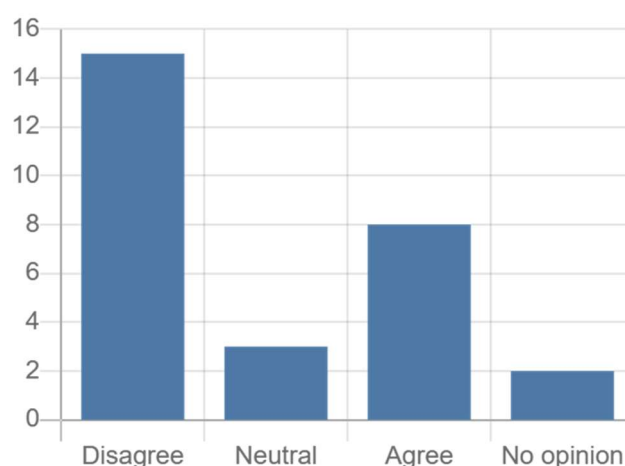
Results from both rounds of the CIRAN Delphi Survey contributed to a better understanding of the perceptions of diverse stakeholders and experts in relevant topics addressed by CIRAN (e.g., the criticality of raw materials, mining in protected areas, policymaking priorities, etc.). At the same time, this step resulted in survey participants' reaching a certain consensus and mutual agreement on certain aspects (reflected in the survey statements). The results from the rounds offer both quantitative and qualitative analyses of the statements. Quantitative analyses, measured by the total number of responses for each option (i.e., level of agreement) elucidate the degree to which the survey brought experts to a consensus. Complemented by the qualitative analysis, several needs, concerns, opportunities, and ideas were extracted and helped shape the following steps of the methodology, especially contributing to the drafting of the CIRAN 2035 scenarios.

More than 60 participants from different countries in Europe, including, by alphabetical order, Austria, Belgium, Czechia, Finland, France, Germany, Greece, Italy, Ireland, Norway, Portugal, Spain, Sweden, and the UK, contributed to both rounds of the CIRAN Delphi Survey. This provided a diverse range of mindsets, cultural aspects, historical traits related to the mining tradition, and political influence in the collected views, resulting in strong and thorough survey outcomes.

3.2.1 Overview of CIRAN Delphi Survey Round 1 results

This section and section 3.2.2 below outline the results of the first and second rounds of the CIRAN Delphi Survey, ordered by statement.

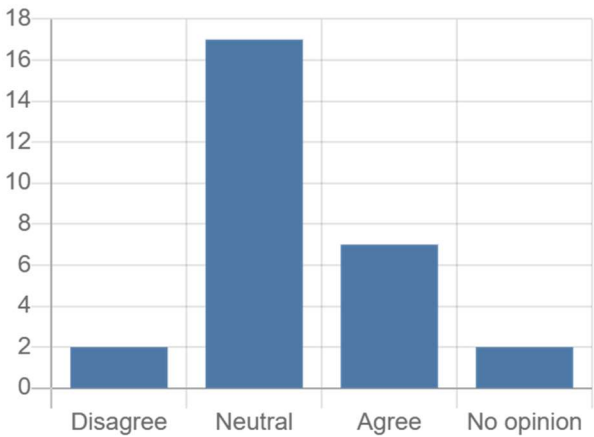
1. **“The rate of improvement by the industry in terms of mining practices towards more sustainability is sufficient to make mining broadly accepted by stakeholders within the next 10 years”**



Overall, it appears that the majority of participants who expressed an opinion believe that the rate at which the industry is improving mining practices towards greater sustainability will NOT be sufficient to achieve wider stakeholder acceptance of mining within the next ten years. In this regard, the short timeframe is considered insufficient to overcome the collective memory of past environmental impacts. Thus, results reflect the challenges of altering perceptions arising from legacy mines which had or are adversely impacting

the environment. Geographical differences have to be taken into consideration, with greater acceptance in mining districts and rural areas. In this framework, one must acknowledge that the industry is also struggling with increasing demands for resources, which seems to offset the sustainability efforts that are pursued to address the local environmental concerns. The distinction between 'good' and 'bad' mining practices, potential government influence and the prevalence of misinformation are barriers to the achievement of a more widespread acceptance of mining. Perception change is highlighted as a long uphill struggle, which will need to be addressed in the first place with improved benefit-sharing models and consideration of post-mining impacts. Moreover, societal acceptance remains a "Not In My Backyard" challenge, also in light of the visual and other impacts of mining. This latter problem emphasises the need for better interaction of the mining industry with civil society and especially with the media. Despite progress, achieving broad stakeholder acceptance within the given timeframe is therefore not considered a likely scenario.

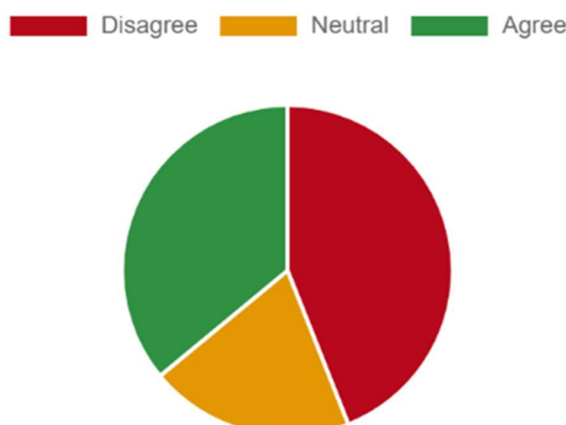
2. “The Critical Raw Materials Act will not produce any meaningful outcomes, and it will not lead to a unified, streamlined permitting process for all Critical Raw Materials”



The potential impact of the CRM Act on the streamlined permitting process for all critical raw materials is questioned, with the majority of participants expressing a neutral opinion. However, many raised concerns about the significant differences in permitting procedures at the national and local level, which pose a significant challenge to achieving a consistent and streamlined permitting process across the EU. The ongoing formulation of the CRM Act adds an element of uncertainty², as its implementation is subject to the discretion of individual Member States. Despite the increasing geopolitical pressure for raw materials, which could be a driving factor for the success of this legislation, the success of the CRM Act is seen as largely dependent on factors such as national land use considerations and the need for a more inclusive knowledge of the issue by civil society. Overall, the sentiment is one of cautious 'wait and see', with the expectation that the CRM Act may face challenges and opposition during its implementation.

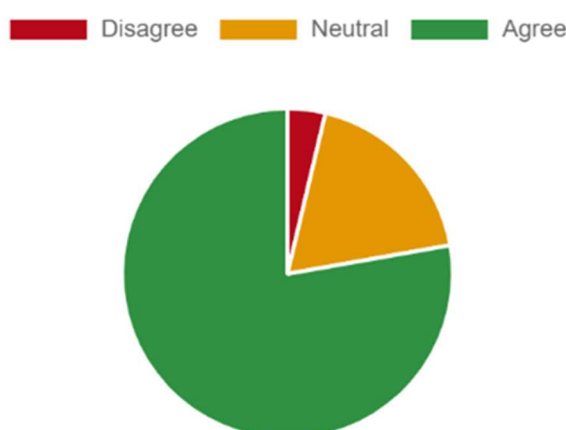
² It shall be noted that, since this Delphi Survey Round 1 was conducted, the Critical Raw Materials Act was legally adopted, removing this uncertainty.

3. “Most of environmentally protected areas should be automatically no-go zone for mining projects”



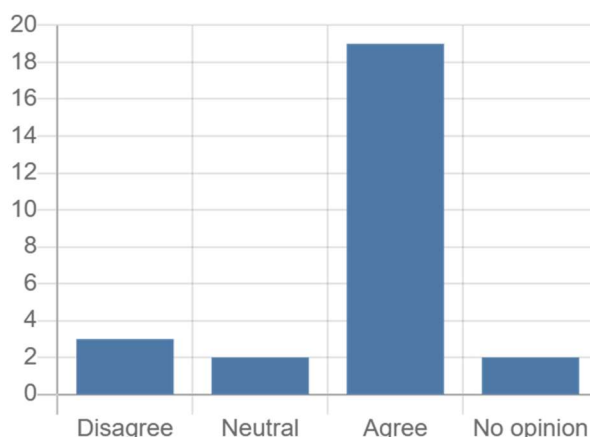
The responses to the statement on mining in protected areas revealed a nuanced perspective, with almost equal numbers of 'agree' and 'disagree' responses, and one fifth of the respondents declaring themselves neutral. While some advocate assessing different activities, including mining, to prioritise land use with compensation considerations, others argue that the uniqueness of each mining project should determine whether certain types of protected areas are automatically considered off-limits. Concerns have been raised that a generic restriction will hinder large mineral projects near protected areas, leading to requests for exemptions in promising cases. One viewpoint challenges the conception of protected areas, suggesting that with the right techniques, mining may not harm them. Agreement with this statement is tempered by a call for differentiation based on levels of protection, species presence and mitigation measures. Finally, one participant highlighted how decisions about mining in protected areas should involve local communities on a case-by-case basis.

4. “Potential conflicts over land use for CRM extraction will escalate unless the protection of mineral resources is better incorporated into land-use planning within the EU”



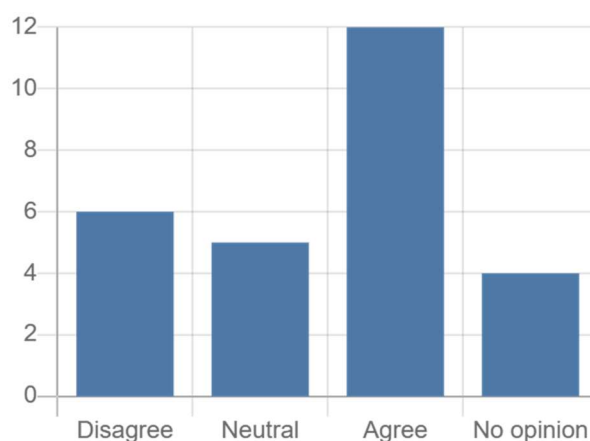
Most participants support the idea that potential conflicts over land use for CRM extraction will escalate unless there is better incorporation of mineral resources in land-use planning. There is a recognised need for increased knowledge and visibility of CRMs. Participants highlight that a clear legal framework for land-use could address this need, providing civil society with a more comprehensive understanding of the issue. While incorporating mineral resources into land use planning is seen as beneficial for addressing conflicts at the planning stage, some participants acknowledge that conflicts may still occur even with such incorporation.

5. “Despite EU-level targets, the balance between environmental conservation and mining will continue to be primarily driven by local public opinion and Member States regulations”



Participants overwhelmingly agree on that, despite EU-level targets, the balance between environmental protection and mining will be largely determined by local public opinion and Member States’ regulations. Some participants highlight external threats, such as geopolitical tensions, as important catalysts for changing attitudes, especially among influential media. In cases of threats from third parties, the importance of minerals can override local public opinion and influence pro-mining regulatory changes. Despite the role of local perceptions, the impact of strong environmental protection at EU level is recognised, with regulations having the potential to shape member states’ approaches, although some scepticism is expressed about the effectiveness of certain environmental regulations.

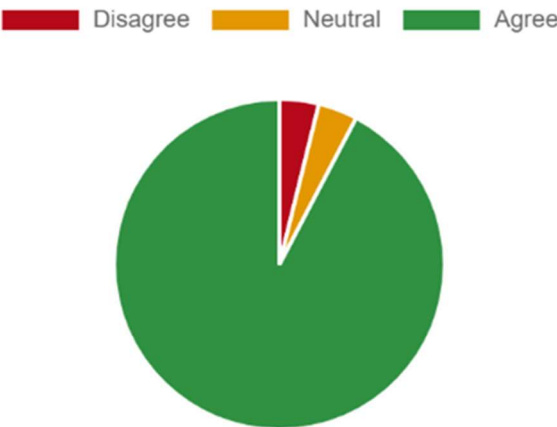
6. “Global frameworks such as the UN SDGs will influence the development of legally binding acts, significantly impacting CRMs policies”



Opinions on the influence of global frameworks, such as the UN Sustainable Development Goals (SDGs), on critical resource management policies vary, with almost half of the participants agreeing that global frameworks will influence the creation of legally binding acts. While participants recognize the compatibility of the SDGs with CRM policies, there are concerns about their limited specificity and legal implications. Some emphasize the autonomy of national and local levels in authorization processes, with reservations about additional global frameworks being potentially counterproductive. Interestingly, economic incentives,

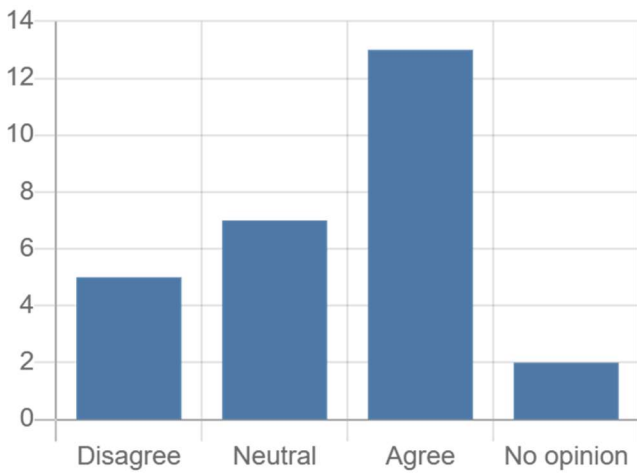
geopolitical conflicts and disruptions to CRMs imports are seen as more immediate and influential factors in shaping binding legislation, as evidenced by references to the CRMs Act.

7. “Environmental concerns and societal opposition to mining will continue to be the leading driver affecting local (un)attractiveness for domestic project development over the next 10 years”



The majority of respondents express scepticism about a shift in the primary driver affecting local (un)attractiveness for domestic mining project development over the next decade. The prevailing sentiment is indeed that environmental concerns and societal opposition will persist as the dominant factors. While acknowledging the importance of jobs and economic improvement in mining districts, a notable portion of respondents see these as secondary drivers. Policy and stakeholder efforts are deemed insufficient and unconvincing. However, a respondent highlighted that clear government and scientific support for CRMs development, reflected in policy, along with efforts to promote understanding of the necessity for CRMs, could influence societal responses positively.

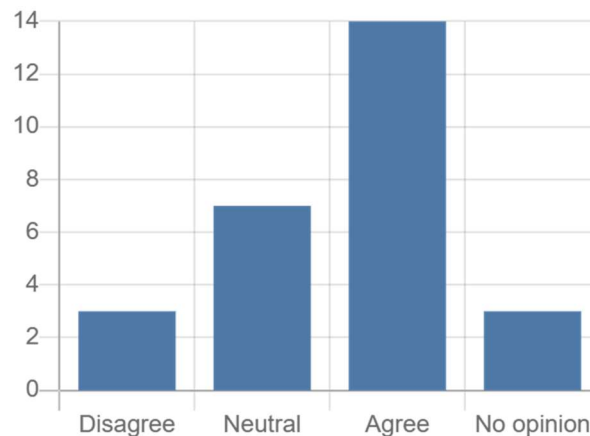
8. “Skills shortages, high wages and energy costs in the CRMs sectors will make extraction and processing operations in the EU less attractive to global investors”



Notably, almost half of the respondents agree with this statement, highlighting the importance of skills shortages, high wages, and energy costs for the attractiveness of the EU's critical raw materials sector. However, the comments section revealed mixed sentiments. Some are indeed more optimistic, citing factors

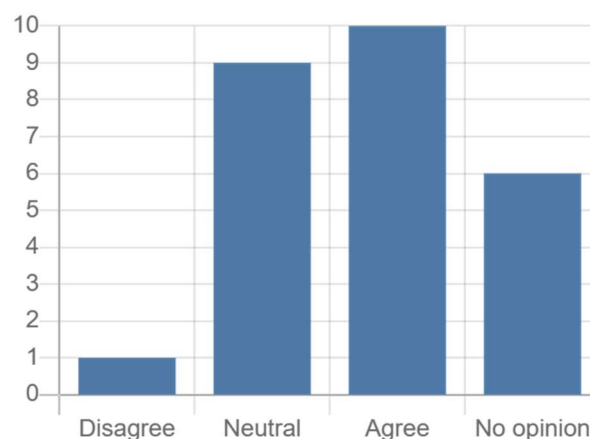
such as a stable political framework and infrastructure as driving forces behind the attractiveness of the EU's CRMs industry. Others, meanwhile, suggest that incentives and workforce development can offset higher costs and thus make the production of these materials more cost-effective. Several respondents anyhow agree that the challenges identified require targeted policies.

9. “Access to capital for developing mining projects will become easier due to increased interest in sustainable CRMs projects over the next 10 years”



Responses to the statement varied, but almost half of the participants agreed that access to capital for developing mining projects will become easier over the next 10 years due to increased interest in sustainable CRMs projects. However, there was also some criticism. One participant used a Norwegian case study to highlight how social acceptance issues affect access to capital, challenging the assumption that increased sustainability guarantees easier financing. Other respondents expect sustainable CRMs to attract international financial interest but doubt substantial change. Challenges are expected to remain in accessing finance for exploration, which hampers the discovery and extraction of CRMs. Finally, views on instability are nuanced, suggesting potential shifts in EU domestic mining, but recognizing investor preferences for safer options.

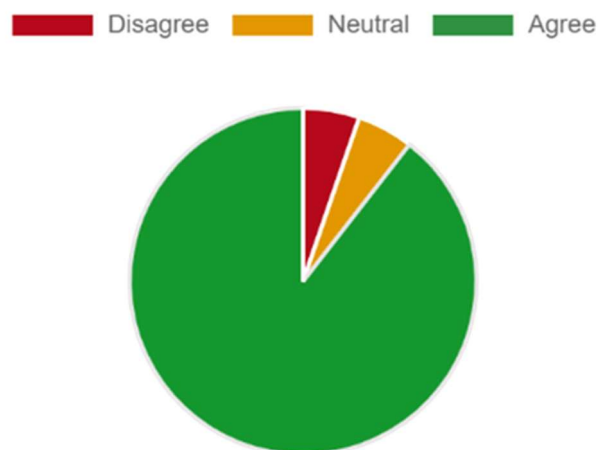
10. “Vertical integration driven by key technology sectors that are dependent on CRMs will become more prevalent. This will lead to more stable raw materials supply chains”



Overall responses to the statement varied widely, with most participants being either neutral or agreeing with it. While some expressed uncertainty about the portrayed scenario due to dynamic geopolitical and economic balances, others argued that the mentioned trend is already happening. Nevertheless, some remain unsure of the direct impact of vertical integration on supply chain stability. In particular, one participant strongly argued for a non-correlation between vertical integration and stability, emphasising the role of politics and government investment to stabilise the supply chains, while vertical integration would only incentivise speculative market manipulation. Doubts were finally expressed even about the occurrence of vertical integration itself.

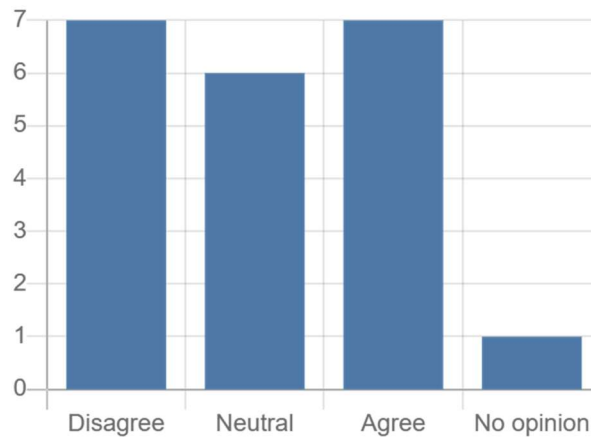
3.2.2 Overview of CIRAN Delphi Survey Round 2 results

1. **“Efforts to address the criticality of raw materials will be aligned with broader sustainability goals, including the promotion of circular economy practices and the reduction of resource consumption”**



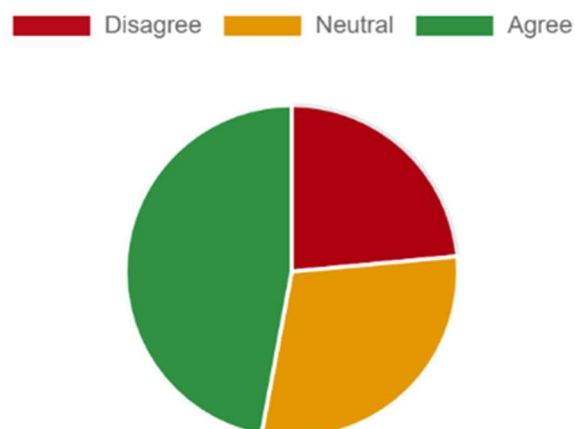
Respondents generally agree with the Delphi statement, emphasising the need for better communication and awareness, aligning efforts with broader sustainability goals and reducing resource use. They highlight the EU's push for exploration, extraction, recycling and environmental protection and stress the importance of aligning these efforts with sustainability. Some are optimistic about the EU's ability to succeed because of its adaptive society and mature market economy, but also point to the need for aggressive trade policies and international cooperation to avoid environmental leakage. One respondent is neutral, acknowledging the challenging sustainability goals but expressing doubts about achieving them due to the increasing consumption of raw materials.

