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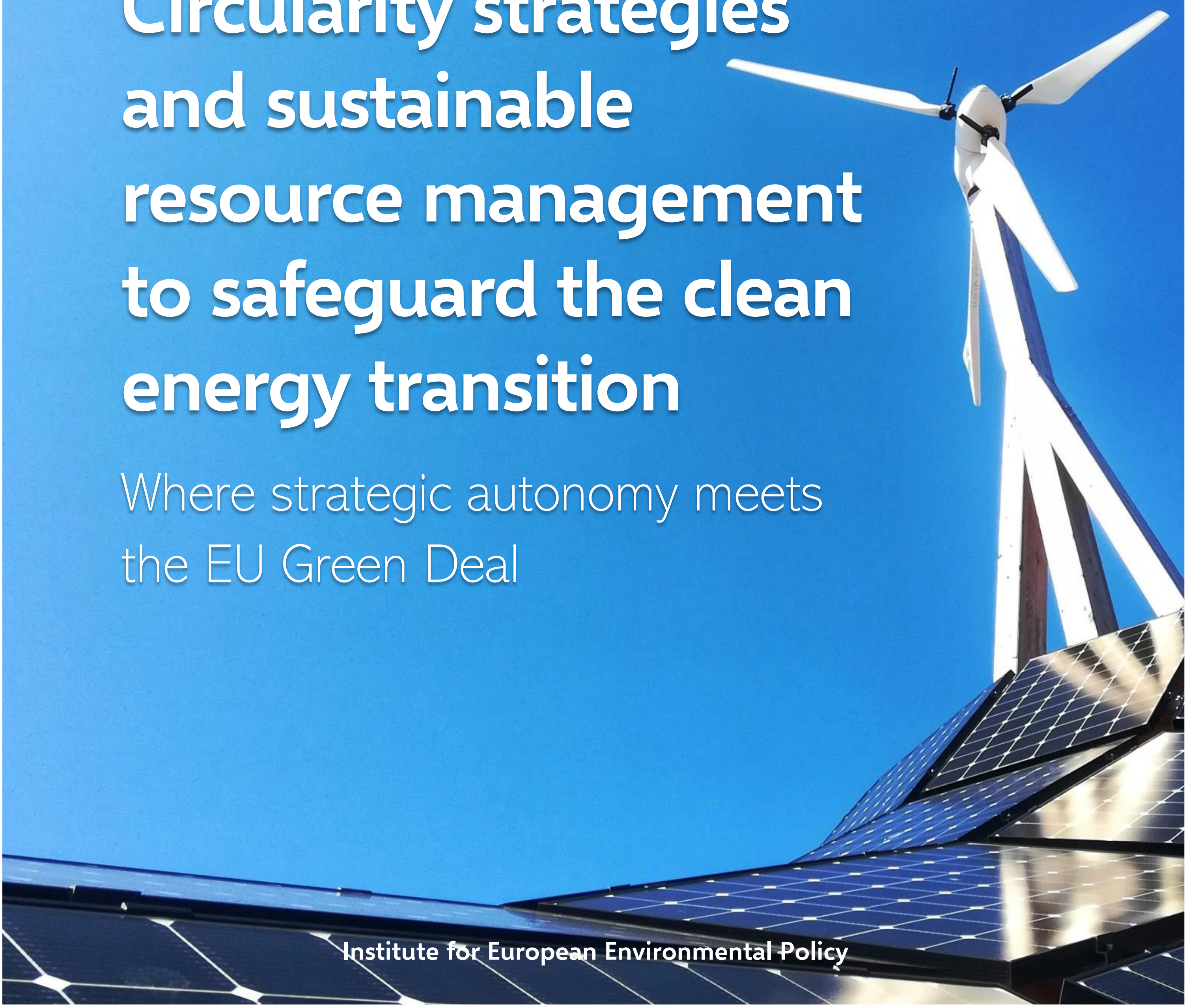
Policy report

Circularity strategies and sustainable resource management to safeguard the clean energy transition

Where strategic autonomy meets the EU Green Deal



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EXECUTIVE SUMMARY

This report is the final deliverable of the project "Review and assessment of EU policies for the use of Critical Raw Materials" implemented by IEEP with the financial support of the Finnish Innovation Fund Sitra. This synthesis report aims to inform stakeholders about the EU's plans to safeguard its clean energy transition ambitions. Specifically, this report highlights how the uptake of circular economy strategies can contribute to the EU's strategic autonomy agenda while being compatible with the Paris Agreement and the Sustainable Development Goals (SDGs). This report also reflects on the EU's overall material footprint in the context of global equities as the Union transitions to a climate-neutral and circular economy.