2. **“The shift towards a circular economy will reduce the pressure on sourcing Critical Raw Materials from protected zones, with recycling and substitution technologies significantly decreasing the demand for primary mining”**



Overall, there is a spread of opinions about the fact that the shift to a circular economy will reduce the pressure on CRM sourcing, differing on the extent and timeframe of this reduction. Some argue that while the circular economy will reduce the demand for CRMs, primary mining will still be necessary due to thermodynamic constraints. They question the short to medium term impact of recycling. Others agree, citing regulatory measures and a move towards greater EU integration in addressing sustainability issues. A neutral view emphasises the need for time to accumulate materials for recycling and the importance of changes in consumer behaviour. However, a dissenting opinion suggests that the growth of the circular economy will not significantly reduce the demand for CRM due to increasing raw material consumption.

3. **“Geopolitical pressures to secure CRM supplies will outweigh environmental concerns, leading to increased investment in mining and exploration activities in environmentally protected areas, despite potential environmental risks”**

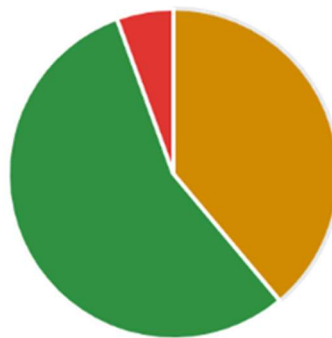


Respondents have different perspectives on the Delphi statement. There is agreement that geopolitical pressures are likely to lead to increased mining in protected areas, highlighting the need for global systemic change to address this issue. They express concern about the current paradigm of profit-driven growth and the disruptive nature of geopolitics. Another agrees, but suggests that this scenario is more likely to occur in less developed countries. One neutral response criticises the clarity of the question regarding national and international scales, emphasising the influence of economic principles and the potential for public opinion

and action to disrupt business as usual. However, two respondents disagree and express optimism that such a scenario can be avoided. One believes it would be a worst-case scenario and hopes for a different outcome, while the other points to the increasing organisation and responsiveness of civil society as a counterforce.

4. **“To inform strategic resource management decisions on raw materials’ needs, it will be necessary to distinguish between materials that are used in large amounts and without satisfactory replacing alternatives (e.g., iron, copper, aluminium), and materials with more uncertain markets (e.g., materials used in novel high-tech applications)”**

■ No opinion ■ Neutral ■ Agree



Most participants agree or are neutral towards the idea of having a differentiation in raw materials by their use-cases, to better inform decision-makers on resource management, considering the needs for those materials.

5. **“Advancements in extraction technologies will minimise the environmental impact of mining in protected zones, making it an accepted practice within the next decade”**

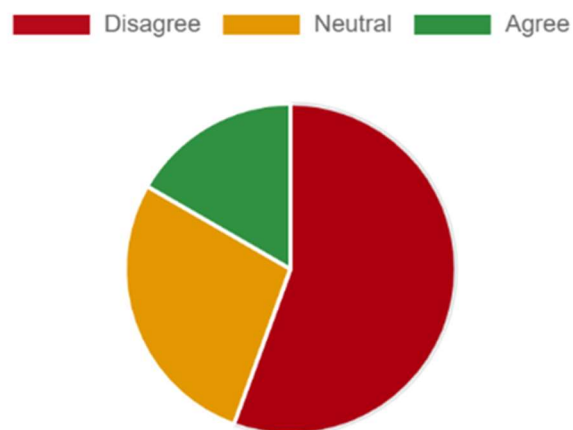
■ Disagree ■ Neutral ■ Agree



Respondents mainly agree on the likelihood that advances in extraction technologies will minimise the environmental impact of mining in protected areas within the next decade. Those who agree are optimistic about the possibility, suggesting that while there will still be impacts, they will be negligible compared to other land use activities. Neutral responses acknowledge the potential for reduced environmental impact, but express scepticism about whether this will increase acceptance, particularly given the projected increase in demand for materials. However, one dissenting opinion believes that while progress may be made, the

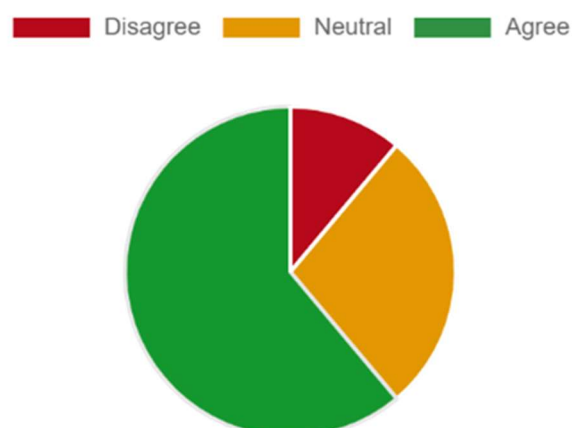
timeframe of a decade is unrealistic, suggesting that it may take closer to 50 years for significant progress to be made.

6. **“By 2035, public opposition to mining in protected zones will significantly decrease due to increased awareness of Critical Raw Materials' importance for green technologies and geopolitical and strategic autonomy”**



Respondents mainly disagree on the likelihood of reduced public opposition to mining in protected areas by 2035. Those who agree are optimistic, suggesting that increased awareness of the importance of critical minerals for green technologies and advances in mining technologies may contribute to this decrease. However, those who disagree argue against this notion, citing the need for improvement within the mining sector, scepticism about the situation improving in Europe, and highlighting that there are other motivations for opposition, like the “NIMBY” view, which will grow due to unequal land ownership and misinformation.

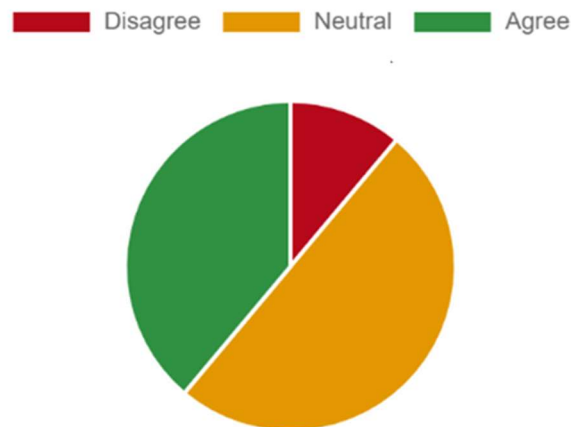
7. **“Increased awareness-raising and educational efforts on the importance of Critical Raw Materials and responsible mining practices will lead to a more informed public”**



Respondents generally agree that increased awareness and education efforts on CRMs and responsible mining practices are critical to creating a more informed public. Those who agree emphasise the importance of a long-term proactive communication strategy, although some express cautious optimism or acknowledge the difficulty of achieving this in a short timeframe. Neutral responses emphasise the need for a broader shift in attitudes and systemic change, suggesting that awareness raising and education, while essential, may not

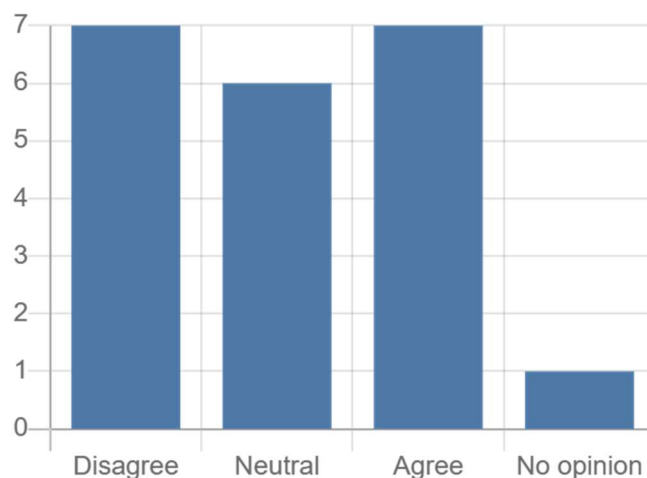
be sufficient on their own. They stress the importance of acting on information and note the challenge of achieving this in a short timeframe.

8. “By 2035, new social contracts and business models will turn stakeholders into shareholders in the European mining sector”



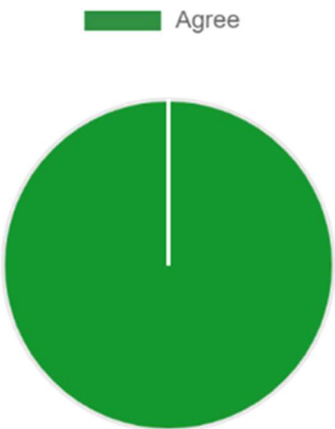
Respondents are divided and mostly neutral on the likelihood of new social contracts and business models turning stakeholders into shareholders in the European mining sector by 2035. One participant who agrees is supportive of the idea, seeing it as a positive shift towards benefit sharing and a win-win situation for all stakeholders. Neutral responses suggest that the feasibility of this change depends on factors such as the economic situation and the awareness of decision-makers, with some expressing scepticism about the pace of societal change required and the potential economic impact. One dissenting opinion believes that such a radical change is unlikely to occur within the time frame given.

9. “Social acceptance issues will pose challenges in accessing capital for Critical Raw Materials exploration and mining projects, challenging the assumption that increased sustainability guarantees easier financing”



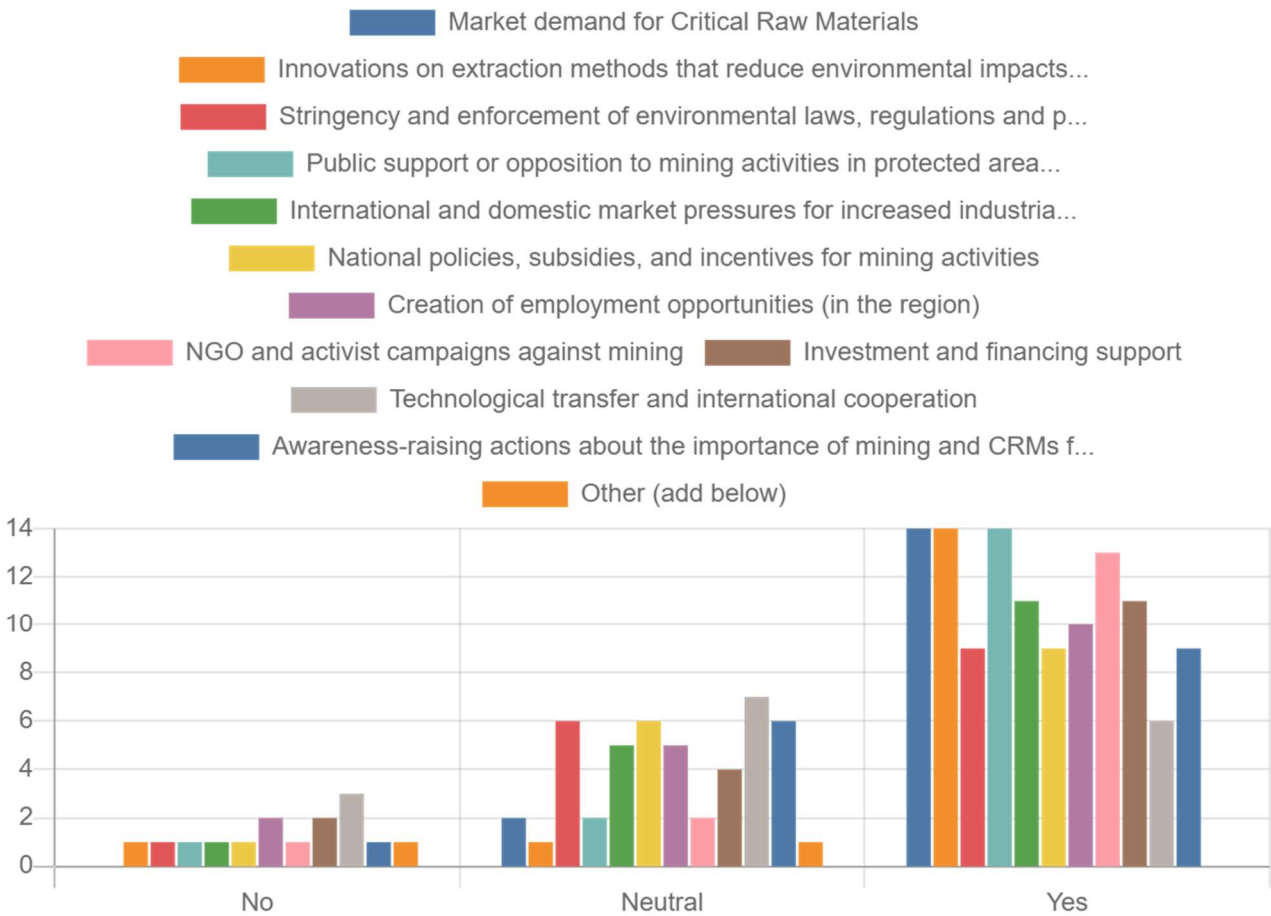
There is an almost equal division of opinions to this statement. Participants take different positions on the effect of social acceptance into acquiring financing for CRM projects, but no further explanations were provided.

10. “Geopolitical conflicts and trade wars (e.g. Russia-Ukraine, China-USA) will be critical in shaping raw material supply chains in Europe over the next decades”



Everyone agrees, one participant points out the impact that certain conflicts will have on the issue.

11. “Do these factors likely shape the decision to mine in environmentally protected areas in 2035?”



Experts are in general agreement that all the listed factors will, to some degree, be relevant for the decision to mine in environmentally protected areas in the future. Among the factors, most certain to impact such a decision are the market demand for CRMs, innovative mining methods that reduce environmental impact of operations, success in obtaining a Social License to Operate, and public support (or lack thereof) for mining

activities and the influence of NGOs and activist campaigns against mining. On the other hand, factors that are less likely to influence the decision to mine in protected areas are the enforcement of environmental laws and regulations, national policies and subsidies attributed to mining companies and activities, international cooperation and awareness raising actions on the importance of mining and CRMs.

12. “By 2035, what are the most important considerations needed in the decision to open a mine in Europe? Would these considerations change if mining is in a protected zone?”

Opening a mining operation in Europe has its challenges. There are several factors that need to be weighed during a proper decision-making process, which might depend on the raw material in question. Furthermore, mining near protected areas poses very specific challenges related to environmental preservation, raises community concerns and concerns over economic benefits. Minimising ecological impact through rigorous Environmental Impact Assessment and low-impact technologies, is then seen as essential. Feasibility of mining projects, their location, and their sensitivity to disputes are critical factors, especially for extracting valuable commodities that generate regional and/or strategic economic benefits. Mining can also be considered, if the specific commodities have great value (e.g., for local industry). Trust-building via transparent communication and meaningful community engagement ensures acceptance and sustainable outcomes. Finally, participants also call for a unique common legal protocol that allows the navigation of CRM extraction in environmentally protected areas.

3.3 CIRAN scenarios for 2035

The CIRAN 2035 scenarios for the future of Critical Raw Materials outline four plausible futures for the EU's approach to securing raw materials to meet demand for various priorities (e.g., green and digital agendas) through different policies and measures. These Scenarios explore the interplay between globalisation, technological innovation, policy frameworks, and societal factors shaping CRM demand and supply dynamics across Europe in the near future. The scenarios aim to guide strategic decision-making by examining key potential drivers, pressures, and responses related to CRM needs and their implications for environmental, economic, and societal sustainability.

3.3.1 Results from the first CIRAN Scenarios’ workshop

Results arising from the discussions with the experts in the Scenario workshop held in Lisbon (Portugal) in January 2024 (*see Section 2.4.1*), together with data from the Drivers of Change Catalogue and Delphi Survey rounds, were reworked into a content/thematic analysis, to cluster statements and identify trends across the drivers outlined at the start of Task 3.3. This process further informed the Scenarios’ development work.

Results from this first Scenarios’ workshop were encompassed in the mapping of (1) Key mining countries/regions, (2) Insights into the narratives, (3) Trends, (4) Opportunities, and (5) Threats for potential future scenarios, as seen from an EU perspective. It is worth noting here that the results obtained in this sub-step are highly connected to the INTRAW 2050 Scenarios’ vision, a framework with a different scope and timeframe. As a results, the outputs from this first workshop were used as a guiding step for the upcoming scenarios work, helping refine the methodology and, hence, the matrix outlining the four scenario overviews.

The connection and relevance for CIRAN from each of the analysed INTRAW 2050 Scenarios is summarised in the table below.

Table 6. Co-relation between INTRAW Future of Mining Scenarios for 2050 and CIRAN 2035 scenarios.

INTRAW 2050 Scenarios	Potential relevance for CIRAN 2035 scenarios
Scenario 1 Unexpected upheaval results in a huge societal disruption and pain, resulting in a progress evolution paradigm change, causing short- and mid-term drawbacks for several generations, yet bringing long-term benefits for humanity and planet.	• Heightened public justification for mining • Continued misinformation affecting social acceptance • Crisis-induced changes in public attitudes towards mining • Early education on mining and CRMs • Adoption of extraction technologies with minimal environmental impact • Improved EU policy alignment and focus on environmental and social issues • Possible adoption of a mix of bottom-up and top-down EU mining policies
Scenario 2 The world is divided into trade blocs, and while most developed nations reaped substantial economic growth and modernisation from the massive global push to rapidly transitioning energy systems during the 2030s, poorer countries lacking investment capital and technical capabilities struggle to catch up.	• Mining is still broadly not socially accepted • The EU will not produce much domestically, but will still need primary mining • There will be less raw materials consumption in countries and regions driven by economic growth, among which the EU • The EU will increase investment in the overall CRMs' value chain • Alignment of environmental with economic and social standards • The EU will include public consultation procedures in the decision-making on CRMs to improve its regulatory framework
Scenario 3 Geopolitical rivalries lead to the formation of self-contained trade blocs, causing a significant amount of market distortion through to 2050 to help a new set of producers enter the minerals sector as "competitive" producers at the expense of long-term economic growth.	• Environmental impacts will still harm the public perception of mining, leading to no societal acceptance • Better economic incentives for mining will help with its justification towards the public • The EU will invest in processing, substitution, and circular economy activities for what concerns CRMs (reducing the need for exploration or extraction within the EU) • High cost of energy and higher prices for CRMs • Mainly domestic production • There will be an improvement in resource management framework conditions (legal, regulatory, fiscal, contractual, etc.) • The EU might allow exploration and exploitation in environmentally protected areas, but only with underground methods and without causing hydro-geological issues

INTRAW 2050 Scenarios	Potential relevance for CIRAN 2035 scenarios
	• The EU might not be willing to sacrifice anything for CRMs – it prefers to sacrifice the security of CRMs supply itself • Less democratic decisions on CRMs • Mining policies will be a result of top-down decisions
Scenario 4 In the landscape of resource nationalism and trade restrictions, countries advance mining efforts amidst economic distress, leveraging tailored solutions based on regional needs. Sustainability takes a back seat to cost considerations, ultimately culminating in widespread opposition and unstable policies.	• Complete isolation to produce CRMs would not be realistic in this scenario • All materials will be critical compared to today as countries will not be able to produce them alone -Mining will be more justified as the extreme need for CRMs as much as possible, that will drive acceptance (survival, wealth, international cooperation, etc.) • Countries willing to give up some prosperity to guarantee supply of CRMs • The EU will have to invest more in exploration and substitution • General “Not In My BackYard” (NIMBY) approach to mining • The environment will be a secondary priority

It should be noted that the column “Potential relevance for CIRAN” lists the topics and ideas arising from the workshop discussions that could better be integrated into the CIRAN 2035 scenarios, acting as catalysts for CIRAN’s own narratives. Since these topics, ideas and opinions are derived directly from the INTRAW scenarios and translated into CIRAN’s perspective, certain statements go against the nature of the scenarios, or even contradict others for the same scenario. This is not seen as a problem, since they were just used to kickstart the ideation of the CIRAN 2035 scenarios.

3.3.2 First iteration of CIRAN 2035 scenarios

After the initial workshop with relevant data collection and processing, a selection of most important drivers/trends that could dictate scenario narratives was carried out. Drivers of Change were classified in a matrix with the following axes: “Degree of Importance” (1 to 10) vs. “Degree of Uncertainty” (1 to 10). Following similar work as previously carried out for the development of scenarios by the World Economic Forum, a special field entitled Critical uncertainties (highlighted in pink in *Figure 8*) was mapped. Within this field fall the drivers and trends that, while being important for the CIRAN framework goals and objectives, are also the most uncertain, and, thus, the best targets for driving scenario narratives.

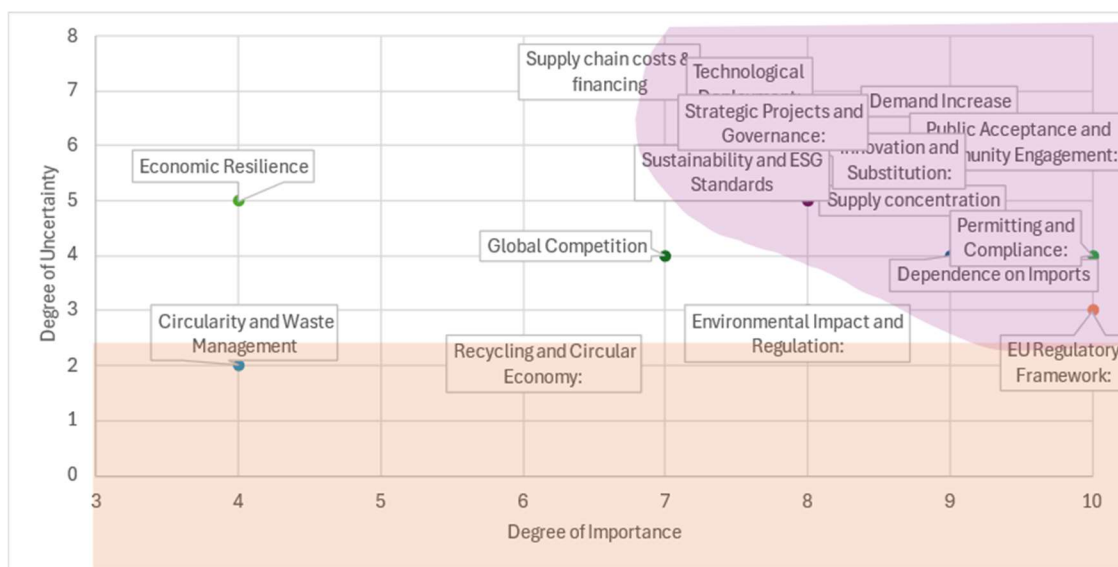


Figure 8. Selected Drivers of Change displayed in a matrix of two axes, by “Degree of Importance” vs. “Degree of Uncertainty”.

For the CIRAN 2035 scenarios’ development, it was decided to use a 2 x 2 scenario matrix formed by two axes that should represent highly critical and uncertain topics, which would help visualise the different scenarios and their narratives. For the first iteration, this choice was on “Governance, Permitting, Acceptance”, chosen for the horizontal axis, and “Change in CRMs and Needs” (i.e., qualitative and quantitative changes in CRM categories due to supply-demand shifts) for the vertical axis. Within “Governance, Permitting, and Acceptance”, topics such as the CRM Act implementation, permitting to mine in protected areas, and public acceptance or the Social License to Operate (SLO) were considered as driving factors. For the “Change in CRMs and Needs”, the drivers under consideration included technological development and internal/external access to CRMs through mining and recycling. After compiling the results from the Delphi Survey and the first scenarios’ workshop, a matrix was formed outlining the four scenario descriptions, included in Table 7 below.

Table 7. First iteration of the CIRAN 2035 scenarios.

Scenario 1: Agile trading	Scenario 2: Agile mining
A scenario where there are high change rates in CRM needs and demand expectations derived from the appearance and uptake of new technologies and societal behaviours, but where the EU has restricted access to supply within its borders due to lower levels of governance, public acceptance for mining activities and lack of trade agreements.	A context characterised by high rates of shifting CRM needs and demand expectations due to new technological advances (e.g. green energy). The EU has high and easy access to CRMs supply through exploration and exploitation of mineral resources, recycling of materials and products and by formalisation trade agreements with international partners.
Scenario 3: Accelerating Raw Materials diplomacy	Scenario 4: Mining renaissance
A scenario where technological innovations have not resulted in big changes for the use and	The slow uptake of new technologies has not created much change in CRM needs or demand expectations.

demand of CRMs, while at the same time the EU faces limited access to supply of CRMs within its borders, due to inefficient governance and high public opposition.	There is high public acceptance of mining and an efficient governance structure for the raw materials value chain, leading to increased mining operations happening within the EU.
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The first iteration of the CIRAN 2035 scenarios was then visualised (Figure 9) to enable internal dissemination to gather feedback and be subsequently adapted to determine the final iteration of the Scenarios.

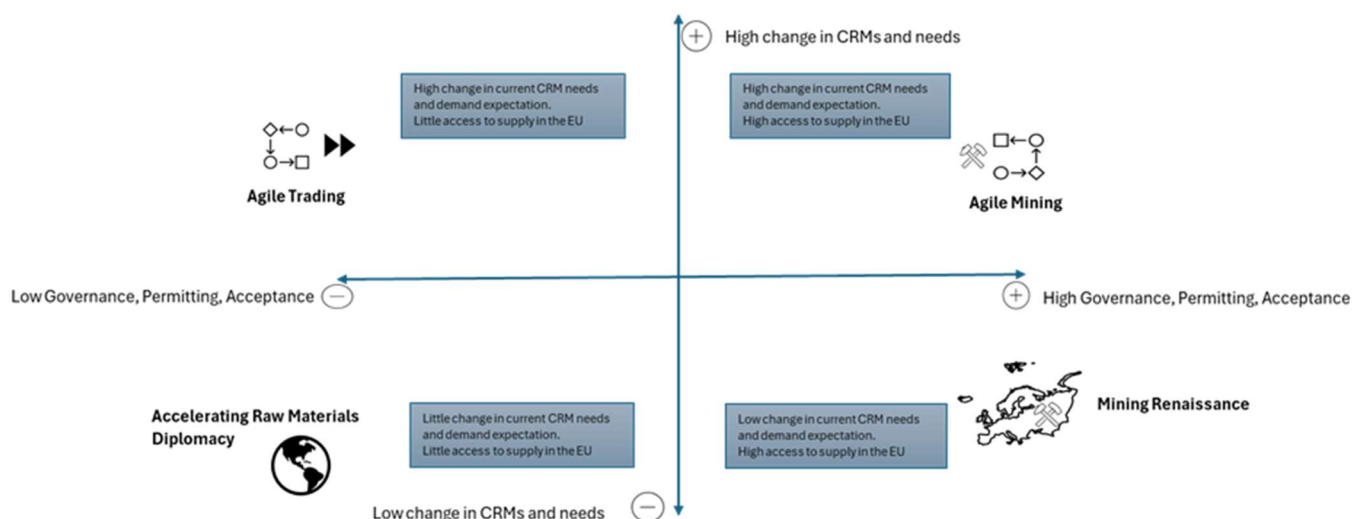


Figure 9. First iteration of the CIRAN 2035 scenarios.

3.3.3 Results from the second CIRAN Scenarios' workshop

The results from the first iteration of the CIRAN 2035 scenarios and the most relevant drivers of change were presented and offered for analysis and discussion by the experts during the second CIRAN Scenarios' workshop, held in the University of Turku (Finland), within the programme of the Futures' Conference in June 2024. In this workshop, experts held a relevant discussion on the pivotal drivers and the consequent axes chosen to structure the scenarios. This resulted in a fruitful debate, where diverse and critical points on the scenarios' division, the main axes, and the predominant respective drivers were collected.

Discussion topics raised included the EU CRMA as a regulatory framework for implementation; the Corporate and Societal Responsibility; the weight of the organised civil society and the relevance of accountability and transparency; consumer behaviour and awareness raising; supply chain stability and market demands; transition into a circular economy and the investment on and potential for recycling; Green Transition dynamics; resource equity, mining/land use rights and regulations; technological innovation and alternatives to current CRM uses and applications; geopolitical and national/EU security concerns. The collected insights from this discussion were the main focus points for the development of the following iteration of the CIRAN 2035 scenarios, as they summarised the nexus between CRMs, socio-economic, and environmental policymaking fields.

Overall, the following key take aways were identified as main contributors to the continuous process for scenario development:

- An integrated approach: addressing CRMs requires a multifaceted strategy involving regulation, technological innovation, and shifts in consumer behaviour and public opinion.
- Impact of regulatory frameworks: effective EU regulations can significantly influence demand and supply dynamics, potentially promoting more sustainable practices at both societal and industrial levels.
- Focus on circular economy: transitioning to a circular economic model offers potential for future investment in strategies including enhanced recycling, extended product lifespans, and eliminating new mining.
- Technological and behavioural innovation potential: continuous innovation in materials and encouraging adaptive consumer behaviour is critical for reducing dependency on scarce resources.

However, it is worth highlighting that the most important outcome of this second and final workshop of the CIRAN 2035 scenarios was a suggestion made by one of the experts, which resulted in a major structural transformation at the last stages of the scenarios' development process. Given that, at the time of the workshop, the EU CRM Act had been officially passed, it would have to be implemented by Member States in the near future. Hence, the "governance" criteria would not be as crucial for the future scenarios anymore as to be considered one of the key axes (i.e., horizontal one). Consequently, it was removed and replaced by another aspect capturing one of the trends currently influencing European (and global) politics: globalisation vs de-globalisation.

3.3.2 Final Iteration of CIRAN 2035 scenarios

Following the outputs of the second Scenarios' workshop, particularly in the view of the above-noted change in the horizontal axis of the matrix (i.e., substituting "Governance, Permitting, and Acceptance" with "degree of Globalisation"), a new 2 x 2 Scenarios' matrix was generated. This one considered as main axes the degree of or influence from Globalisation (on the horizontal axis) and Technology development (on the vertical one). These two key uncertainties are high impact drivers that can directly influence the direction of the future of CRM needs, which would thus lead to one or another Scenario. The visualisation of the final version of the CIRAN 2035 scenarios is provided in Figure 10.

Following the initial imagination of the scenarios, descriptions and narratives were developed. Each scenario is described following the same "recipe". First, a short summary outlines the main points of the scenario to set the stage and scope of its narrative and context. Then, the main drivers and trends are presented, while divided into several sub-clusters, linked to the political, environmental, social, technological, economic, and legal framework. In further points, a CRM Outlook offers insight into the shape of the CRM supply and demand trends, while policy guidelines are mentioned to address the evolution of the European scope towards 2035. Figure 11 details the descriptive elements used for the scenarios' narrative.

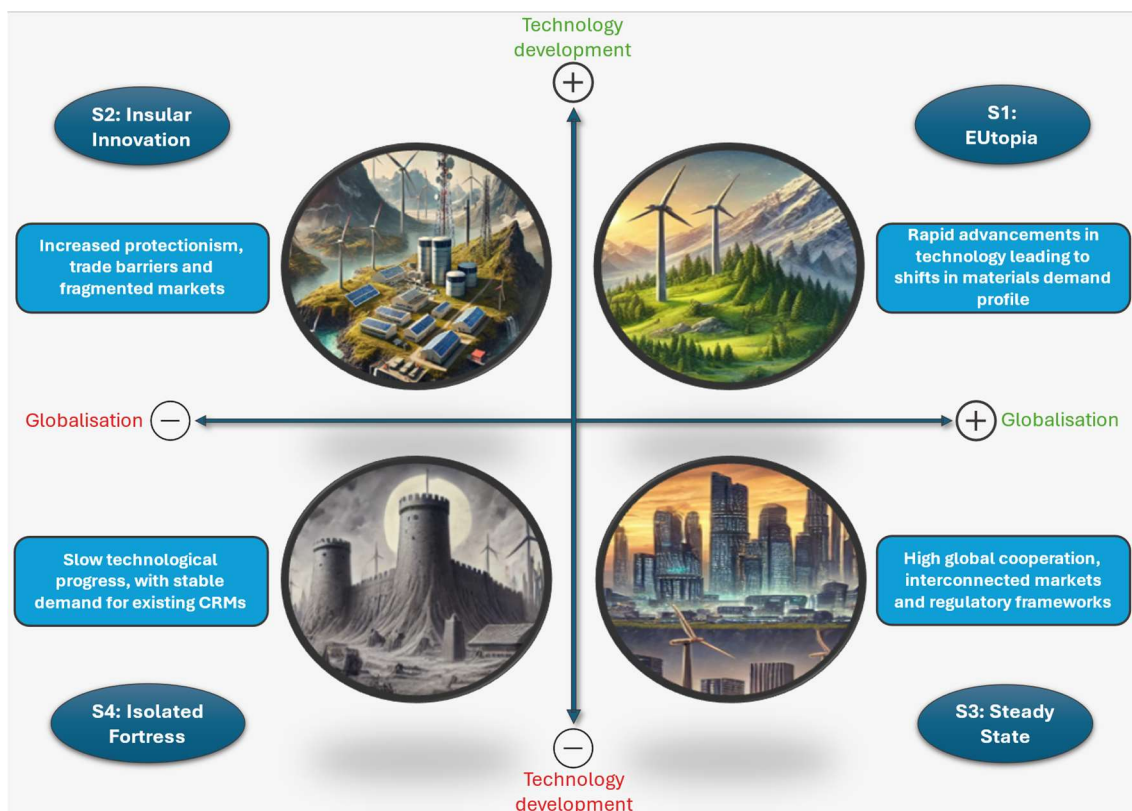


Figure 10. Final iteration of the CIRAN 2035 scenarios.



Figure 11. Guiding description lines for the development of the CIRAN 2035 scenarios narratives.

The thorough overview of the CIRAN 2035 scenarios can be found in Annex 1. In this section, the main outcomes are presented. Firstly, the main drivers of change identified for each of the two axes are described in Table 8 below.

Table 8. Descriptions of the axes in the CIRAN 2035 scenarios.

Horizontal axis	
De-globalisation (-) Increased protectionism, trade barriers or obstacles to market interconnection, fragmented sectors of the economy, and lower levels of institutional cooperation (i.e., within the same country rather than between countries), resulting in less harmonised regulatory frameworks and directives.	Globalisation (+) High global cooperation, more interconnected markets and supply webs, and aligned regulatory frameworks, including a higher international commitment to sustainable development and biodiversity preservation.
Vertical axis	
Technology Stagnation (-) Slow technological development, with steady progression on the demand profile for current CRMs.	Innovation-driven (+) Rapid advancements in the development of technology, particularly, those associated with the green transition and other technologies to various sectors of the society, lead to shifts in CRMs priorities and demand levels.

These axes define four distinct scenarios —EUtopia, Insular Innovation, Steady State, and Barren Fortress—, each presenting unique trajectories for CRM demand, policymaking, and market developments in a 2035 Europe. It is worth highlighting that each one of the Scenarios gives rise to different demands and pressures for accommodating CRM extraction in environmentally protected areas. As such, the scenario building process provides insights for the strategic assessments needed to ensure sustainable CRM value chains and outlines key uncertainties influencing the path towards realising the green and digital transitions at the core of the EU agenda. Tables 9 and 10 provide an overview of the structure of the Scenarios’ narratives and their short descriptions (see Annex 1 for the thorough overview).

Table 9. Outline of the CIRAN 2035 scenarios’ narratives.

1. Short summary
2. Drivers & Trends a. Dependence on imports b. Supply concentration c. Global competition d. Demand profile e. Supply Chains and financing f. Social Acceptance and Community Engagement g. Social Equity and Human Rights h. Workforce i. Innovation & Substitution j. Recycling and Circular Economy k. Rate of technology deployment l. Environmental m. EU Regulatory frameworks n. Permitting & Compliance o. Strategic Projects and Governance

Table 10. Short descriptions of the four CIRAN 2035 scenarios.

Scenario 1: EUtopia	Scenario 2: Insular Innovation
• A globally interconnected and cooperative world drives innovation in green and digital technologies. • Strong international agreements enable diversified and sustainable CRM supply chains. • Emphasis on recycling, circular economy practices, and international partnerships reduces the need for domestic mining in protected areas.	• Protectionist policies prioritise self-sufficiency and domestic innovation. • The EU invests heavily in domestic mining and recycling but faces high costs and supply chain inefficiencies. • Mining in protected areas becomes a contentious necessity for ensuring resource security.
Scenario 3: Steady State	Scenario 4: Barren Fortress
• Stable global trade relationships maintain existing CRM supply chains with incremental improvements. • Limited technological innovation results in steady CRM demand focused on traditional applications. • Minimal pressure for domestic mining, including in protected areas, due to stable demand.	• Increased protectionism and low technological advancement lead to resource scarcity and stagnation. • Dependence on domestic resources puts pressure on protected areas by mining, compromising environmental standards. • Fragmented policies and governance weaken CRM supply chain stability.

Furthermore, the main driving forces and aspects identified for each of the Scenarios are further summarised below, as they served as the stepping stones for the next methodological step, the definition of the “What-If” Case studies:

Scenario 1: EUtopia (Globalisation, Innovation-driven)
In this scenario, the world is highly interconnected and global cooperation is strong. Technological innovations resulting from new research areas lead to new material demands, impacting the existing raw materials landscape. The EU benefits from robust global supply chains, allowing it to cope with the changing demand profiles for the key raw materials needed. International agreements and globally-harmonised institutional frameworks ensure more sustainable business practices in the extractive industries and for other stakeholders, including producers and importers of CRMs. Governmental action in CRM market regulation is strong, fostering sustainable practices and resource security. National, regional, and local regulations are built based on international consensus. The role of organisations such as the UN and the EU is highly influential in global governance and policymaking, and these institutions are highly trusted by citizens, as there is also a general trust in local and national politics. This is highly correlated to the fact that Civil Society Organisations are active and strong, and operate through supra-national networks, collectively pushing for their shared demands on high environmental standards and sustainable mining practices. Another element explaining why citizens' trust in government and political institutions does not deteriorate is

Scenario 1: EUtopia (Globalisation, Innovation-driven)

due to moves towards more transparent and inclusive policy-making processes. CRMs hold a high priority on the political agenda, given their strategic importance for technological and economic development. The EU's trade policy is proactive, securing global supply chains and fostering international cooperation for shared knowledge, technology, and resources.

- This scenario is characterised by high innovation and a strong focus on energy transition technologies, such as renewable energy systems, electrified vehicles and industrial processes, and advanced digital infrastructure.
- There is strong global cooperation, with extensive trade agreements and a generally stable flow of CRMs from geographically diverse sets of producers in most cases.
- Due to the emphasis on environmental sustainability, coupled with a stable geopolitical landscape and trade flows of raw materials, mining in protected areas is of limited interest: focus is on innovation in recycling, circular economy practices, and global imports instead.
- Supply chains of CRMs such as lithium, cobalt, nickel, rare earth elements (REEs), copper, and graphite are under focus — as these are essential for green technologies such as batteries, wind turbines, and solar panels.

Scenario 2: Insular Innovation (De-globalisation, Innovation-driven)

Despite a trend towards de-globalisation and increased protectionism, technological innovation continues to advance rapidly. Technology is developed in-house, highly protected against other countries/blocks. The EU focuses on self-sufficiency, adapting to new materials demands driven by technological progress. However, the lack of global cooperation leads to fragmented markets and higher costs. Supply chain resilience is challenged, but the EU manages to innovate domestically to meet its critical raw material needs, allied with exploration and mining in new areas.

Governments are active in CRM market regulation, seeking self-sufficiency and support for local industries. Civil society organisations are active, advocating for local solutions and sustainability. Citizens' trust in government and political institutions is moderate, influenced by protectionist policies and local focus. CRMs hold a high priority on the political agenda due to the need for self-sufficiency and technological progress. The EU's trade policy tilts towards more protectionism, supporting local industries and reducing dependency on external sources. International cooperation is limited, focused on strategic partners and regional alliances.

- Despite de-globalisation, innovation within the EU continues to drive the development of green technologies, with a focus on self-sufficiency.
- The EU adopts a more insular approach, forming trade blocks with a limited number of trusted partners and emphasising local production.
- Due to the need for self-reliance and domestic sourcing, the EU may face pressure to exploit protected areas, though with advanced, more sustainable mining techniques.
- Through a combination of domestic mining, recycling, and limited trade agreements, the EU manages to secure its resources, though at potentially higher costs.
- Lithium, cobalt, rare earth elements (REEs), and possibly domestic-focused CRMs such as copper and aluminium would gain more attention.

Scenario 3: Steady State (Globalisation, Technology stagnation)

In this scenario, characterised by high globalisation and low technological innovation, the demand for raw materials currently considered 'critical' (CRMs) remains steady with relatively small changes over the next decade. Key materials such as copper, aluminium, and silicon, essential for established technologies including solar panels, wind turbines, and electrical infrastructure, will continue in their demand trajectories.

Global trade relationships play a crucial role in maintaining continued supply chains, with international cooperation ensuring a stable flow of CRMs from trusted global partners. Policy focus in this scenario is on maintaining and upgrading existing infrastructure, with incremental improvements in CRM usage and recycling. These policies work together to uphold sustainability and stability in supply chains, though they do not drive significant innovation or shifts in CRM demand.

- Technological innovation slows down, resulting in a reduced pace of new green technologies. The focus shifts to maintaining existing infrastructure development and industry adaptation.
- Global trade continues, with the EU relying on stable international relations and existing supply chains to meet its needs.
- With less pressure for resource extraction due to the slowdown in technological advancement, mining in protected areas is largely not needed.
- Stable global trade allows the EU to continue securing the CRMs it needs, although at a stable but non-expanding rate.
- Aluminium, copper, and other traditional metals used in more mature applications would still be in the spotlight.

Scenario 4: Barren Fortress (De-globalisation, Technology stagnation)

In this scenario, both globalisation and technological innovation are limited. The EU faces significant challenges in securing critical raw materials due to increased protectionism. Extraction in protected areas becomes more contentious as traditional methods lead to higher environmental impacts. The focus shifts to local solutions and circular economy practices, but progress is slow, and demand pressures remain high.

Governments are active in CRM market regulation, supporting local production and self-sufficiency. Civil society organisations advocate for sustainability and local solutions. Citizens' trust in government and political institutions is moderate, influenced by protectionist policies and local focus. CRMs hold a high priority on the political agenda to ensure local self-sufficiency and resource security. The EU's trade policy aims at reducing dependency on external sources. International cooperation is limited, focused on regional and strategic partnerships.