With nations increasingly investing in their domestic capacities to safeguard their strategic autonomy to produce key technologies for the clean energy transition in addition to defence, space and digital applications, the global demand for critical raw materials (CRMs) to produce these technologies has skyrocketed. The EU, being far from self-sufficient in sourcing the CRMs required for these technologies, published the European Critical Raw Materials Act (ECRMA) in March 2023 which aims to improve the availability and secure a stable supply of CRMs to deliver the clean energy transition. The ECRMA proposes several targets to strengthen the EU's position: by sourcing more primary and secondary CRMs internally through extraction, processing and recycling, and by diversifying its imports of CRMs from resource-rich countries through Strategic Partnerships.

The project's first deliverable "Circularity and the European Critical Raw Materials Act" explores how circularity can support ECRMA targets and recommends measures to achieve these targets while promoting a circular economy. The second deliverable "Sourcing critical raw materials through trade and cooperation frameworks" examines existing frameworks for CRM trade and cooperation and their role in a global just and clean energy transition.

The main gaps identified in these briefings reflect the missed opportunities to strengthen the responsible and circular sourcing of CRMs. The table below presents the main gaps concerning the external sourcing of CRMs, the Strategic Projects and Partnerships and circularity gaps in the ECRMA (i.e., gaps between legislative ambition in the ECRMA and current levels of circularity).

Considering the speed at which not only the EU but all industrialised countries aim to boost their strategic autonomy and secure a stable supply of CRMs, this report highlights the intricacies of maintaining an equitable share of demand for

CRMs and safeguarding the clean energy transition to remain compatible with the Paris Agreement.

Strategic Project & Partnership gaps	Circularity gaps
They do not uphold a sufficiently high level of ESG standards to ensure that projects and third countries' regulatory frameworks are aligned with international agreements and standards. **They lack concrete definitions or initiatives to foster value addition** in the trade partner country. Examples of value-addition green industrialisation could be assisting the shift away from third countries' primary raw materials towards developing their industrial capacities to produce inputs or final products for the global green transition. **They fail to prioritise the roll-out of circular projects and business models**, such as recycling or processing projects employing circular best practices.	**There is inadequate attention to product design for circularity** to increase longevity and facilitate the access, removal and recovery of CRMs at the end of the product's life. **There is a lack of information on product composition and materials**, which can lead to the loss of CRMs at the end-of-life stage. **Little attention to the low collection and recycling rates for many CRMs** in the EU which contributes to missed opportunities to improve CRM circularity through recycling. **There is a lack of adequate recycling facilities, technologies, and economic viability of recycling**, which can reduce both the quantity and quality of CRM recycling, thereby hampering circularity.

Though **CRMs equal only a small share of the EU's total material footprint**, they receive significantly more attention than traditional metals due to their price volatility and soaring demand. Moreover, their central role in the clean energy transition only further highlights existing material footprint inequities between the Global North and South as the former endeavours to achieve climate neutrality. However, it is important to keep in mind that decarbonisation and material footprint reduction are not at odds with one another and that **a decarbonised economy will require fewer materials overall than the current fossil-based economy**. Yet, until the uptake of more circular economy strategies becomes more mainstream in our economic models, **the demand for CRMs will continue to increase in the coming years before it decreases**.

However, as the EU's overall circularity rate has remained relatively stable over the past decade fluctuating between 11-11.5%, significant efforts remain to be undertaken to promote the uptake of circular economy strategies in the Union. This report presents the application of the **9Rs list of circularity strategies** to increase material usefulness, extend product lifecycles, and encourage smart product use and production. **Recovery** and **recycling** are the most widely applied in the linear economy, the latter being especially important as secondary CRMs retain their value which is relevant for materials facing price volatilities. Considering this value retention, the EU must consider guaranteeing its ability to process these secondary materials as opposed to exporting them for End-of-Life (EoL) treatment.

Re-use, repair, refurbish, remanufacture, and **repurposing** aim to extend product lifecycles, the former four being most relevant for the Ecodesign for Sustainable Products Regulation (ESPR) which aims to enhance a product's durability, reusability, repairability, recyclability, upgradability, and environmental impact. The uptake of the latter strategy, repurposing, is not as common throughout EU legislative proposals as it is a bit more creative, for example repurposing a household storage battery with an EV battery.

The final three circularity strategies aim to encourage smarter product use and manufacturing. **Reducing** the overall quantity of materials used for production can be encouraged by setting a minimum recycled content rate and by providing incentives for businesses to innovate their production method to increase their material efficiencies and product longevity. **Rethinking** how certain goods are bought and used can significantly increase product use intensity. Here, the role of circular business models is particularly relevant, such as product-as-a-service models and sharing platforms. **Refusing** is linked to the untapped potential of demand-side solutions that maintain or increase well-being levels while decreasing pressure on planetary boundaries.

This report also reflects on the EU's overall material footprint. Though CRMs are used in relatively small quantities, their use is still coupled with that of other materials to produce key defence, space, digital and clean energy technologies. Considering that the EU has transgressed the planetary boundaries for five impacts and the effect of material overuse on achieving the SDGs, this report highlights the policy option to **design a long-term sustainable resource management strategy** as a solution to the triple planetary crises of climate change, biodiversity loss, and pollution. Such a strategy could outline required actions to be undertaken by governments to facilitate not only an industry-wide shift to more circular practices (recalling the 9Rs list) but also induce society-wide systemic changes. This strategy could include ambitious but amenable targets for material footprint reduction, considering that the impact of material use varies between types of materials and over time with changing practices and innovation.

Maintaining a dual focus on decarbonisation and reducing its material footprint, both of which are essential for the EU to meet its climate and circularity goals and get within planetary boundaries, this report puts forward several recommendations for EU policymakers:

Address gaps in the Strategic Project and Partnership approaches to ensure mutually beneficial economic and environmental outcomes for both Parties. These approaches should prioritise high ESG standards, circularity and add value towards global green industrialisation.

Tackle circularity gaps in the general approach to managing CRMs by ensuring policy coherence between the ECRMA, ESPR, EU Batteries Regulation, Waste Framework Directive, and the Waste Shipment Regulation. These legislations should serve to maximise CRM usefulness by lengthening product lifecycles, improving material efficiencies, and guaranteeing the appropriate management of high-value EoL CRM-products and scrap metals.

Encourage the uptake of the 9Rs circular economy strategies in CRM-relevant sectors and products. This should go hand in hand with safeguarding EU secondary raw material processing, supporting innovative product design for material efficiency, and backing ambitious circular business models and societal changes.

Contribute to closing the circular divide by pursuing multilateral cooperation efforts, including financing and capacity building. As both demand for CRMs and the application of circular economy strategies increase, the Global North will inevitably accumulate CRMs originally extracted in the Global South.

Evaluate overall material footprint levels and benefits of a long-term strategy for sustainable resource management as a solution to the triple planetary crises of climate change, biodiversity loss, and pollution.

1. A EUROPEAN CRITICAL RAW MATERIALS ACT

The demand for critical raw materials (CRMs) at a global level is quickly rising (Gregoir & van Acker, 2022) as the Global North doubles down on industrial policies to reduce emissions and upscale their clean energy industries, defence, digital and space technologies. Indeed, the race for CRMs for the clean energy and digital transition is well underway and has spurred new policies and initiatives in developed countries.