- With both de-globalisation and technological stagnation, there is minimal development of new green technologies, and existing technologies are maintained without significant advancement.
- The world becomes more fragmented, with the EU relying on limited, possibly unstable trade relationships and is struggling with self-sufficiency.
- The EU, facing resource scarcity, might be forced to mine in protected areas, compromising environmental standards to secure basic materials, also facing societal opposition.
- Due to limited trade and insufficient domestic supply, the EU faces significant challenges in securing necessary CRMs, leading to potential resource shortages.
- Basic metals such as iron, aluminium, and possibly some copper, with reduced need for CRMs such as lithium and cobalt due to stagnation in technology-driven industries.

Finally, coupled with the development of the four scenarios, two other main results were obtained. Firstly, an assessment of the demand for CRMs in each scenario. Secondly, a set of strategic actions designed to guarantee a sustainable and secure supply of CRMs in Europe. Consequently, the demand for CRMs is expected to vary across the four scenarios, driven by the interplay of globalisation, de-globalisation, technological innovation, and stagnation (Figure 12). Concretely, metals such as lithium, cobalt, and rare earth elements (REEs) exhibit high demand in innovation-driven scenarios (e.g., EUtopia), where green and digital transitions accelerate. Conversely, in technology-stagnant or protectionist scenarios (e.g., Barren Fortress), demand shifts to traditionally used materials such as aluminium and copper, reflecting reduced technological and industrial activity. Each scenario highlights the evolving priorities for CRMs, based on drivers such as value-chain dynamics, technological progress, and policy decisions.

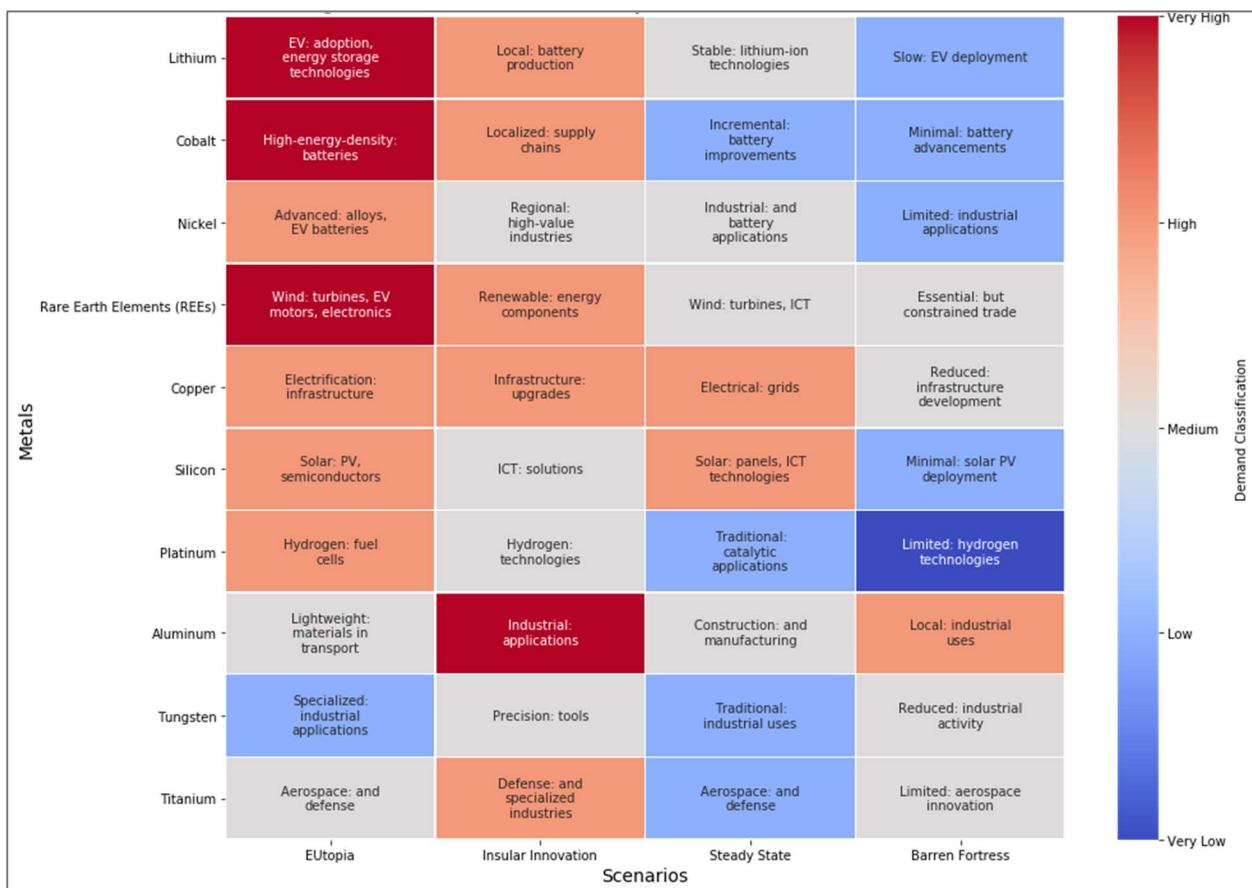


Figure 12. Demand of several mineral raw materials under different CIRAN 2035 scenarios.

To ensure a sustainable and secure supply of critical raw materials, strategic actions must address the complex interplay of global cooperation and technological advancements. Recommendations should align policy, innovation, and governance with the demands of the green and digital transitions while mitigating environmental and social challenges. By tailoring actions with consideration to different scenarios, the EU can build resilience in its CRM supply chains and maintain its competitive edge in a rapidly evolving global landscape. Several options of recommended strategic actions include:

- Accelerate investments in research and development for alternative materials and recycling technologies.
- Strengthen circular economy frameworks to reduce dependency on primary extraction.

- Streamline permitting processes for mining projects, balancing environmental protection with resource needs.
- Enhance international collaboration in globalisation-driven scenarios and regional integration in protectionist settings.
- Foster societal engagement and equitable distribution of benefits to maintain public support and trust.

To conclude, as this section has elucidated, the CIRAN 2035 scenarios offer an insight into possible futures that can help policymaking, industry leaders, and civil society navigate uncertainties and thus prepare for the evolving CRM landscape in Europe. Hence, they provide linkages between policy decisions and a range of possible states, in order to adapt to or influence potential futures.

3.4 DPSIR framework

The DPSIR framework was used against the four CIRAN 2035 scenarios, leading to the identification of the main Drivers, Pressures, States, Impacts, and Responses dictating the development of those scenario perspectives. Such a framework shows light onto how current uncertainties, depending on the way they are resolved, can impact policymaking and permitting in a future perspective. Results of this analysis are provided in Table 11 below, with DPSIR elements mapped and described for each CIRAN Scenario.

Table 11. DPSIR framework applied to the CIRAN 2035 scenarios, by scenario.

Scenario 1: EUtopia	
DPSIR element	Description
Driver	Global cooperation and innovation-driven policies prioritising rapid decarbonisation and digitalisation efforts.
Pressure	High demand for CRMs such as lithium, cobalt, REEs, and copper driven by green technologies (e.g., EVs, wind turbines, solar panels). Mounting pressure on recycling and circular economy efficiency initiatives.
State	Diversified global supply chains, increased domestic production, improved recycling capabilities, and strong reliance on international partnerships. Supply concentration risk is on average alleviated due to diversified imports from key regions such as Africa, Canada, Latin America, and Australia.
Impact	Enhanced resource security and reduced reliance on China, but challenges persist in financing innovations, managing ESG compliance, and mitigating environmental impacts of CRM extraction.
Response	Investments in R&D for substitution technologies, strong international trade agreements, and streamlined permitting processes ensure a steady CRM supply. Emphasis on ESG standards and transparent community engagement bolsters public trust.

Scenario 2: Insular Innovation	
DPSIR element	Description
Driver	Protectionist policies oriented at reducing reliance on external suppliers, emphasising domestic innovation.
Pressure	Increased demand for domestic CRMs and pressure to explore protected areas. High operational costs due to limited trade diversification and rising energy prices.
State	Concentrated supply chains within the EU, with dependence on mining regions such as Scandinavia and the Iberian Peninsula. While recycling is set to become a cornerstone of resource management, it is limited by availability of feedstock supply.
Impact	Potential resource bottlenecks within EU member states, limited market influence globally, and growing societal resistance to mining in sensitive areas.
Response	Regional policies focus on innovation in material substitution, recycling and low-impact mining technologies. Strategic projects and public-private partnerships to address supply challenges, but at higher costs and with significant environmental trade-offs.
Scenario 3: Steady State	
DPSIR element	Description
Driver	Incremental technological advancements supported by stable global trade relationships and moderate green transition ambitions.
Pressure	Moderate and steady demand for CRMs such as copper, aluminum, and silicon for existing infrastructure like solar panels and wind turbines.
State	Continued reliance on imports from established trade partners (e.g., China, Australia, Africa), with slow progress in recycling and diversification of CRM sources.
Impact	Dependence on concentrated supply chains remains a key vulnerability. Limited innovation prevents significant cost reductions or breakthroughs in recycling efficiency.
Response	Policies focus on maintaining existing trade agreements, stabilizing CRM prices, and enhancing recycling systems incrementally. ESG and traceability initiatives are supported but evolve slowly.
Scenario 4: Barren Fortress	
DPSIR element	Description
Driver	Protectionist policies combined with slow technological progress and limited global cooperation.
Pressure	Stagnant raw materials demand due to limited development of energy transition technologies, but increased pressure on domestic resources due to restricted access to global markets.
State	Isolated supply chains reliant on domestic production and recycling, with high supply concentration and inefficiencies. Vulnerabilities in specific parts of the value chain become more pronounced.
Impact	Severed supply constraints, rising production costs, environmental degradation risks from domestic mining, and societal resistance to CRM extraction in protected areas.
Response	Relaxation of permitting standards in protected areas but limited investment, resulting in a resource-constrained and less competitive EU market.

To conclude, it is worth outlining certain aspects highlighted by the DPSIR framework for the CIRAN 2035 scenarios:

- Globalised scenarios (i.e., EUtopia, Steady State), where high global cooperation, interconnected markets, and aligned regulatory frameworks supporting sustainable development and biodiversity preservation are seen, present broader supply chains and diversified imports.
- De-globalised scenarios (Insular Innovation, Isolated Fortress), where protectionism, fragmented economies, trade barriers, and limited international cooperation, leading to less harmonised policies

and market isolation, are seen) face resource bottlenecks and greater dependence on domestic CRMs.

- Innovation-driven scenarios ((EUtopia, Insular Innovation)), where there is innovations, particularly in green and digital sectors, with a shift in CRM priorities and demand, require accelerated technological advancements and robust recycling systems.
- Technology stagnant scenarios (Steady State, Isolated Fortress), where there is slow development, experience steady or reduced raw materials demand, minimizing pressure on supply chains.
- Scenarios with strong global cooperation (EUtopia, Steady State) benefit from trade agreements and ESG initiatives
- Protectionist scenarios (Insular Innovation, Isolated Fortress) rely heavily on domestic solutions, often at higher costs and environmental trade-offs.

4 Nexus between policy decisions and drivers of change

The nexus between policy decisions and Drivers of Change³ relates to the adapting relationship where the selection and implementation of certain policies/actions is directly influenced by, and influences, drivers and trends shaping political, economic, social, technological, environmental and legal aspects. In the case of CIRAN, these are looked at through the lens of the shifting CRM needs, and the project's objective to propose a framework that would permit mining in environmentally protected areas, if a sufficient justification (caused e.g., by overarching policy decisions), can be put forward.

The interaction between chosen policies and the drivers of change creates a feedback loop where policy responses to regional and global challenges such as climate change, resource scarcity, technological disruption, trade barriers, raw materials needs, and other factors, drive systemic change, while emerging trends drive policy-makers to adapt their approaches to address them. This feedback loop between policies and drivers of change can be set in three principles:

1. Policies are often the catalysts, accelerating transitions in energy supply, technology, or industry.
2. Policymakers respond with policy formulation as technological, geopolitical, or economic realities shift.
3. Policies might lag behind or conflict with emerging drivers of change.

The results obtained with the help of the foresight methods present a complex connection between drivers of change in, or affecting, the raw materials' sector and the policy decisions made to address these trends. This is even more noticeable in the case of certain (mineral) raw materials for which the use is considered 'critical', for instance, in technological developments linked to the green transition. This and other drivers of change will require policy decisions, that could include, among others, exploration and mining activities in environmentally protected areas. Furthermore, any chosen policy can have impacts on the demand and supply sides of CRMs.

Several Drivers of Change and their possible influence in the world of mineral raw materials were studied against the backdrop of the four CIRAN 2035 scenarios developed. Depending on the specific drivers of change dictating the development of the scenario under consideration, several policy decisions can be introduced to ensure the supply of CRMs.

The demand for CRM materials is expected to vary across the four scenarios, driven by the interplay of globalisation, de-globalisation, technological innovation, and technology stagnation. Metals such as lithium, cobalt, and rare earth elements exhibit high demand in current innovation-driven scenarios (e.g., EUtopia), where green and digital transitions are assumed to accelerate. Conversely, in technology-stagnant or protectionist scenarios (e.g., Isolated Fortress), demand shifts to basic materials such as aluminium and copper, reflecting reduced technological and industrial activity. Each scenario highlights the evolving priorities for CRMs based on supply chain dynamics, technological progress, and policy choices.

As a general approach, it was found that there are actions that can be taken to address the risk of certain mineral raw materials deemed critical becoming exposed to supply risks:

³ For CIRAN, the Drivers of Change are seen as trends and influencing forces that might dictate the development of the CRM fields in one way or another, depending on how they evolve.

- Accelerate investments in R&D for alternative materials and recycling technologies.
- Strengthen circular economy frameworks to reduce dependency on primary extraction (long-term).
- Streamline permitting processes for mining projects, balancing environmental protection with resource needs.
- Enhance international collaboration in globalisation-driven scenarios and regional integration in protectionist settings.
- Foster societal engagement and equitable distribution of benefits to maintain public support and trust.

More specifically, each scenario entails a set of dedicated policy decisions, that aim at best addressing the particular scenario. These are detailed below:

Scenario 1: EUtopia

- EUtopia prioritises substantial investments in research and development (R&D) to drive technological innovation, particularly in CRM-intensive sectors such as renewable energy, digital technologies, and advanced manufacturing.
- High R&D spending accelerates the development of new technologies. These innovations mitigate the risks associated with high CRM demand by enabling more efficient use of resources and reducing reliance on imports.
- Policies are directed towards maintaining and expanding global trade agreements to secure diversified CRM supply chains. This aligns with the consensus on the need to mitigate geopolitical risks, particularly those associated with China's dominance in the CRM market.
- Through active global engagement, the EU secures access to a broad range of CRM sources, reducing the vulnerability of its supply chains. This policy approach also includes establishing strategic partnerships with resource-rich countries and investing in international mining projects.
- Strong emphasis on ESG standards in both domestic and international CRM projects. By enforcing stringent ESG criteria, the EU positions itself as a leader in sustainable resource management, which also helps to avoid the social and environmental impacts often associated with past mining activities. This approach supports long-term sustainability and public support for CRM-related initiatives.
- Policies heavily favour a circular economy, with a significant focus on research and development for recycling technologies and encouraging the reuse of CRMs. This is supported by the consensus on the importance of a circular economy in reducing CRM supply risks, while also possibly reducing demand for CRM extraction from environmentally protected areas.

Scenario 2: Insular Innovation

- Significant attention is directed to developing domestic CRM resources. This includes incentives for local mining, exploration in protected areas, and support for domestic processing facilities, reflecting the divergence in emphasis on domestic sourcing versus global supply chains.
- Policies are directed towards innovations that improve resource efficiency and reduce waste. This includes developing advanced recycling technologies and finding substitutes for critical materials, consistent with the consensus on innovation as a tool for reducing CRM dependencies.
- These policies ensure that, despite limited access to global supply chains, the EU remains competitive by optimising the use of available resources. The focus on efficiency and sustainability helps to mitigate the environmental impact of increased domestic mining.

- Policies are crafted to protect domestic industries, including tariffs on imported CRMs and restrictions on foreign ownership in the mining sector. This reflects the divergence from a globalised approach, focusing instead on insulating the domestic market from external shocks.
 - While these protectionist measures help secure domestic industries, they could also lead to higher costs and inefficiencies, potentially making European CRMs less competitive on the global market. This approach may also strain international relations, particularly with countries that export CRMs.
- Governments actively collaborate with private companies to drive innovation and resource development within the EU. Policies support public-private partnerships (PPPs) in areas such as CRM extraction, processing, and recycling, reflecting the consensus on the importance of collaboration for achieving innovation-driven goals.
 - By fostering strong partnerships between the public and private sectors, the EU can pool resources and expertise to overcome the challenges posed by limited global engagement. This approach is critical for maintaining technological leadership while adhering to the scenario's insular focus.

Scenario 3: Steady State

- In this scenario, policies are directed towards maintaining and slightly expanding existing global trade agreements. The consensus on the importance of diversified supply chains is less pressing here, as technological stagnation reduces the need for aggressive CRM sourcing strategies. The EU ensures a consistent supply of CRMs such as copper, rare earths, vanadium, and PGMs. However, the lack of new trade initiatives could make the EU vulnerable to shifts in global markets or geopolitical tensions.
- R&D for new CRM-dependent technologies is limited. The EU continues to rely on established technologies and supply chains, with lower impetus to develop new solutions or reduce CRM consumption through innovation.
- Policies are geared towards supporting traditional industries, which remain the backbone of the economy in this scenario. This includes subsidies for sectors such as construction and manufacturing, which have steady but not increasing CRM needs.
- Environmental policies are maintained but not significantly strengthened. The consensus on the importance of ESG is acknowledged but not expanded upon, reflecting a conservative approach to regulation in this scenario. The stability of environmental regulations provides predictability for industries but may also limit progress in sustainability. The lack of strong enforcement of ESG policies could result in slower adoption of environmentally friendly practices in CRM extraction and processing, hence not necessarily limiting the extraction of CRMs from EPAs.

Scenario 4: Barren Fortress

- Policies are heavily focused on self-sufficiency, with economic resources allocated to maximising domestic mineral production and minimising imports, thus aiming to prevent any minerals from becoming 'critical'. This reflects a divergence from global engagement, with a strong emphasis on insulating the EU from global market volatility. The drive for self-sufficiency leads to extensive domestic mining pressure, potentially in environmentally sensitive areas. However, without innovation, these efforts may be inefficient, leading to higher costs and greater environmental degradation.

- Lack of innovation results in a static economy where traditional industries dominate, and CRM consumption remains steady and muted. The absence of available end-of-life products and materials as well as new technologies exacerbates resource inefficiencies and environmental impacts.
- Isolationist policies dominate, with high tariffs on imported goods and strict controls on foreign investment. These policies diverge from the global trade and diversification strategies seen in other scenarios. The approach leads to reduced access to global CRMs, further straining domestic resources. This could lead to resource shortages, economic decline, and increased reliance on environmentally damaging mining practices.
- Environmental and social governance regulations are weak or selectively enforced, reflecting a divergence from the ESG consensus seen in other countries outside of Europe. Policies may prioritise economic survival over environmental protection. Weak implementation of regulations results in significant environmental degradation, particularly as domestic mining expands into protected areas. This could lead to long-term ecological damage and social unrest, exacerbating the challenges faced by the EU in this scenario.

To conclude, the DPSIR framework applied to the CIRAN 2035 scenarios further extends the understanding of the connection between policy decisions and drivers of change. In a scenario determined by high global cooperation and innovation trends, policies focus on investments in R&D for substitution and recycling technologies, strong international trade agreements, and streamlined permitting processes. On the other hand, in a scenario where the main drivers are the incremental technological advancements supported by stable global trade relationships and moderate green transition ambitions, policies are put in place to maintain existing trade agreements, stabilising CRM costs, and enhancing recycling systems incrementally.

The scenarios – and their policies to address CRM needs – elucidate how different policies can evolve and adapt to different societal needs. Furthermore, it is also demonstrated that policies can –and should– address several drivers of change at the same time and that global challenges are better addressed by coordinated international policies. Lastly, the use of the selected foresight tools, and especially the development of the CIRAN 2035 scenarios, highlights the importance of anticipating trends and drivers for improved future policymaking; that is, acting now can help prevent and mitigate potential risks and effectively use present and upcoming opportunities.

5 Summary and conclusions

The objective of the EU-funded CIRAN project is to study the complex interconnections between the needs in Critical Raw Materials (CRMs) value chains and Europe's ambition to secure their supply within its territorial boundaries, without compromising environmental protection guidelines and regulations; that is, exploring whether Europe can rapidly achieve CRM autonomy as expressed by the CRM Act (EC, 2023) in order to accelerate the policy priorities related to the green and digital transitions, while ensuring its compliance with its own regulatory framework on environmental protection and biodiversity preservation (e.g., Nature Restoration Law, Birds Directive, Water Directive...). Within this context, this Deliverable has aimed at providing a thorough examination of the nexus between policy objectives and their consecutive decisions and the environmental and societal vulnerabilities affected by them. Concretely, it has connected the current state of the art with four possible futures, designed in the form of the CIRAN 2035 scenarios.