The EU's strategy to become a global frontrunner of clean technologies and achieve the EU's 2050 climate neutrality target is outlined in its Green Deal Industrial Plan. Part of that plan, known as the Net-Zero Industry Act, aspires to bolster the regulatory framework and accelerate the deployment and permitting of domestic projects to build up the EU's capacity for clean technologies. However, the EU's ability to re-shore and establish a leading net-zero industry largely depends on the consistent availability of CRMs.

Several CRMs play a pivotal role in advancing the clean energy transition, such as enabling the production of electric vehicles (EVs), battery storage systems, the scaling up of electricity grids, and the manufacturing of wind and solar photovoltaic (PV) panels. Consequently, the International Energy Agency predicts a substantial surge in global demand for materials like aluminium, cobalt, copper, lithium, manganese, nickel, and rare earth oxides (REOs) by 2040 (IEA, 2021).

As a means to address the EU's stocks of CRMs, the European Commission published its proposal for a European Critical Raw Materials Act (ECRMA) in March 2023 (European Commission, 2023c). The Act aims to improve the availability and secure a stable supply of CRMs to deliver the clean energy transition. After an exceptionally swift policy process, the EU Institutions reached an agreement on the ECRMA text in November 2023. The European Parliament and Council adopted the agreed text in December and March 2024, respectively (Council of the EU, 2024; European Parliament, 2023). On 23 May 2024, the Regulation officially entered into force, with a scheduled first meeting of the CRM Board – meant to advise member countries and the Commission – to discuss its rules and procedures, the process for the selection of strategic projects, future financing, Strategic Partnerships, monitoring and stockpiling of critical raw materials (Official Journal of the EU, 2024b).

Achieving the clean energy transition will undoubtedly be accompanied by an increase in the EU's demand for raw materials required to produce clean technologies and end products. However, the EU's current material footprint of 14.8 tonnes per capita stands well above the global average. It is estimated that for the EU's material use to remain within the planetary boundaries and amount to an equitable share of the earth's resources, that figure should be halved (EEA, 2023). The share of metallic materials makes up about 10% of the EU's material footprint, or 1.48 tonnes per capita, with biomass (21%), fossil-energy materials (18%), and non-metallic materials (51%) making up the bulk of EU material use. Notably, since 2010, the share of fossil-energy materials has decreased while non-metallic materials increased. Yet, the EEA highlights that the total material footprint climate and environmental impact of non-metallic materials is less than that of metals and fossil fuels (EEA, 2023).

This project aims to inform stakeholders about the EU's plans to safeguard its clean energy transition ambitions while identifying how the uptake of circular economy strategies can contribute to the strategic autonomy agenda while being compatible with the Paris Agreement and the Sustainable Development Goals (SDGs). Moreover, additional reflections are made concerning the EU's overall material footprint in the context of global equities as the Union transitions to a climate-neutral and circular economy. This project's first deliverable "Circularity and the European Critical Raw Materials Act" considers how circularity can support the targets proposed in the ECRMA and proposes recommendations for measures that could help to realistically achieve these targets while promoting a more circular economy. The second deliverable "Sourcing critical raw materials through trade and cooperation frameworks" examines existing frameworks for trade and cooperation on Critical Raw Materials with key partners and highlights the role of trade and cooperation approaches to achieve a global just and clean energy transition.