The methodological approach followed has encompassed techniques like Horizon Scanning, Delphi Survey, Scenarios-building, a framework for What-If analysis coupled with gaming elements and DPSIR-based frameworks. This has enabled a better understanding of the connection between drivers of change in the and/or affecting the raw materials' sector and their related policy formulations, especially the ones taken by the EU to address its CRM agenda priorities. As a first conclusion, it is worth noting that the world is changing, and so are the needs and priorities to effectively address the CRM sector and related policy formulations. This has been elucidated by the research on the current state of the art, and further highlighted by the results of the foresight exercises implemented. As such, the Horizon Scanning method led to the creation of 17 main Drivers of Change impacting and changing the world of raw materials, divided in six main clusters. Moreover, the Delphi Survey collected and made sense of the opinions and views of stakeholders from various fields on relevant questions examined in CIRAN. Finally, the CIRAN 2035 scenarios paint four pictures of potential futures, while the "What-If" framework for upcoming community engagement opportunities, and the DPSIR framework developed based on the Scenarios allow a further understanding of the connections between drivers, trends, and policy formulations.

Throughout the exercises and interactions with experts, several elements that can potentially explain and justify mining beneath protected areas in Europe and their respective root causes, were identified. The highlights include elements from the political, economic, technological, environmental, and social perspectives and can be summarised in Table 12 below.

Table 12. Identified justifications to mining in environmentally protected areas, by dimension, driver, and cause.

Political dimension	
Element	Justification
Geopolitical considerations and strategic resource independence	• Driver: Over-reliance on the import of raw materials from third countries, which often have lower environmental and social standards. The EU (like other countries in the world) is starting to prioritise the domestic production of critical raw materials due to disruptions in supply chains (e.g. through the CRMA). • Imperative: Domestic exploration and mining of critical mineral resources in environmentally protected areas increases localisation of the supply chain,

	improves supply chain resilience and reduces dependency on imports from other countries.
Global competition	• Driver: The EU wants to lead and be a flagship in technological advancements in high-end industries such as semiconductors, green energy, and advanced manufacturing. • Imperative: Mineral resources are needed for the development of these technologies, and only by acquiring them, can the EU become more sovereign in technological dominance.
Economic dimension	
Element	Justification
Access to CRMs and market demand for green technologies	• Driver: Increasing demand for raw materials for green technologies (e.g. renewable energy), electronics, defense industry and electrification of society. Several raw materials are linked to these, including rare earth elements, lithium and cobalt. • Imperative: Environmentally protected areas are in or near high-value raw materials resources that are essential for achieving energy transition and technological advancements.
Cost of CRMs	• Driver: Raising costs for critical raw materials imports • Imperative: Localising raw materials supply chains to reduce costs.
Economic growth	• Driver: High value of raw materials value chains, that can be more localized to extend economic benefits, with an important share on GDP of a country/region. • Imperative: Exploration and mining projects, and to a certain extent processing and recycling activities, provide local and regional employment, stimulating local, regional and supra-regional economic development.
Social dimension	
Element	Justification
Local community benefits (e.g., job creation)	• Driver: Improving local communities socio-economic standards, in cases where communities face limited economic opportunities. • Imperative: Development of mining-related activities translates into infrastructure development, healthcare, education, socio-cultural and economic opportunities.
Technological dimension	
Element	Justification
Low-Impact mining innovations (e.g. precision mining, robotisation and automation)	• Driver: Research and Development of environmentally friendly mining technologies to obtain raw materials, while limiting environmental and human impacts, through the use of advanced robotics, automated drilling or AI technologies. • Imperative: Innovative mining technologies reduce environmental footprint, enabling mining in environmentally protected areas to occur without significant environmental degradation.

Resource extraction optimisation	• Driver: Innovative mining technologies obtain raw materials with enhanced performance, making mining operations viable in environmentally protected areas. • Imperative: Access to environmentally protected areas is feasible with the use of innovative mining technologies that focus on optimising raw materials extraction.
Lacking substitution and recycling outputs	• Driver: Certain minerals required for green technologies either have no viable alternatives or recycling technology and capacity does not meet demand. • Imperative: Raw materials found in or near environmentally protected areas are essential to meet demand.
Environmental dimension	
Element	Justification
Decarbonisation and clean energy goals	• Driver: The need to combat climate change, reduce CO2 emissions and meet decarbonisation and energy goals, requires raw materials for several technologies. • Imperative: Environmentally protected areas (or areas near them) host critical raw materials resources that are essential for technologies that help meet the decarbonisation and energy goals.
Context-specific elements	
Element	Justification
Geological uniqueness	• Driver: Environmentally protected areas can host raw materials that are essential, that are rare and not easily available in other areas. • Imperative: Environmentally protected areas are the only feasible solution to obtain specific raw materials.

Furthermore, responses to these drivers and imperatives for mining in protected areas can appear in the form of low-impact mining technologies, accountable Environmental Impact Assessments, effective restoration post-mining activities, high-level continuous engagement of local communities including in decision-making and benefit-sharing models, creation of new areas of biodiversity preservation, and development and implementation of strong legal protocols that clearly demonstrate the imperative for mining in environmentally protected areas and its consequences as a whole, including how they will be effectively mitigated and by whom, before any potential activity is conducted in such regions.

In terms of technology trajectories, several pathways are open, considering the different technological needs of the CIRAN 2035 scenarios. Analysis on the raw materials and their use in several technological areas demonstrates that the most relevant CRMs for the near future are aluminium/bauxite, copper, REEs and lithium, followed by cobalt, silicon metal, nickel, and titanium metal. On the other side of the spectrum, tungsten and platinum group metals are deemed as less relevant for technological implementation, particularly in line with both green and digital transition priorities. Such conclusion can be extracted from an

overall look at the demands portrayed by the CIRAN 2035 scenarios. For each case scenario, the concrete expected demand shifts in CRMs are outlined below:

- For the **EUtopia** scenario demand will fall heavily in lithium (e.g. energy storage for electrification), cobalt (used as a high-energy density element in batteries), REEs (used in wind turbines, electric vehicles and electronics industries), nickel (also used in batteries for electrical vehicles as well as for alloys for several industries), copper (used for several infrastructures used in electrification), silicon (important element for semiconductors and photovoltaics) and platinum (relevant for the development of fuel cells).
- **Insular Innovation** is a scenario where the demand is similar to Eutopia for lithium, cobalt, REEs and copper, although with different goals. Lithium and cobalt will be necessary for local battery production and localised supply chains, REEs used for several energy components in renewables and copper used for upgrading the several infrastructure pieces towards electrification. Then, aluminium becomes highly relevant for industrial applications and titanium for defence and other specialised industries.
- The **Steady State** scenario shows a high demand for two materials, copper and silicon metal. The first needed for the electrification of the energy grid, the second used for solar panels and ICT technologies. Then, medium demand is mapped for lithium (battery technology), nickel (industrial and battery applications), REEs (wind turbines, ICT technologies) and aluminium (used for construction and manufacturing).
- The **Barren Fortress** scenario sees overall different demand needs for critical raw materials. There is high demand for aluminium, mainly used for local industries, and moderate demand for REEs (essential, but faces constrained trade), copper (used for infrastructure development), tungsten (used for several industrial activities) and titanium (used in aerospace).

Hence, after this thorough overview, it should be noted that exploration and mining activities in environmentally protected areas can become a reality due to presented drivers and their imperatives. At the same, EU-localised raw materials supply chains advanced on aluminium/bauxite, copper, REEs and lithium, followed by cobalt, silicon metal, nickel and titanium metal, are the best bets if CRM extraction is necessary and is to be allowed, considering relevant drivers, in protected zones. These CRMs will be necessary to advance technological advancements in areas such as electrification of the society (e.g. electrical vehicles, infrastructure), energy storage (e.g. batteries), renewables (e.g. wind turbines, solar panels), electronics (e.g. ICT technologies, semiconductors), fuel cells, defence, aerospace and other specialised industries.

Overall, mining-related activities in environmentally protected areas remains a hot topic to be discussed by all stakeholders. While it is inherently controversial – as is most of the mining activities – there is no denying on the drivers and needs for mining of critical raw materials. The DPSIR framework structure shows that there exist relevant drivers, but that need to be well assessed through their pressures and impacts, to create robust responses to meet socio-environmental and economic needs.

Lastly, it has been shown how different policies can evolve and adapt to different societal needs. It was also demonstrated that policy implementation can – and should – address several drivers of change at the same time and that global challenges are better addressed by coordinated international policies, whenever possible. The use of the foresight-adapted tools, and especially the CIRAN 2035 scenarios, also showcases

the power of anticipating trends and drivers – acting now can help to mitigate risks and make use of opportunities.

To conclude, the work developed results in a middle ground of objective and subjective analysis, deriving from the nature of the methodological steps used. It is necessary to understand then, that all the methodological steps could provide different results, if they were implemented with another focus. This is especially relevant for the outcome of the four CIRAN 2035 scenarios, which are highly dependent on collected information. Furthermore, it must be stressed that the scenarios (and none of the other techniques for that matter) try to predict the future. These just offer possible considerations for the future of raw materials and how policy formulations might affect them.

6 References

- ACCA Global (2016). 50 drivers of change in the public sector. Accessed at: https://www.accaglobal.com/content/dam/ACCA_Global/Technical/Future/drivers-of-change-in-the-public-sector.pdf
- Aguilar Hernandez, G. A., Kleijn, E. G. M., Mancheri, N., Loibl, A., & Tercero, L. (2022). D7. 2. Sectors with highest CRM demand growth potential: a review of future critical raw material demand in 11 key technologies for transport, energy, electronics and telecommunication sectors. *D7. 2. Sectors with highest CRM demand growth potential: a review of future critical raw material demand in 11 key technologies for transport, energy, electronics and telecommunication sectors*.
- Amer, M., Daim, T. U., & Jetter, A. (2013). A review of scenario planning. *Futures*, 46, 23-40.
- Bertrand, G., Eilu, P., & Paulick, H. Potential primary CRM supply from EU sources.
- Blengini, G. A., El Latunussa, C., Eynard, U., De Matos, C. T., Wittmer, D. M. A. G., Georgitzikis, K., ... & Pennington, D. W. (2020). *Study on the EU's list of critical raw materials (2020)*. Publications Office of the European Union.
- Bobba, S.; Carrara, S.; Huisman, J.; Mathieux, F.; Pavel, C. (2020). *Critical raw materials for strategic technologies and sectors in the EU. A Foresight Study*.
- Carrara, S., Bobba, S., Blagoeva, D., Dias, P. A., Cavalli, A., Georgitzikis, K., ... & Christou, M. (2023). *Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU: A foresight study*. Luxembourg: Publications Office of the European Union.
- Correia, V.; Keane, C.; Komac, M.; Oysul, Z.; Wulf, A.; Woodring, D.; Schuele, S. (2024). *Future Mining Scenarios*. Brussels: INTRAW and SAFE. DOI: 10.5281/zenodo.13238689, p. 38.
- Cuhls, K. E. (2020). *Horizon Scanning in Foresight—Why Horizon Scanning is only a part of the game*. *Futures & Foresight Science*, 2(1), e23.
- Dean, M. (2019). Scenario planning: A literature review. *A report of project*, (769276-2).
- Draghi, M. (2024). The future of European competitiveness – A competitiveness strategy for Europe.
- EC (2018). *Report on critical raw materials and the circular economy*, Publications Office, 2018, <https://data.europa.eu/doi/10.2873/167813>
- European Commission (2020). Communication and roadmap on the European Green Deal.
- European Commission (2020) *Communication from the Commission to the European Parliament, the council the European Economic and Social Committee of the Regions. EU Biodiversity Strategy for 2030: Bringing nature back into our lives*. Brussels, 20.5.2020 COM(2020) 380 final. Available at: https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en
- European Commission (2020). Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability.
- European Commission (2022). REPowerEU. In: European Commission – European Commission. https://commission.europa.eu/publications/key-documents-repower.eu_en.
- European Commission (2023). European Critical Raw Materials Act. In: European Commission - European Commission. https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1661.

- European Commission (2023). Regulation (EU) 2023/1542 of the European Parliament and of the Council. Official Journal of the European Union.
- European Commission (2024a). *Biodiversity Strategy for 2030*. Available at: https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en
- European Commission (2024b). *Degraded ecosystems to be restored across Europe as Nature Restoration Law enters into force*. Directorate-General for Environment. Available at: https://environment.ec.europa.eu/news/nature-restoration-law-enters-force-2024-08-15_en
- European Commission (2024c). *The European Green Deal: Striving to be the first climate neutral continent*. Available at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en
- European Defence Agency (2023). *Impacts of climate change on defence-related critical energy infrastructure*.
- European Environment Agency (2020). *Drivers of change of relevance for Europe's Environment and Sustainability*.
- Girardi, B., Patrahau, I., Cisco, G., & Rademaker, M. (2023). *Strategic Raw Materials for Defence: Mapping European Industry Needs*. Hague Centre for Strategic Studies (HCSS).
- Grohol, M., & Veeh, C. (2023). *Study on the Critical Raw Materials for the EU 2023*. Publications Office of the European Union.
- Hines, A.; Bengston, D. N.; Dockry, M. J.; Cowart, A. (2018). *Setting up a horizon scanning system: A US federal agency example*. World Futures Review, 10(2), 136-151.
- Ingvarsson, C.; Hallin, A.; Kier, C. (2023). *Project stakeholder engagement through gamification: what do we know and where do we go from here?*. International Journal of Managing Projects in Business, 16(8), 152-181.
- International Energy Agency. (2024). *Global critical minerals outlook 2024*. Paris: IEA.
- Konno, N.; Nonaka, I.; Ogilvy, J. (2014). *Scenario planning: the basics*. World Futures, 70(1), 28-43.
- Lead, C.; Nelson, G. C.; Bennett, E. (2005). Drivers of change in ecosystem condition and services. *Ecosystems and human well-being: scenarios: findings of the scenarios working group*, 2, 173.
- Linstone, H. A.; Turoff, M. (2002). Delphi bibliography. *Journal Articles*, 14(54), 68.
- McGowan, L.; Jay, S.; Kidd, S. (2019). Scenario-building for marine spatial planning. *Maritime Spatial Planning: past, present, future*, 327-351.
- NATO (2021). *Advisory group on emerging and disruptive technologies: Annual report 2021*.
- Ovaskainen, N.; Luodes, N.; Eerola, T.; Marasmi, C. (2024). *Sensitivity maps of potential conflicts over natural resources usage*. Deliverable 3.2 of the Critical Raw materials extraction in eNvironmentally protected areas (CIRAN) project. Grant Agreement No. 101091483 of the European Union's Horizon Europe research and innovation programme.
- Palomino, M. A.; Bardsley, S.; Bown, K.; De Lurio, J.; Ellwood, P.; Holland-Smith, D.; Owen, R. (2012). Web-based horizon scanning: concepts and practice. *Foresight*, 14(5), 355-373.

- Pinnegar, J. K.; Viner, D.; Hadley, D.; Dye, S.; Harris, M.; Berkout, F.; Simpson, M. (2006). *Alternative future scenarios for marine ecosystems: technical report*.
- Rüttinger, L., Ackern, P. V., Lepold, T., Vogt, R., & Auberger, A. (2020). *Impacts of climate change on mining, related environmental risks and raw material supply. Final report* (No. UBA-FB--000279/ENG). Umweltbundesamt.
- Schrijvers, D., Hool, A., Blengini, G. A., Chen, W. Q., Dewulf, J., Eggert, R., ... & Wäger, P. A. (2020). A review of methods and data to determine raw material criticality. *Resources, conservation and recycling*, 155, 104617.
- Shariff, N. (2015). Utilizing the Delphi survey approach: A review. *J Nurs Care*, 4(3), 246.
- Smeets, E., & Weterings, R. (1999). Environmental indicators: Typology and overview.
- Tejaswi, D., & Samuel, C. (2017). Techniques for environmental risk assessment: a review. *RASAYAN j. Chem*, 10(2), 499-506.
- van Hoof, L., Hendriksen, A., & Bloomfield, H. J. (2014). Sometimes you cannot make it on your own; drivers and scenarios for regional cooperation in implementing the EU Marine Strategy Framework Directive. *Marine Policy*, 50, 339-346.
- World Economic Forum (2010). *Mining and Metals: Scenarios to 2030*.

Annex 1 - CIRAN 2035 scenarios for CRM extraction in environmentally protected areas

EXECUTIVE SUMMARY

The CIRAN 2035 scenarios for CRM extraction in environmentally protected areas outline four plausible futures for the EU's approach to securing critical raw materials (CRMs). These scenarios explore the interplay between globalization, technological innovation, policy frameworks, and societal factors in shaping CRM demand and supply dynamics. The scenarios aim to guide strategic decision-making by examining key drivers, pressures, and responses related to CRM needs and their implications for environmental, economic, and societal sustainability.

The scenarios are shaped by two critical axes that define the future of CRM needs:

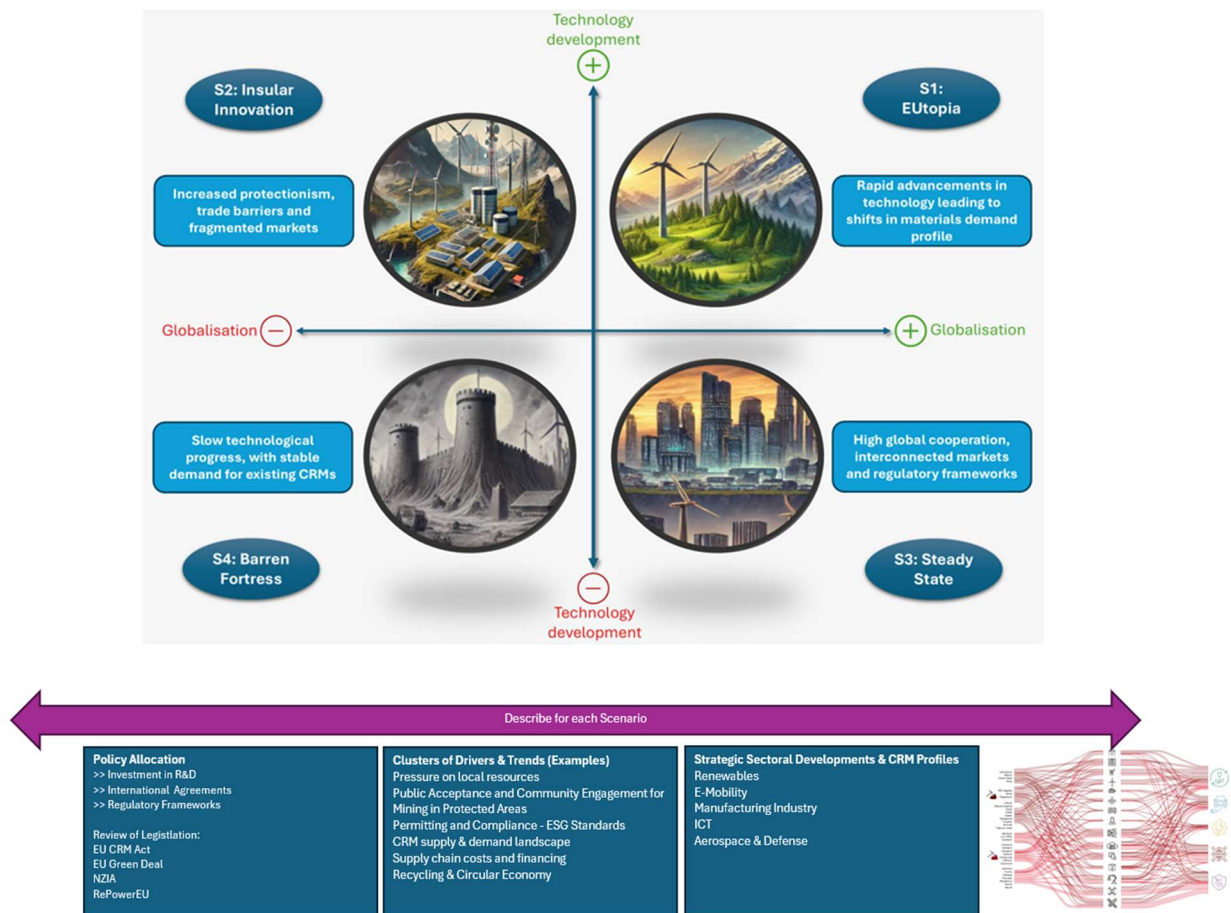
1. Globalisation vs. De-globalisation (Horizontal Axis):

- **Globalisation:** Characterized by high global cooperation, interconnected markets, and aligned regulatory frameworks supporting sustainable development and biodiversity preservation.
- **De-globalisation:** Marked by protectionism, fragmented economies, trade barriers, and limited international cooperation, leading to less harmonized policies and market isolation.

2. Technology Innovation vs. Technology Stagnation (Vertical Axis):

- **Innovation-driven:** Rapid technological advancements, particularly in green and digital sectors, shift in CRM priorities and demand.
- **Technology Stagnation:** Slow development maintains steady demand for existing CRMs with limited shifts in priorities.