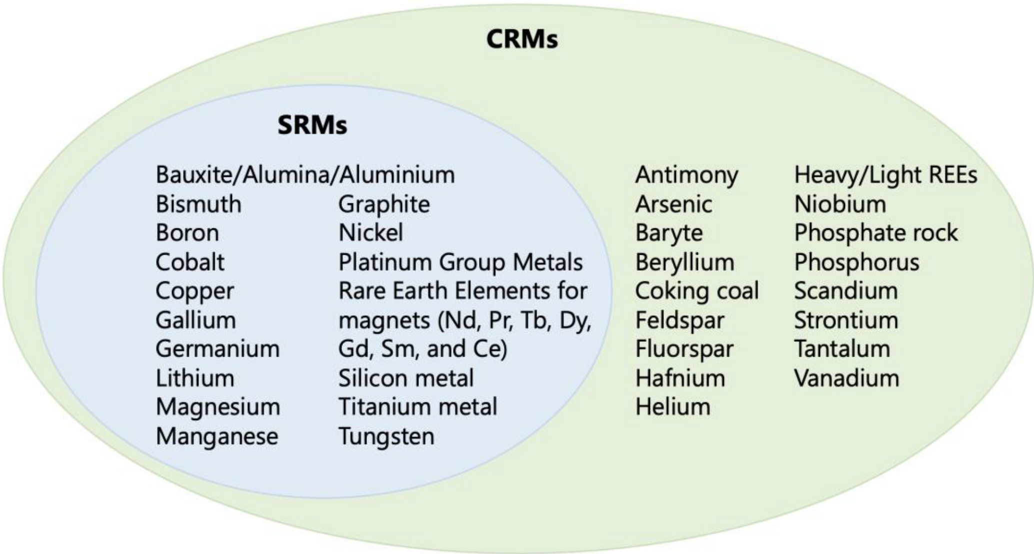
This final policy report provides a brief overview of the ECRMA (Sections 1.1-1.5) and synthesises the findings from the previous two briefings in addition to the EU's plans to launch new extractive projects in the Union (Section 2). In Section 3, this policy report reflects on the role of circular economy strategies in delivering the clean energy transition (Section 3), as increased material efficiencies contribute positive impacts on climate and environment and thus the EU's Green Deal objectives, in addition to reflections concerning the EU's material footprint. The final section of this policy report provides a conclusion summarising the main findings of this policy report and a list of recommendations (Section 4).

The following subsections (Sections 1.1-1.5) provide an overview of the main elements of the ECRMA which are highly relevant to the sourcing of CRMs for the clean energy transition such as the objectives and targets, strategic project and partnerships, risk monitoring, and circularity elements.

1.1 Objectives and targets of the ECRMA

The European Commission defines materials are defined as "critical" based on their importance for the European market and the risk of supply chain disruption. Of these CRMs, the ECRMA[1] establishes a subcategory of CRMs, known as strategic raw materials (SRMs), which are those materials considered both highly strategic and at risk of future supply and demand imbalances. Furthermore, the European Commission expands the 2020 CRM list from 30 CRMs to 34 in the ECRMA. Figure 1 below provides an overview of the CRM and SRM lists.

Figure 1: List of CRMs and SRMs in the ECRMA



The main objective of the ECRMA is to boost the domestic availability of CRMs by facilitating domestic extraction, processing, and recycling of CRMs and diversifying the EU's external supply. This overarching objective will be achieved by addressing:

1. The EU's low diversification of supply sources, leading to its high dependency on specific countries, and consideration of EU domestic sourcing of CRMs through new mining activities;
2. The adverse social, environmental, and human rights impacts of CRM mining operations, currently outsourced to other countries;
3. The lack of circularity for CRMs in existing regulatory frameworks;

[1] As adopted by the European Parliament in December 2023 unless otherwise stated as the European Commission's proposal for a Regulation.

4. Monitoring and risk management mechanisms to anticipate and prevent disruptions in the supply of CRMs; and
5. Research & innovation to provide necessary solutions across the CRM value chain.

Following the inter-institutional negotiations on the proposal, the ECRMA proposal's targets were revised to increase the EU's sourcing of SRMs from domestic recycling from 15% to 25%. Accordingly, EU consumption of SRMs by 2030 should be sourced from the following four areas:

1. 10% from domestic extraction;
2. 40% from domestic processing;
3. 25% from domestic recycling; and
4. The remainder is from a diversified external supply, of which no single country's supply share should exceed 65% of any SRM.

1.2 Strategic Projects and Partnerships (in third countries)

Strategic Projects (SPs) play a critical role in the EU's strategy for securing a stable supply and strategic stock of SRMs. These projects aim to directly improve and contribute to the achievement of the ECRMA's overall targets above. There are slightly different approaches to SPs located inside versus outside of the EU, specifically in developing countries and emerging economies. To be recognised as and receive the priority status of an SP, projects must[2]:

1. Meaningfully contribute to the security of the EU's supply for SRMs;
2. Be, within a reasonable timeframe, technically feasible and can report an expected production volume with a sufficient level of confidence;
3. Be implemented sustainably and meeting the adequate environment, social and governance (ESG) criteria;
4. Produce cross-border benefits beyond the Member States (MS) for SPs in the EU.
5. Be mutually beneficial, adding value to the EU and the third country for SPs outside the EU.