These axes define four distinct scenarios—EUTopia, Insular Innovation, Steady State, and Isolated Fortress—each presenting unique trajectories for CRM demand, policy-making, and market aspects. This exercise provides insights for the strategic assessments needed to ensure sustainable CRM supply chains and outlines key uncertainties influencing the green and digital transitions.



Main guiding description lines for the development of the CIRAN 2035 scenarios narratives.

Scenario 1: EUtopia (Globalization, Innovation-Driven):

- A globally interconnected and cooperative world drives innovation in green and digital technologies.
- Strong international agreements enable diversified and sustainable CRM supply chains.
- Emphasis on recycling, circular economy practices, and international partnerships reduces the need for domestic mining in protected areas.

Scenario 2: Insular Innovation (De-Globalization, Innovation-Driven):

- Protectionist policies prioritize self-sufficiency and domestic innovation.
- The EU invests heavily in domestic mining and recycling but faces high costs and supply chain inefficiencies.
- Mining in protected areas becomes a contentious necessity for ensuring resource security.

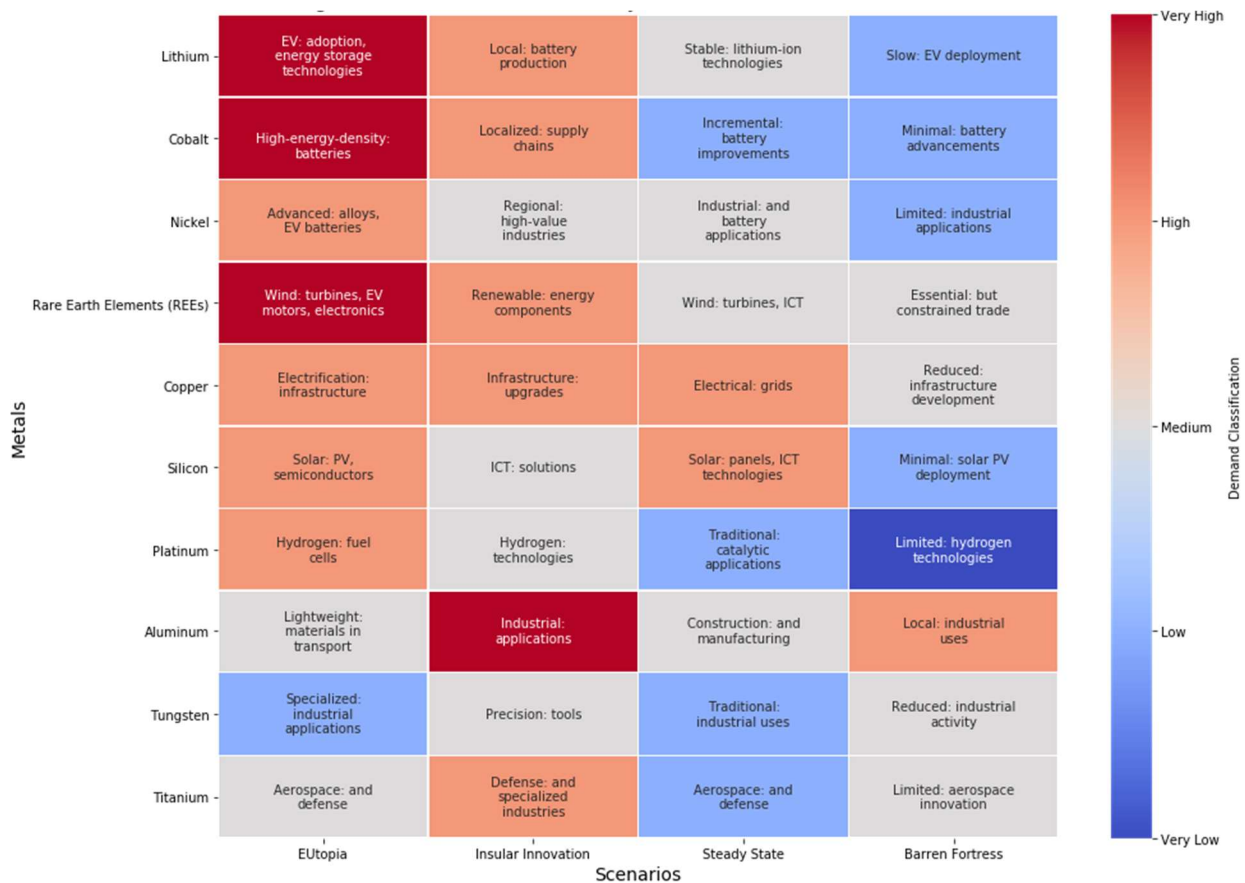
Scenario 3: Steady State (Globalization, Technology Stagnation):

- Stable global trade relationships maintain existing CRM supply chains with incremental improvements.
- Limited technological innovation results in steady CRM demand focused on traditional applications.
- Minimal pressure for domestic mining, including in protected areas, due to stable demand.

Scenario 4: Isolated Fortress (De-Globalization, Technology Stagnation):

- Increased protectionism and low technological advancement lead to resource scarcity and stagnation.
- Dependence on domestic resources puts pressure on mining in protected areas, compromising environmental standards.
- Fragmented policies and governance hinder CRM supply chain stability.

The demand for critical raw materials is expected to vary across the four scenarios, driven by the interplay of globalization, de-globalization, technological innovation, and stagnation. Metals like lithium, cobalt, and rare earth elements (REEs) exhibit high demand in innovation-driven scenarios (e.g., EUtopia), where green and digital transitions accelerate. Conversely, in technology-stagnant or protectionist scenarios (e.g., Isolated Fortress), demand shifts to basic materials like aluminum and copper, reflecting reduced technological and industrial activity. Each scenario highlights the evolving priorities for CRMs based on supply chain dynamics, technological progress, and policy choices.



Demand of several mineral raw materials under different CIRAN 2035 scenarios.

To ensure a sustainable and secure supply of critical raw materials, strategic actions must address the complex interplay of global cooperation and technological advancements. Recommendations should align policy, innovation, and governance with the demands of the green and digital transitions while mitigating environmental and social challenges. By tailoring actions with consideration to different scenarios, the EU can build resilience in its CRM supply chains and maintain its competitive edge in a rapidly evolving global landscape.

- Accelerate investments in R&D for alternative materials and recycling technologies.
- Strengthen circular economy frameworks to reduce dependency on primary extraction.
- Streamline permitting processes for mining projects, balancing environmental protection with resource needs.
- Enhance international collaboration in globalization-driven scenarios and regional integration in protectionist settings.
- Foster societal engagement and equitable distribution of benefits to maintain public support and trust.

The CIRAN 2035 scenarios offer strategic foresight for policymakers, industry leaders, and civil society to navigate uncertainties and prepare for the evolving CRM landscape. They provide linkages between policy formulation and a range of future realities, to potentially adapt to or influence possible futures.

INTRODUCTION

The next decade will be pivotal for the European Union (EU) as it seeks to secure a stable and sustainable supply of critical raw materials (CRMs) necessary for the green and digital transitions, defence, and other strategic sectors. Recognising the increasing demand for these materials and the associated risks due to high dependency on non-EU sources, the EU has initiated several regulatory and strategic initiatives, such as the 2023 EU Critical Raw Materials Act and the 2023 EC Raw Materials Foresight Study, to address these challenges.

The CIRAN Project aims to develop, test, and validate principles supporting systemic policymaking, balancing environmental protection and societal needs for accessing CRMs on European territory. This will be achieved through:

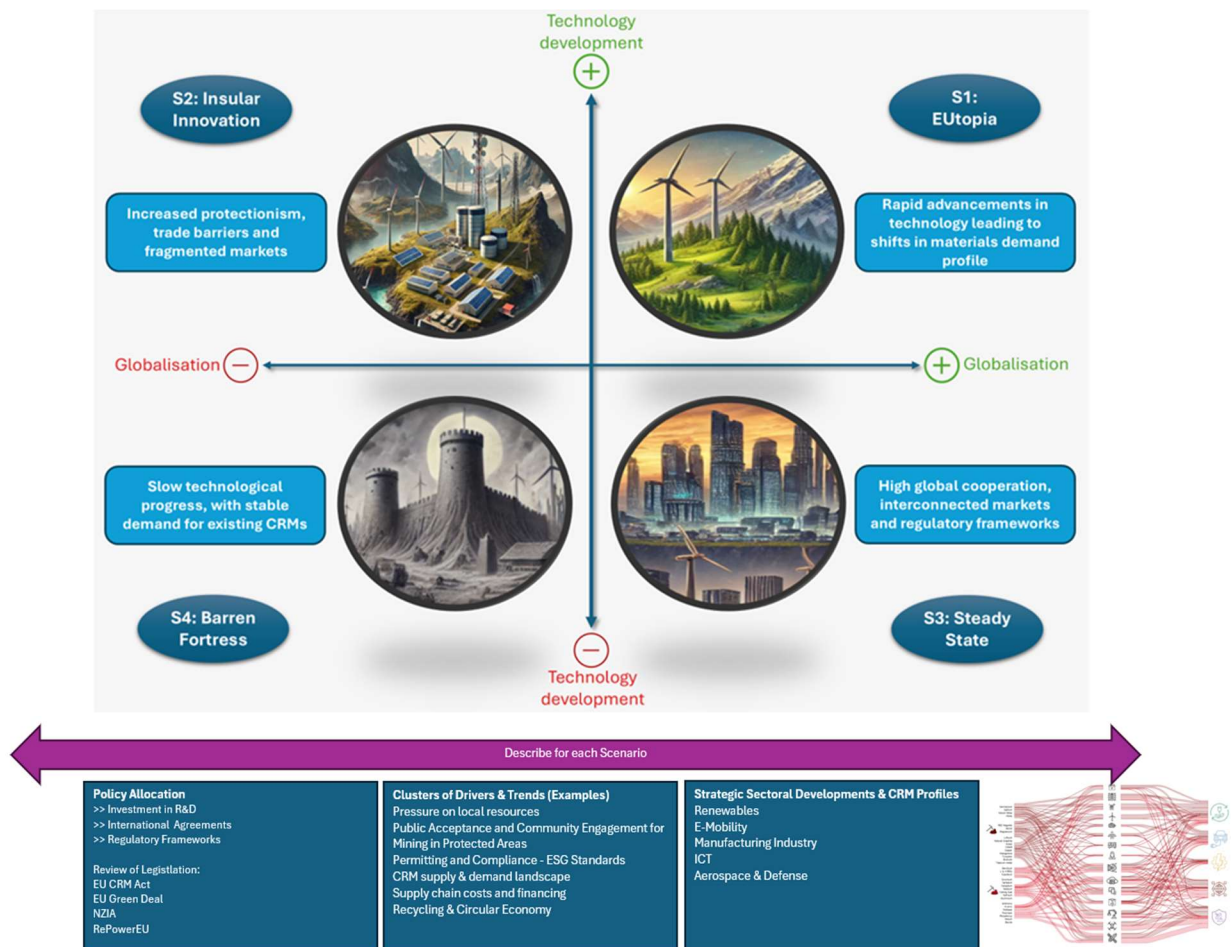
- 1) Streamlined permitting procedures in environmentally protected areas;
- 2) Modern policies and social contract frameworks that reconcile the protection of environmentally sensitive areas and domestic sourcing of CRMs in the EU; and
- 3) The development of a community of practice in support of CIRAN goals. that will remain active after the project funding period.

The scenario development exercise aims to construct four detailed scenarios of CRM needs and their intricacies with other areas over the coming ten years. The CIRAN 2035 scenarios explore various future states, providing insights into how different policies can either adapt to or influence these potential futures. By examining economic, geopolitical, technological, environmental, legal, and social drivers of change, this exercise will help stakeholders anticipate and prepare for uncertainties in the CRM landscape.

Approach:

- Review and analysis of projected CRM demand and supply scenarios influenced by technological developments in sectors considered strategic for the EU.
- Identify drivers of change of social, technological, economic and (geo)political nature, that can impact expected trajectories of the future CRM landscape. Classify these drivers in terms of importance and level of uncertainty.
- Develop policy linkages, establishing connections between policy decisions and potential future states. Specifically, policies can be directed to investments, R&D, International Cooperation Agreements, and updated regulatory frameworks.
- Create the four CIRAN 2035 scenarios, each with its own set of specificities, in an effort to help stakeholders make strategic decisions. Scenarios include visuals and descriptions that are fit for everyone to analyse and understand.
- The scenarios also provide input to the DPSIR-framework as they explain the possible drivers behind CRM needs and, hence, the pressures to extract more CRM.

SCENARIO BUILDING



Overview of the four CIRAN 2035 scenarios and the key elements identified to define each scenario.

Key uncertainties affecting all Scenarios

The two key dichotomies outlined below represent the two axes of the Scenarios' matrix, as they are high impact drivers that can directly influence the direction of the future of CRM needs, which would thus lead to one or another Scenario:

Globalisation vs De-globalisation (horizontal axis)

Globalisation: High global cooperation, more interconnected markets and supply webs, and aligned regulatory frameworks, including a higher international commitment to sustainable development and biodiversity preservation.

De-globalisation: Increased protectionism, trade barriers or obstacles to market interconnection, fragmented sectors of the economy, and lower levels of institutional cooperation (i.e., within the same country rather than between countries), resulting in less harmonised regulatory frameworks and directives.

Technology Innovation vs Technology Stagnation (vertical axis)

Innovation-driven: Rapid advancements in the development of technology, particularly, those associated with the green transition and other technologies to various sectors of the society, lead to shifts in CRMs priorities and demand levels.

Technology Stagnation: Slow technological development, with steady progression on the demand profile for current CRMs.

Describing the scenarios

Each scenario is described following the same guidelines. First a short summary with the main points and key aspects of the scenario is provided to set the stage and scope of the scenario narratives. Then, the main drivers and trends are presented, while divided into several sub-clusters, detailing connections to political, environmental, social, technological, economic and legal areas. In further sections, a Critical Raw Materials Outlook offers insight into the shape of the CRM supply and demand needs, while policies guidelines are mentioned to address the evolution of the world towards 2035.

While these scenarios provide insights into potential future developments, it is important to note that they may not be expected to fully materialize within the projected timeframe. Instead, they serve as illustrative models, offering strong signposts that signal key trends and the direction of change. These early indicators are meant to guide strategic decision-making and highlight areas where proactive actions can shape and adapt to evolving circumstances over time.

OVERVIEW OF CIRAN 2035 SCENARIOS

EUtopia (Globalisation, Innovation-driven)
Short Summary In this scenario, the world is highly interconnected and global cooperation is strong. Technological innovations resulting from new research areas lead to new material demands, impacting the existing raw materials landscape. The EU benefits from robust global supply chains, allowing it to cope with the changing demand profiles for the key raw materials needed. International agreements and globally-harmonised institutional frameworks ensure more sustainable business practices in the extractive industries and for other stakeholders, including producers and importers of CRMs. Governmental action in CRM market regulation is strong, fostering sustainable practices and resource security. National, regional, and local regulations are built based on international consensus. The role of organisations such as the UN and the EU is highly influential in global governance and policy-making, and these institutions are highly trusted by citizens, as there is also a general trust in local and national politics. This is highly correlated to the fact that Civil Society Organisations are active and strong, and operate through supra-national networks, collectively pushing for their shared demands on high environmental standards and sustainable mining practices. Another element explaining why citizens' trust in government and political institutions does not deteriorate is due to attempts at more transparent and inclusive policy-making processes. CRMs hold a high priority on the political agenda, given their strategic importance for technological and economic development. The EU's trade policy is proactive, securing global supply chains and fostering international cooperation for shared knowledge, technology, and resources. ➤ This scenario is characterised by high innovation and a strong focus on energy transition technologies, such as renewable energy systems, electrified vehicles and industrial processes, and advanced digital infrastructure. ➤ There is strong global cooperation, with extensive trade agreements and a generally stable flow of CRMs from geographically diverse sets of producers in most cases. ➤ Due to the emphasis on environmental sustainability, coupled with a stable geopolitical landscape and trade flows of raw materials, mining in protected areas is of limited interest: focus is on innovation in recycling, circular economy practices, and global imports instead. ➤ Supply chains of CRMs such as lithium, cobalt, nickel, rare earth elements (REEs), copper, and graphite are under focus — as these are essential for green technologies like batteries, wind turbines, and solar panels.
Drivers & Trends / Horizon Scanning
➤ Dependence on imports: The EU is globally interconnected and is actively reducing its dependency on imports from China by diversifying its supply chains. The EU would secure novel partnerships with other CRM-rich regions such as Africa, Latin America, and Australia, diversifying its dependencies in these areas but reducing its reliance on China. Investments in domestic CRM production, processing, and recycling would also increase, helping reduce import reliance, particularly for materials such as lithium, cobalt, and rare earth elements. ➤ Supply concentration: The EU reduces its reliance on a few key suppliers by diversifying its sources. Investments in CRM production within the EU and in stable countries would help disperse supply concentration, particularly through partnerships aimed at sustainable mining and CRM extraction. Recycling initiatives and technological innovations would further contribute to supply diversity in the longer term, easing bottlenecks in specific parts of the supply chain, particularly in battery materials and rare earth elements for electronics.

➤ Global competition: The EU would position itself as a leader in sustainable CRM practices and recycling technologies, using international partnerships to ensure reliable access to critical materials. By investing in innovative technologies and establishing diplomatic and economic alliances, the EU would be able to secure a competitive position globally, avoiding trade friction with other major players like China and the US in the race for CRMs. ➤ Demand Profile: Driven by rapid technological innovation and strong global cooperation leading to faster technological developments, demand profiles for materials significantly change and increase. The EU green and digital transitions, alongside global economic transformation plans, can spur a strong demand for a certain array of raw materials and depress the demand for other materials critical to energy storage (batteries), renewable energy (wind turbines, solar panels), and advanced electronics (semiconductors, AI and 5G infrastructure). Ambitious targets for carbon neutrality and digitalisation worldwide would entail a strong and growing market for these materials. ➤ Supply Chains & Financing: While demand shifts, supply chain costs also inflate. Long-term price pressures are a major concern due to rising energy prices and the declining quality of feedstocks. Meeting stringent ESG requirements increases operational complexity and costs for raw materials producers. Financing hinges on securing investment in sustainable mining practices and circular economy initiatives. Margins for producers may be squeezed in the short term due to the high costs of innovation and compliance with ESG standards, but long-term benefits would include access to more sustainable, higher-value markets and reduced societal costs for rehabilitation of environments. Investments in energy efficiency and clean energy within the supply chains could help mitigate rising operational costs.
➤ Social Acceptance and Community Engagement: Effective community engagement remains crucial to support the rapid expansion and shifts of supply chains driven by technological innovation and sustainability goals. Transparent communication about the environmental and social impacts of mining and processing activities remains a key factor in gaining and maintaining public support for CRM access. The EU will prioritise proactive measures to ensure communities are informed and involved in decision-making processes. This includes public consultations, benefit-sharing mechanisms, and active as well as constructive participation of civil society organisations. The need for maintaining public support will remain high due to the increasing reliance on mining activities, both domestically and internationally, making it essential to manage the environmental footprint and uphold social licenses to operate (SLO). ➤ Social Equity and Human Rights: The EU places strong emphasis on social equity and human rights, especially in the context of its CRM supply chains. The high level of globalisation in this scenario provides the EU with opportunities to actively foster the implementation of fair labour practices and community benefit programmes in the countries from which it sources materials, supported by the Brussels Effect, i.e. the de facto adoption of EU norms and regulations in partner countries. In partnerships with CRM-rich regions, the EU pushes for adherence to internationally recognised labour standards, environmental protection, and equitable distribution of benefits. However, fostering compliance with these standards, particularly in developing countries, will require robust monitoring and cooperation. This could be achieved through strategic alliances and global frameworks that tie social equity and human rights compliance to trade agreements and sourcing contracts. ➤ Workforce: Rapid technological advancements and expanding CRM supply chains require a highly specialised labour force. The EU invests heavily in education and training programmes aimed at developing skills related to mining, processing, recycling, and advanced manufacturing technologies. Public-private partnerships, apprenticeships, and specialised degree programmes will be developed in cooperation with industries to ensure the supply of skilled labour meets the demands of the green and digital transitions. Additionally, the EU will likely create incentives for technology-driven industries to upskill workers in utilisation of automation and AI, as well as sustainable mining practices.
➤ Innovation & Substitution: Innovation in materials science and technology accelerates significantly due to strong global cooperation and investment. The EU prioritises research into advanced materials, alternative technologies, and the substitution of certain CRMs to ensure strategic autonomy and leadership. Major

breakthroughs in battery chemistry, such as solid-state batteries requiring less lithium or cobalt, are prone to consolidate. Additionally, innovation in materials efficiency and the development of novel, less resource-intensive technologies are also contributing to the raw material demand (intensity) landscape. The EU actively supports R&D programmes that focus on reducing dependence on critical raw materials through substitution, improving both economic competitiveness and security.

- **Recycling & Circular Economy:** Investments in cutting-edge recycling technologies allow for the recovery of increasingly significant quantities of critical raw materials from end-of-life products such as batteries, electronics, and renewable energy components. The EU is a global market leader for secondary CRMs, driven by a strong regulatory framework that promotes recycling, waste reduction, and material reuse. Circular economy initiatives manage to benefit from technological advancements that improve material recovery rates by design for recycling and reduce energy consumption in recycling processes.
- **Rate of technology deployment:** Rapid pace due to strong global collaboration, innovation, and favourable policy environments. The EU takes the lead in the deployment of electric vehicles, wind turbines, and solar PV to meet its ambitious climate and energy targets. High rates of deployment will drive up the demand for critical raw materials, but innovations in material efficiency, recycling, and substitution will help manage this demand. The availability of CRMs will be critical to sustaining this deployment, and the EU will work to ensure supply chain resilience through diversification and investment in recycling.

- **Environmental:** ESG standards and sustainability practices evolved rapidly and became deeply integrated into global supply chains. The EU leads the way in pushing for high ESG standards, with a strong focus on transparency, responsible mining practices, and the circular economy. The global nature of the economy and extensive collaboration between countries will allow for the widespread adoption of stringent ESG regulations and voluntary sustainability standards. Responsible sourcing practices consolidate as key priority, with stringent environmental regulations and requirements for social impact assessments at all stages of the value chain. Companies are required to adhere to rigorous standards for reducing carbon footprints, water usage, and land degradation, driven by a global consensus on sustainability goals. Voluntary sustainability standards such as the Initiative for Responsible Mining Assurance (IRMA) and the EU's own Green Deal provisions prosper, with a strong emphasis on materials traceability to ensure responsible sourcing. Materials traceability initiatives, powered by novel technologies such as blockchain-based ones, improve the conditions for ethically sourced CRMs, with verified origins and adherence to social and environmental standards.

- **EU Regulatory Frameworks:** With strong global collaboration, ample financial support, and innovation driving evolution, the EU successfully achieves its goals of energy, decarbonisation, strategic autonomy, and sustainable resource management. The CRM Act will streamline the supply of critical raw materials through domestic production, recycling, and international partnerships. RePowerEU enhanced energy independence, accelerating the shift to renewable energy sources and reducing reliance on fossil fuels. The Net-Zero Industry Act (NZIA) boosts the competitiveness of the EU's clean energy industries, while the EU Green Deal will continue driving comprehensive climate action.
- **Permitting & Compliance:** Permitting for mining in protected areas remains challenging but evolve under streamlined policies that balance environmental preservation with the need for critical raw materials. Thanks to advanced technologies and stricter regulations, mining operations are required to maintain a small environmental footprint. Innovative mining techniques, such as precision mining and minimal-impact technologies, become mature and a common choice, ensuring that sourcing is compatible with conservation efforts. The EU in collaboration with Member States leads to a highly efficient permitting environment for projects that meet these advanced standards, ensuring timely approval for strategic mining operations.
- **Strategic Projects & Governance:** The designation of Strategic Projects becomes a highly successful initiative, with streamlined permitting processes and improved access to finance. These projects benefit from strong political, financial and even societal backing, allowing the EU to secure reliable CRM supplies for key industries. A dedicated Critical Raw Materials Board plays an essential role in coordinating efforts,

enhancing crisis preparedness, and ensuring that CRM supply chains remain resilient. This governance system supports the entire CRM value chain, from extraction to recycling, alleviating the effects of potential supply disruptions and supporting coordinated response.

CRM Outlook

The global push for green and digital transitions will drive demand for key metals such as lithium, cobalt, and rare earth elements (REEs) due to their critical role in EV batteries, renewable energy systems, and electronics. High demand will also be seen for nickel, copper, silicon, and platinum, reflecting the rapid deployment of clean energy technologies, hydrogen fuel cells, and advanced digital infrastructure. Moderate demand for aluminium aligns with lightweight material applications in transport, while lower demand for tungsten and titanium indicates less emphasis on specialized industrial and aerospace uses. The strong focus on innovation and international cooperation will support diversified supply chains and accelerated recycling efforts.

Policy Formulation

- EUtopia prioritises substantial investments in research and development (R&D) to drive technological innovation, particularly in CRM-intensive sectors such as renewable energy, digital technologies, and advanced manufacturing.
- High R&D spending accelerates the development of new technologies. These innovations mitigate the risks associated with high CRM demand by enabling more efficient use of resources and reducing reliance on imports.
- Policies are directed towards maintaining and expanding global trade agreements to secure diversified CRM supply chains. This aligns with the consensus on the need to mitigate geopolitical risks, particularly those associated with China's dominance in the CRM market.
- Through active global engagement, the EU secures access to a broad range of CRM sources, reducing the vulnerability of its supply chains. This policy approach also includes establishing strategic partnerships with resource-rich countries and investing in international mining projects.
- Strong emphasis on ESG standards in both domestic and international CRM projects. By enforcing stringent ESG criteria, the EU positions itself as a leader in sustainable resource management, which also helps to avoid the social and environmental pitfalls often associated with mining activities. This approach supports long-term sustainability and public support for CRM-related initiatives.
- Policies heavily favour a circular economy, with significant focus on developing recycling technologies and encouraging the reuse of CRMs. This is supported by the consensus on the importance of a circular economy in reducing CRM supply risks.

Insular Innovation (De-globalisation, Innovation-driven)
Short Summary Despite a trend towards de-globalisation and increased protectionism, technological innovation continues to advance rapidly. Technology is developed in-house, highly protected against other countries/blocks. The EU focuses on self-sufficiency, adapting to new material demands driven by technological progress. However, the lack of global cooperation leads to fragmented markets and higher costs. Supply chain resilience is challenged, but the EU manages to innovate domestically to meet its critical raw material needs, allied with exploration and mining in new areas. Governments are active in CRM market regulation, seeking self-sufficiency and support for local industries. Civil society organisations are active, advocating for local solutions and sustainability. Citizens' trust in government and political institutions is moderate, influenced by protectionist policies and local focus. CRMs hold a high priority on the political agenda due to the need for self-sufficiency and technological progress. The EU's trade policy tilts towards more protectionism, supporting local industries and reducing dependency on external sources. International cooperation is limited, focused on strategic partners and regional alliances. ➤ Despite de-globalisation, innovation within the EU continues to drive the development of green technologies, with a focus on self-sufficiency. ➤ The EU adopts a more insular approach, forming trade blocks with a limited number of trusted partners and emphasising local production. ➤ Due to the need for self-reliance and domestic sourcing, the EU may face pressure to exploit protected areas, though with advanced, more sustainable mining techniques. ➤ Through a combination of domestic mining, recycling, and limited trade agreements, the EU manages to secure its resources, though at potentially higher costs. ➤ Lithium, cobalt, rare earth elements (REEs), and possibly domestic-focused critical and strategic raw materials such as copper and aluminium would gain more attention.
(Drivers & Trends/ Horizon Scanning)
➤ EU dependence on imports: Due to the protectionist policies in this scenario, the EU strives for self-sufficiency and reduces its dependence on imports from China. Instead, it focuses on developing local CRM sources, recycling technologies, and partnerships within the EU. However, novel dependencies might emerge within the EU itself, particularly in regions such as Scandinavia, the Balkans and the Iberian Peninsula, which have significant CRM deposits. The value chains would likely shift towards mining, processing, and recycling within the EU, with high focus on technologies such as battery materials, where the EU has traditionally relied on imports. ➤ Supply concentration: The EU works to reduce reliance on external sources by heavily investing in domestic CRM production and recycling. However, without global cooperation, the concentration of supply may remain high, potentially creating internal dependencies. The concentration of CRM processing and recycling capabilities would likely be higher within specific countries, such as Germany, Poland and Finland, leading to regional specialisation within the EU. ➤ Global Competition: The EU largely steps away from global competition for CRMs, focusing instead on securing its internal supply through regional innovation and production. While this insular approach may reduce global competition, thus affecting the price of raw materials and their supply webs, it may also limit the EU's influence in international CRM markets, leaving it even more vulnerable to external pressures or global supply shocks, particularly in areas where domestic production may not be sufficient to meet demand. ➤ Demand Profile: Demand for strategic and critical materials remains high, driven largely by regional green and digital transitions within the EU. However, the focus remains on securing and utilising local resources for energy storage and renewable energy technologies. Materials such as lithium, cobalt, and

rare earth elements would see high demand, but the EU would heavily invest in recycling technologies and domestic production to meet this demand. The lack of access to global markets may limit the scale of supply, but innovation in material usage and recycling within the EU would remain strong as the region aims to meet its decarbonization and digitalisation goals.

- **Supply Chain & Finance:** The focus on local production and self-sufficiency creates supply chain inefficiencies due to higher operational costs in a more localised, less diversified system. Rising energy prices persist due to limited global competition in energy markets, further driving up production costs. The declining quality of local feedstocks exacerbates these challenges. Financing challenges would be pronounced, as high capital flows are required for regional mining, processing, and recycling infrastructure, all while meeting strict ESG standards. Operational costs for raw materials producers increase in many cases due to the inefficiencies in localised production, further compressing margins. However, long-term stability and reduced exposure to global supply chain risks could be a potential advantage.

- **Societal Acceptance and Community Engagement:** The EU focuses on self-sufficiency and regional innovation, since community engagement is a critical aspect of securing access to CRMs. Public consultations and transparency about environmental and societal impacts are sought and seen as paramount in gaining community acceptance. To mitigate these concerns, the EU implements frameworks that emphasise sustainability and localised benefit-sharing models to build trust and support from communities directly affected by CRM extraction and processing activities.
- **Social Equity and Human Rights:** Strong labour laws and protections support fair working conditions for those employed in the CRM sector. Communities near mining operations still benefit from social programmes that emphasise local economic development, infrastructure improvements, and environmental rehabilitation efforts. However, the inward focus of the scenario may limit the EU's ability to influence human rights practices in international supply chains. Nevertheless, within the EU, high standards of social equity will be maintained, with emphasis on equitable distribution of benefits from CRM extraction to local populations.
- **Workforce:** Ensuring a skilled workforce in this scenario becomes a priority. The EU focuses on developing domestic talent pools through investment in technical education, apprenticeships, and vocational training programmes geared toward the CRM sector. With the need for expertise in mining, recycling, and advanced material processing, educational institutions realign their programmes with industry demands, emphasising sustainability, circular economy practices, and cutting-edge technologies. Regional innovation hubs and partnerships between governments and industries become highly active, driving workforce development, ensuring that the EU has the necessary human capital to support CRM supply chain developments.

- **Innovation & Substitution:** Innovation is largely driven by EU needs and protectionist policies. The EU prioritises R&D in alternative materials and technologies to reduce reliance on external suppliers of mineral raw materials deemed critical for the current technological ecosystem. However, the pace of innovation may be slower compared to globally connected scenarios due to reduced access to international knowledge-sharing and collaboration. Substitution efforts will focus on EU solutions, such as finding alternatives for imported CRMs in domestic technologies. This focus on EU autonomy will spur innovation in material efficiency and alternatives, but the scope of breakthroughs might be more limited to what can be developed within the EU.
- **Recycling & Circular Economy:** The EU remain heavily focused on recycling technologies to improve the reuse of domestic waste streams. There will be significant progress in creating closed-loop supply chains within Europe, reducing reliance on external sources for CRMs. Circular economy practices mature, with strong regulatory frameworks incentivising companies to design products for recyclability and consumers to participate in recycling programmes. However, without global trade, secondary markets might be somewhat limited in size and scope.

➤ Rate of technology deployment: moderate pace due to regional innovation efforts and government support. While the EU pushes for widespread adoption of electric vehicles, wind turbines, and solar PV, deployment may be slower compared to the "EUtopia" scenario due to constrained supply chains and regionalised resource management. The reliance on EU domestic CRM supplies and recycling helps stabilising deployment rates, but any bottlenecks in material availability could slow progress toward meeting climate and energy targets.
➤ Environment: sustainability and ESG standards evolved primarily within the EU's borders, with a focus on local self-sufficiency and responsible use of domestic resources. The EU maintained its commitment to high ESG standards, but these will be applied primarily to domestic mining and processing operations. Since international collaboration is limited, the adoption of global ESG standards may stagnate outside the EU, with some regions failing to meet the same level of transparency or responsible mining practices. However, within the EU, voluntary sustainability standards and traceability initiatives will remain strong. The EU prioritises responsible sourcing from within its borders and from closely allied regions. While global adoption may be limited, the EU will continue to set the standard for responsible mining and ESG compliance domestically and in its close partners.
➤ Regulatory Framework: The EU CRM Act, RePowerEU, NZIA, and the EU Green Deal had varying degrees of success in this scenario, where protectionism and regional autonomy dominate. The CRM Act focused on local production and recycling, and is effective in reducing the EU's reliance on imports. RePowerEU will drive regional energy independence, promoting investments in domestic renewable energy projects, but progress is slower than in globally connected scenarios due to limited external partnerships. The NZIA pushed forward low-carbon technology developments within the EU, but the scale of deployment may be constrained by limited access to global supply chains. The EU Green Deal remained heavily influential in guiding climate policies, though its full potential might not be realised due to the focus on inward-looking economic policies. ➤ Permitting & Compliance: The permitting environment for mining in protected areas evolved into flexible forms of regulation, with a strong emphasis on environmental preservation in principle but with a high degree of flexibility for projects considered strategic. Streamlined permitting processes that align with the EU's sustainability goals are ramped up, and high standards for compliance are maintained. Advanced, low-impact mining technologies evolved rapidly globally, but the pace of implementation might be slower in the EU due to limited access to such innovations. Permitting policies will focus on ensuring minimal environmental damage and the EU will emphasise transparency and accountability. ➤ Strategic Projects & Governance: The designation of Strategic Projects is successful. Streamlined permitting and access to finance remain crucial for supporting these projects. A Critical Raw Materials Board will be essential in coordinating efforts, ensuring that domestic CRM supply chains are resilient, and that crisis preparedness is robust. This governance system will have to navigate internal EU dynamics, balancing the interests of member states while pushing for strategic autonomy.
CRM Outlook Emphasis is on self-sufficiency within the EU, resulting in strong demand for aluminium, a widely available domestic resource for industrial and renewable energy uses. Lithium, cobalt, and REEs will remain in high demand due to localized battery and renewable energy production. Moderate demand for nickel, silicon, and platinum will reflect regional technological development and limited access to external resources. Supply constraints will lead to moderate demand for tungsten and titanium, which are critical for precision tools and defense industries. Recycling and substitution will gain prominence to support self-reliance.
Policy Formulation ➤ Significant attention is directed to developing domestic CRM resources. This includes incentives for local mining, exploration in protected areas, and support for domestic processing facilities, reflecting the divergence in emphasis on domestic sourcing versus global supply chains.

- Policies are directed towards innovations that improve resource efficiency and reduce waste. This includes developing advanced recycling technologies and finding substitutes for critical materials, consistent with the consensus on innovation as a tool for reducing CRM dependencies.
- These policies ensure that, despite limited access to global supply chains, the EU remains competitive by optimising the use of available resources. The focus on efficiency and sustainability helps to mitigate the environmental impact of increased domestic mining.
- Policies are crafted to protect domestic industries, including tariffs on imported CRMs and restrictions on foreign ownership in the mining sector. This reflects the divergence from a globalised approach, focusing instead on insulating the domestic market from external shocks.
 - While these protectionist measures help secure domestic industries, they could also lead to higher costs and inefficiencies, potentially making European CRMs less competitive on the global market. This approach may also strain international relations, particularly with countries that export CRMs.
- Governments actively collaborate with private companies to drive innovation and resource development within the EU. Policies support public-private partnerships (PPPs) in areas such as CRM extraction, processing, and recycling, reflecting the consensus on the importance of collaboration for achieving innovation-driven goals.
 - By fostering strong partnerships between the public and private sectors, the EU can pool resources and expertise to overcome the challenges posed by limited global engagement. This approach is critical for maintaining technological leadership while adhering to the scenario's insular focus.

Steady State (Globalisation, Technology stagnation)
Short Summary In this scenario, characterised by high globalization and low technological innovation, the demand for raw materials currently considered ‘critical’ (CRMs) remains steady with relatively small changes over the next decade. Key materials such as copper, aluminium, and silicon, essential for established technologies such as solar panels, wind turbines, and electrical infrastructure, will continue in their demand trajectories. Global trade relationships play a crucial role in maintaining continued supply chains, with international cooperation ensuring a stable flow of CRMs from trusted global partners. Policy focus in this scenario is on maintaining and upgrading existing infrastructure, with incremental improvements in CRM usage and recycling. These policies work together to uphold sustainability and stability in supply chains, though they do not drive significant innovation or shifts in CRM demand. ➤ Technological innovation slows down, resulting in a reduced pace of new green technologies. The focus shifts to maintaining existing infrastructure development and industry adaptation. ➤ Global trade continues, with the EU relying on stable international relations and existing supply chains to meet its needs. ➤ With less pressure for resource extraction due to the slowdown in technological advancement, mining in protected areas is largely not needed. ➤ Stable global trade allows the EU to continue securing the CRMs it needs, although at a stable but non-expanding rate. ➤ Aluminium, copper, and other traditional metals used in more mature applications would still be in the spotlight.
(Drivers & Trends/ Horizon Scanning) ➤ EU dependence on imports: The EU continues to rely on imports for CRMs, particularly from established trade partners like China, Australia, and African countries. The EU focus is on maintaining stable global trade relations, which would ensure steady access to necessary materials. The dependence on China may not significantly reduce, but the risk associated with this reliance would be mitigated by strong diplomatic and trade agreements. Dependency remains highest in the upstream parts of the value chain, namely raw material extraction and processing/refining. ➤ Supply concentration: The EU faces a challenge in reducing its reliance on concentrated sources of CRMs, particularly from China. While the EU prioritises diversification efforts, these are incremental and focused on securing stable relationships with existing suppliers. The concentration of supply may remain high for certain CRMs, such as rare earth elements, for which China remains the dominant global producer. Recycling could help alleviate some supply issues, but it would not dramatically reduce reliance on imports. ➤ Global Competition: The EU would take a more cooperative approach to global competition for CRMs, focusing on maintaining its position within established global supply chains. Rather than aggressively competing with other powers, the EU would rely on diplomatic measures and long-term trade agreements to ensure access to CRMs. This approach would ensure a degree of stability but may leave the EU less competitive in acquiring new sources of CRMs as global demand rises. ➤ Demand Profile: The demand trajectory for strategic and critical materials remains stable, with only moderate increases driven by gradual technological advancements. The global green and digital transitions continue, but at a slower pace compared to more innovative scenarios. Materials such as copper, aluminium, and silicon would be in consistent demand for existing energy infrastructure, including solar panels and wind turbines. However, materials with new and expanded uses such as lithium and cobalt may see stabilised demand as technological breakthroughs remain limited, resulting in fewer disruptive changes to CRM requirements.

➤ Supply Chain & Financing: Costs remain relatively stable, with some fluctuations due to external factors such as geopolitical tensions or minor disruptions in global trade. Energy prices may see incremental increases, but the persistence of global cooperation keep them largely under control. Feedstock quality declines more slowly than in more isolated scenarios, allowing raw materials producers more predictable operational costs. ESG requirements would still be a concern but would be managed through incremental adjustments. Financing challenges would revolve around maintaining existing infrastructure rather than significant new investments in disruptive technologies. Margins for producers would remain tolerable, supported by relatively predictable demand offtake and manageable supply chain costs.
➤ Societal Acceptance and Community Engagement: Technological innovation is limited and reliance on established global supply chains is prioritised, community engagement remains important but may not be as urgent or expansive as in more innovation-driven scenarios. Public support for CRM extraction and processing is maintained through transparency and moderate environmental protections. Engagement efforts will likely focus on maintaining existing operations with incremental improvements in environmental management. However, as technological breakthroughs are limited, community concerns around disruptive projects are minimised, with public consultations centred on maintaining trust in current practices. ➤ Social Equity and Human Rights: The EU continues to uphold high standards for social equity and human rights in its CRM supply chains, particularly through trade agreements that enforce fair labour practices and human rights protections. Without significant shifts or expansions, the focus will be more on strengthening current standards and ties. The EU will rely on established partnerships with countries that already have reasonable labour standards and governance frameworks in place. In this scenario, social equity efforts may be incremental, with gradual improvements in fair labour practices and community benefits. ➤ Workforce: Focus on maintaining the skills needed to support established CRM supply chains and industries. Since technological advancements are incremental, the need for dynamic upskilling or retraining programmes is lower compared to more innovation-driven scenarios. The EU will continue to support technical education and vocational training programmes, but the emphasis is on sustaining current operations rather than preparing for disruptive technological shifts. Efforts will also be directed toward improving efficiency and productivity within existing labour frameworks, with some attention given to emerging sectors like renewable energy.
➤ Innovation & Substitution: Innovation is much more incremental and evolving at a steady but conservative pace, rather than frequent radical breakthroughs. Research into advanced materials and substitution will continue but may lack the urgency or bold investment seen in more innovation-driven scenarios. Focus is on refining existing technologies, improving materials efficiency, and securing long-term global partnerships for stable CRM supplies rather than developing entirely new materials or technologies. ➤ Recycling & Circular Economy: The EU maintains a strong commitment to recycling and circular economy principles, but the focus is on optimising existing systems rather than driving radical change. Recycling technologies evolve incrementally, with an emphasis on improving efficiency and reducing costs. While circular economy practices will be well-integrated into the EU's industrial strategy, the pace of advancement is slower compared to more dynamic scenarios. Efforts to encourage the reuse and recycling of materials remain a central part of the EU's strategy for reducing supply risks. ➤ Rate of technology deployment: Deployment rates are carefully managed in line with existing infrastructure and resource availability.
➤ Environment: ESG standards and sustainability practices evolve with less urgency compared to the EUtopia scenario. The focus is on maintaining existing standards rather than pushing for new initiatives. Transparency and responsible mining practices will continue to be prioritised, particularly through long-term international agreements and partnerships that ensure compliance with ESG regulations. Voluntary sustainability standards are upheld by major industry players, but there may be

less innovation in this space. Traceability initiatives are still important for ensuring responsible sourcing, particularly from high-risk regions. However, the lack of disruptive change in technology or trade relations may result in slow adoption of new material traceability systems. Established practices still dominate, with incremental improvements focused on ensuring long-term environmental and social responsibility. Material traceability systems are used primarily to verify compliance with established standards rather than to push the envelope on new sustainability initiatives.
➤ Regulatory Framework: In this scenario, the EU CRM Act, RePowerEU, NZIA, and the EU Green Deal are functioning moderately well. These frameworks continue to support steady progress towards climate and energy goals but without the urgency or radical shifts seen in other scenarios. The CRM Act secures stable supply chains through long-term partnerships with trusted global suppliers. ➤ Permitting & Compliance: While the need for new CRM sources is well acknowledged, the pace of permitting for mining in protected areas is cautious and conservative. There will be pressure to maintain high environmental standards and compliance. However, without an economic and technological dynamism, permitting processes remain cumbersome and lengthy. Policies aim to strike a balance between environmental protection and raw material sourcing needs, but without heavy shifts towards more efficient systems. ➤ Strategic Projects & Governance: The designation of Strategic Projects is moderately successful, focusing on maintaining and enabling existing supply chains and ensuring resilience rather than driving major new initiatives. Streamlined permitting and access to finance is implemented in some cases.
CRM Outlook
With limited technological advancement, demand for metals will stabilize. Traditional materials such as copper and aluminium will maintain high demand for existing energy infrastructure, ICT technologies, and manufacturing. Moderate demand for nickel and REEs supports industrial applications, while demand for lithium and cobalt will be limited due to a slower shift to EVs and energy storage technologies. Limited innovation reduces the likelihood of demand growth for platinum, tungsten, and titanium, which are mainly used in niche or established sectors like hydrogen and aerospace.
Policy Formulation ➤ In this scenario, policies are directed towards maintaining and slightly expanding existing global trade agreements. The consensus on the importance of diversified supply chains is less pressing here, as technological stagnation reduces the need for aggressive CRM sourcing strategies. The EU ensures a consistent supply of traditional CRMs such as copper, rare earths, vanadium, and PGMs. However, the lack of new trade initiatives could make the EU vulnerable to shifts in global markets or geopolitical tensions. ➤ R&D for new CRM-dependent technologies is limited. The EU continues to rely on established technologies and supply chains, with lower impetus to develop new solutions or reduce CRM consumption through innovation. ➤ Policies are geared towards supporting traditional industries, which remain the backbone of the economy in this scenario. This includes subsidies for sectors such as construction and manufacturing, which have steady but not increasing CRM needs. ➤ Environmental policies are maintained but not significantly strengthened. The consensus on the importance of ESG is acknowledged but not expanded upon, reflecting a conservative approach to regulation in this scenario. The stability of environmental regulations provides predictability for industries but may also limit progress in sustainability. The lack of strong enforcement of ESG policies could result in slower adoption of environmentally friendly practices in CRM extraction and processing.

Isolated Fortress (De-globalization, Technology stagnation)
Short Summary In this scenario, both globalisation and technological innovation are limited. The EU faces significant challenges in securing critical raw materials due to increased protectionism while also seeing a lack of shifts in material demands. Extraction in protected areas becomes more contentious as traditional methods lead to higher environmental impacts. The focus shifts to local solutions and circular economy practices, but progress is slow, and demand pressures remain high. Governments are active in CRM market regulation, supporting local production and self-sufficiency. Civil society organisations advocate for sustainability and local solutions. Citizens' trust in government and political institutions is moderate, influenced by protectionist policies and local focus. CRMs hold a high priority on the political agenda to ensure local self-sufficiency and resource security. The EU's trade policy aims at reducing dependency on external sources. International cooperation is limited, focused on regional and strategic partnerships. ➤ With both de-globalisation and technological stagnation, there is minimal development of new green technologies, and existing technologies are maintained without significant advancement. ➤ The world becomes more fragmented, with the EU relying on limited, possibly unstable trade relationships and is struggling with self-sufficiency. ➤ The EU, facing resource scarcity, might be forced to mine in protected areas, compromising environmental standards to secure basic materials, also facing societal opposition. ➤ Due to limited trade and insufficient domestic supply, the EU faces significant challenges in securing necessary CRMs, leading to potential resource shortages. ➤ Basic metals such as iron, aluminium, and possibly some copper, with reduced need for CRMs such as lithium and cobalt due to stagnation in technology-driven industries.
Drivers & Trends/ Horizon Scanning ➤ EU dependence on imports: The EU has limited access to global markets due to protectionism and de-globalisation. As a result, the EU attempts to minimise its dependence on imports, including those from China, by relying on domestic sources and recycling. However, the EU struggles to fully replace imports with domestic production. Parts of the value chain that depend on advanced processing technologies and the availability of specific raw materials would face significant disruptions due to the lack of external supply. ➤ Supply concentration: High levels of supply concentration. With limited access to global supply chains, the EU struggle to diversify its sources of CRMs. This would increase the risk of bottlenecks in production and create dependencies between specific member states that have access to CRM resources, exacerbating internal vulnerabilities within the EU. ➤ Global Competition: The EU largely withdraws from global competition for CRMs in this scenario, focusing instead on local solutions and recycling. However, this inward focus could leave the EU vulnerable in the long term, as it becomes increasingly isolated from international CRM markets. Without the ability to secure global resources, the EU may find itself at a disadvantage compared to other regions that continue to compete for and secure access to CRMs, especially as global demand rises and available resources become scarcer. ➤ Demand Profile: Low globalisation and low technological innovation, demand for strategic and critical materials would stagnate. The green and digital transitions progress is slow. Basic materials such as copper, aluminium, and silicon would continue to be used, but the lack of technological advancement would keep demand for materials specific to these technologies low. This stagnation extends across industries, with minimal progress towards ambitious climate or digitalisation targets globally.

➤ Supply Chain & Financing: Costs rise significantly due to protectionist policies, inefficiencies, and rising local energy prices and labour costs. Localised industries face persistent challenges from declining feedstock quality, driving up extraction and processing costs. Producers struggle to fund operations that are less efficient and more expensive to run. ESG requirements might be deprioritized in favour of basic operational survival, but the absence of innovation means that costs and margins remain under significant pressure. Operational costs for most raw materials producers escalate, and margins shrink due to a combination of high costs, inefficiency, and low demand.
➤ Societal Acceptance and Community Engagement: Public scepticism towards CRM extraction and processing increases. Communities still perceive mining activities as harmful. The EU faces challenges in maintaining public support for CRM access, especially in areas where extraction activities cause significant disruptions. Transparency and localised benefit-sharing programmes will be key, but gaining trust in stagnating industries could be difficult. Failing to achieve energy and sustainability targets due to the protectionist measures and lack of innovation will likely exacerbate social unrest. ➤ Social Equity and Human Rights: Compromised in this scenario due to limited international cooperation and slow progress in addressing labour and human rights issues. Within the EU, labour protections remain intact, but outside of the EU, without strong international agreements, poor labour conditions and limited community benefits persist in source countries. The lack of economic growth and innovation also mean fewer resources are available for improving social conditions and addressing negative social impacts, both domestically and in supply chains abroad. ➤ Workforce: Ensuring a skilled workforce is a challenge in this scenario, as stagnation reduces incentives for education and training. The EU will struggle to develop and retain talent in the CRM sector due to the lack of technological advancement and economic growth. Educational programmes went underfunded or misaligned with industry needs, further exacerbating the skills gap. Without investment in innovation or skills development, workforce shortages contribute to declining productivity and efficiency.
➤ Innovation & Substitution: Innovation in advanced materials and alternative technologies stagnates. Without global cooperation, and with minimal investment in R&D, the EU struggles to make significant progress in developing new materials or finding substitutes for critical raw materials. Technological innovation is largely limited to maintaining existing systems and attempting to make incremental improvements with limited resources. Substitution efforts are constrained, and reliance on traditional materials such as copper, aluminium, and silicon will persist. Advancements in material efficiency or alternative technologies are slow and reactive rather than proactive. ➤ Recycling & Circular Economy: While Recycling and circular economy efforts face significant challenges due to stagnation, room for alternative circular business models gain traction. On the other hand, circular economy initiatives falter due to a lack end-of-life products and material stocks and the economic strain of operating in a protectionist and resource-constrained environment. The use of secondary CRMs will be limited, and the EU may struggle to meet its sustainability goals due to insufficient progress in recycling and resource management. ➤ Rate of technology deployment: Deployment of clean technologies such as electric vehicles, wind turbines, and solar PV is relatively slow and fragmented. The EU struggles to scale up clean technologies to meet its climate and energy targets. Deployment rates will be limited by supply chain disruptions, lack of innovation, and poor access to critical raw materials.
➤ Environment: Limited technological innovation, global cooperation, and economic growth hinder the adoption of more sophisticated ESG standards. Ensuring sustainability standards become more challenging, both domestically and in any remaining external supply chains. Responsible mining practices may be deprioritised in favour of maintaining basic production levels, particularly in regions where resource scarcity and economic stagnation take precedence over environmental concerns. Voluntary sustainability standards see limited progress, as many companies focus on survival rather than leading new initiatives. Material traceability efforts stall, with reduced investments in technologies such as blockchain that ensure transparent and ethical sourcing. The focus is on

maintaining basic levels of compliance with ESG standards, but innovation and adoption of new responsible mining practices is slow.
➤ Regulatory Framework: The CRM Act is implemented with minimal success, as the EU face difficulties in securing sufficient raw materials and financing for strategic projects. RePowerEU makes limited progress toward energy independence due to constrained access to the technologies and materials required for renewable energy infrastructure. The NZIA is ineffective in fostering significant low-carbon technology deployment, and the EU Green Deal falters as stagnating economies and geopolitical tensions take priority over climate action. ➤ Permitting & Compliance: The permitting environment for mining in protected areas is restrictive and bureaucratic, with limited progress in terms of streamlining. Permitting policies become stagnant, with minimal adaptation to emerging needs, and compliance requirements discourage investment and delaying projects. ➤ Strategic Projects & Governance: Designation of Strategic Projects is largely unsuccessful in this scenario due to a lack of political cohesion, limited funding, and bureaucratic hurdles.
CRM Outlook
As global trade is constrained while technological progress is limited, there will not be strong shifts in demand for most metals. Basic materials like aluminium and copper will see moderate demand growth for minimal industrial and energy uses. Lithium, cobalt, and nickel will face limited demand increase due to limited adoption of EVs and advanced batteries. Tungsten and titanium will maintain modest relevance in specialized industrial and defence applications, but the lack of innovation and collaboration will limit a broader utilization.
Policy Formulation ➤ Policies are heavily focused on self-sufficiency, with economic resources allocated to maximising domestic CRM production and minimising imports. This reflects a divergence from global engagement, with a strong emphasis on insulating the EU from global market volatility. The drive for self-sufficiency leads to extensive domestic mining pressure, potentially in environmentally sensitive areas. However, without innovation, these efforts may be inefficient, leading to higher costs and greater environmental degradation. ➤ Lack of innovation results in a static economy where traditional industries dominate, and CRM consumption remains steady and muted. The absence of available end-of-life products and materials as well as new technologies exacerbates resource inefficiencies and environmental impacts. ➤ Isolationist policies dominate, with high tariffs on imported goods and strict controls on foreign investment. These policies diverge from the global trade and diversification strategies seen in other scenarios. The approach leads to reduced access to global CRMs, further straining domestic resources. This could lead to resource shortages, economic decline, and increased reliance on environmentally damaging mining practices. ➤ Environmental and social governance regulations are weak or selectively enforced, reflecting a divergence from the ESG consensus seen in other countries. Policies may prioritise economic survival over environmental protection. Weak implementation of regulations results in significant environmental degradation, particularly as domestic mining expands into protected areas. This could lead to long-term ecological damage and social unrest, exacerbating the challenges faced by the EU in this scenario.

Annex 2 - “What If’s” roleplay gaming framework

Concept of the game

Objective	It consists of a discussion-based game, oriented to foster interaction amongst the players towards decision-making.
Skills	Designed to enable players to develop abilities useful in conflict-management, diplomacy, and other cooperative environments where decision-making and consensus are of daily practice.
Topics addressed	Green transition, clean energy, new technologies/technological development, consumers’ practices, market supply-demand trends, CRM availability/dependency in the EU and the world, local awareness, community engagement/civil society mobilisation, role of governmental and political leaders (multiscale), employment, health, environmental impacts, etc.
From a global and European framework to a local geographical focus	Aimed at fostering local-based discussions, with a general awareness of the global and European umbrella within which the discussion is framed. This enables for concrete local-themed outputs and solutions, allowing players to better connect with the game’s purpose and content and feel more integrated and participatory of the discussion and its outcomes, hence fostering their “sense of belonging” to the community and to the potential solution to the issues at stake. They might later bring these issues to other sectors of their community/local environment, fostering new conversations with more diverse groups, acting as multipliers.
Target group	Regarding the age of the participants, the first version of the game is aimed at adult public (+18). Yet, the game can experience adaptations in its future editions, envisioning a design targeting children or young people (for example, to be implemented with students from primary to university courses). The design can be further amended in the future to comply with specific accessibility criteria to enable for a more inclusive participation of all society groups, including the elderly communities, or people with any physical impairments such as visual or hearing loss.
Language	The original language of the game is English as the official language of the EU-funded project CIRAN. The game materials have been translated with the help of Consortium partners to the official languages of the local communities where the game would be tested, including Italian, Czech, Portuguese, etc. Editions of the game in Portuguese, Italian, and Slovak will also be made available in the coming months for the upcoming activities in these countries. Further translations of the game could be provided upon request.

Content of the game

- Character (roles) **cards**
- Instructions, including **guiding questions** to facilitate the group discussion. Cards including questions to make decisions on.
- Card/Visual with **Scenario key points** and **What If** to familiarise themselves with the topic/situation (introduced previously during the session).

Methodological approach of the game

Preliminary note: This game will be played after there has been an introduction by CIRAN partners, where the topic of CRMs/use of materials is easily explained to them (no jargon, no technical language). This is outlined in the methodology for community events developed in WP5 and intended to allow for a much more meaningful and informed discussion based on the gaming-What If's framework.

Each participant will put themselves in the shoes of a different stakeholder. They will be expected to engage in the discussion from that perspective, not necessarily aligning their contributions with their own thoughts on the topics discussed. This will enable a multi-perspective discussion, mitigating the risk that all or most participants in the conversation will be aligned in their point of view from the beginning, since they would come from the same community and might be biased by the local/regional cultural influences, their employment status/sector, their community beliefs, etc.

This will induce each participant to discuss the issues at stake not from their own point of view but from the character they represent, fostering the development of out-of-the-box thinking and developing interpersonal intelligence abilities such as empathy and mutual understanding.

Character cards

Characters represent the various stakeholders in the debate. Each character card will have a **name**, **background** information, **role**, **personality traits**, and **viewpoint** on the issue. These sample character cards may be modified in the version of the game that will be used for implementation in WP5 events.

Environmental scientist

- **Name:** Free
- **Background:** A leading environmental scientist specializing in ecosystems and biodiversity.
- **Role:** Advocate for environmental preservation in the local/regional branch of a European/international NGO.
- **Personality Traits:** Logical, detail-oriented, passionate about conservation.
- **Viewpoint:** Opposes extraction in or near the protected area, citing the potential damage to local wildlife and ecosystems.

Local farmer

- **Name:** Free
- **Background:** A local farmer whose land borders the protected area.
- **Role:** Concerned local landowner.
- **Personality Traits:** Practical, community-focused, independent.
- **Viewpoint:** Undecided but leaning against mineral extraction. Worried about the potential disruption to the land, water sources, and the local climate, but also sees economic potential if done responsibly, although would need to see how this affects the land they're working

Believes the area is too valuable to sacrifice for short-term economic gain.	with and their current economic activity - which is, nevertheless, decreasing and generating less income than ever.
Mining company CEO ○ Name: Free ○ Background: CEO of a mining company looking to expand operations. ○ Role: Advocate for resource extraction. ○ Personality Traits: Confident, results-driven, persuasive. ○ Viewpoint: Supports extraction, arguing that it will boost the economy, create jobs, and provide critical resources for the community. Believes modern technology can minimize environmental impact.	Local/regional government official, Office for the Environment and Sustainable Agenda ○ Name: Free ○ Background: The town's third advisor to the mayor, responsible for making or influencing the final decision based on the environmental perspective. ○ Role: Mediator and decision-maker, with a master's in environmental sciences from a prestigious foreign university. Part of a network of European municipalities advocating for sustainability. ○ Personality Traits: Diplomatic, pragmatic, and good communicator. ○ Viewpoint: Sees both sides. Wants to balance economic growth with protecting the natural heritage of the area, much more leaning towards the latter given their position in the local/regional government. Interested in a sustainable solution that benefits the community in the long term.
Local/regional government official, Office for Markets, Economy, and Technological Growth ○ Name: Free ○ Background: The town's second advisor to the mayor, responsible for making or influencing the final decision based on the economic and technological perspective. ○ Role: Profit driven, tech geek, convinced decision-maker, member of a network of international municipalities advocating for technological progress, AI, and smart cities and tech hubs. ○ Personality Traits: Proactive, intellectual, convincing communicator. ○ Viewpoint: Driven by technological development. Observes what is happening in other countries, mainly outside of Europe, and wants the same	Local community association leader ○ Name: Free ○ Background: Leader of the local community association who believes in the societal spiritual and ancestral connection to the land. ○ Role: Advocate for the importance of spiritual and cultural heritage connected to nature. ○ Personality Traits: Wise, deeply connected to nature, proud of cultural traditions, calm, and patient. ○ Viewpoint: Opposes current extraction methods and philosophy (for profit). Believes the land is sacred and must be preserved for future generations. To them, nature and humans are at the same level and, hence, destructive extractive

for the municipality/region. Prioritises economic growth over the natural protection of the area, arguing that this will not bring economic benefits to the population and the local businesses in the long-term. Yet, technology labs and innovation hubs will.	techniques are exploiting nature and disrespectful to society. Defends ancestral knowledge and practices prior to “green-washing” and technologically driven techniques.
Tourism operator ○ Name: Free ○ Background: Owner of a small locally owned eco-tourism business that brings visitors to the protected area, with georoutes and sport activities to consciously explore the site. ○ Role: Advocate for eco-tourism, with a high respect for nature over economic profit. ○ Personality Traits: Optimistic, community-oriented, entrepreneurial. ○ Viewpoint: Opposes extraction, as it could harm the area's natural beauty and biodiversity, which is the foundation of their business. Advocates for sustainable tourism to generate income (without unnecessary capital accumulation) without harming the environment.	Multinational electronic store worker ○ Name: Free ○ Background: Works in the local store of a multinational electronic brand, whose products mainly depend on resource extraction and global supply chains. ○ Role: Worker in the resource extraction industry. ○ Personality Traits: Practical, flexible and emphatic, but pragmatic. ○ Viewpoint: Supports extraction in general, as it provides the resources currently needed for the technologies and products that have become “basic” for our daily lives, which people from all ages and groups come to buy at the store they work at, searching for the cheapest offer. Defends that extraction provides job opportunities, however, thinks that most products are currently produced outside of Europe, and we should be concerned about the long-term effects on the environment and the local/regional economy.

Game instructions

How to play? ✓ Each group shall be formed by 6-8 players ✓ Each participant (player) will start by picking up a card (role) blindly ✓ They will read their card, not showing it to others ✓ The facilitator will present the “What If” again (presented during the previous part of the session), to remind players of their context for discussion ✓ They will have time for discussion, to reach a conclusion on whether they can make a decision based on the “What If” question and their perspectives (roles)* ✓ Once the moderator announces the end of the discussion, players will have 3-5 more minutes to define their final decision and put it into writing (with, e.g., 3 bullet points) in the “What If” card (presented during the first part of the session)
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- ✓ Players within each group will reveal each other's roles, trying first to guess what everyone was representing
- ✓ At the end of the game, the players will become participants again, and leaving their role aside, they will engage in a feedback round, sharing their valuable contributions that will help improve the future versions of the game concept and implementation.

Each group will be invited to share the discussion's main outcomes and anecdotes from representing the various roles with the rest. Then, the moderator will ask each group if they were able to guess the other players' characters in their group and explain to the rest of the participants in the room how they guessed it (if they did). All participants will be invited to provide feedback to the moderator regarding the design and implementation of the game, including any difficulties encountered in representing a character whose view was not aligned with their own. Such input shall be used for improving further editions of the game to be tested in future occasions.

**The duration of the discussion will vary based on the event's whole structure, but should be at least 20 minutes long. This shall be done in coordination with the WP5 leader and the organisers of the event.*