To apply for the status of an SP, project promotors must develop and send their applications to the European Commission. For SPs outside the EU, the Commission shall share the application with the third country and condition its

[2] Annex III of the ECRMA provides more information regarding the recognition criteria for SPs.

approval of the SP to the prior approval of the third country. Concerning extractive projects abroad, the application shall be accompanied by a plan to restore the environmental state of the project site upon closure, considering the technical and economic feasibility of doing so.

The maximum duration of the permit granting process for SPs in the EU shall be 27 months for SPs involving extraction and 15 months for SPs involving processing or recycling. For SPs outside the EU, the maximum duration is not specified as the approval process is subject to the third country and the European Commission's approval. A national competent authority shall grant the permits to SPs in the EU and shall be set up within nine months of entry into force of the Regulation. It is up to the MS to provide adequate resources, including qualified staff and the necessary financial, technical, and technological resources, to enable effective implementation of tasks under this Regulation.

The EU's strategy to disseminate SPs in resource-rich countries is by pursuing targeted raw materials Strategic Partnerships. The Strategic Partnerships aim to secure the EU's supply of CRMs through diversification of EU imports of CRMs and improve cooperation along the CRM value chain fostering economic and social development in the partner country through capacity building, technology transfer programs, promoting sustainable and circular practices, decent working conditions, and human rights (European Parliament, 2023). The European Commission will take into account several criteria for the negotiation of a Strategic Partnership with a third country:

1. A country's potential reserves, extraction, processing, and recycling capacities;
2. The potential to improve a third country's regulatory framework for monitoring, prevention and minimisation of environmental impacts, socially responsible practices, in addition to transparent business practices and robustness of public administration and the rule of law;
3. Existing cooperation agreements with the EU with potential utilisation of Global Gateway investment projects;
4. If and how a partnership adds value to the partner country.

Since 2021, the EU has signed ten Strategic Partnerships on raw materials with countries such as Canada, Ukraine, Kazakhstan, Namibia, Argentina and Chile, the latest being with Australia on 28 May 2024. For more information on the EU's approach to sourcing CRMs through trade and cooperation frameworks, consult this project's second briefing (Blot, 2024).

1.3 Risk monitoring and mitigation

The ECRMA includes specific provisions related to the monitoring and mitigation of CRM supply risks for both the European Commission, the MS and large companies in the MS.

The Commission shall monitor and make public supply risks such as trade flows in and outside the EU of CRMs, supply and demand trends, concentration of supply, EU and global production and capacities for production along the value chain, price volatility, bottlenecks concerning EU production or SPs in the EU, and potential obstacles to trade in raw materials or in goods that use CRMs as input within the internal market. The MS are expected to contribute to this monitoring exercise where relevant, in addition to reporting on strategic stocks of SRMs, on new or existing CRM projects and key market operators along the CRM value chain.

Within twelve months following the entry into force of the ECRMA[3], the MS are required to identify large companies within their borders that use SRMs to manufacture specific products for the clean energy and digital transition[4]. These companies are expected to conduct a risk assessment of their SRM supply chain every three years, which would involve:

1. Mapping the extraction, processing and recycling of relevant SRMs used;
2. Analysing factors that might affect their SRM supply;
3. Assessing their company's vulnerabilities to supply disruptions of SRMs.

In light of the findings of these risk assessments, companies that might face supply vulnerabilities of their relevant SRMs shall make efforts to develop and implement mitigation measures to address these weaknesses in their supply, which could include the diversification of their supply chains or the substitution of certain SRMs.

[3] And twelve months following an update of the SRM list.

[4] E.g., batteries for energy storage and e-mobility, equipment related to hydrogen production and utilisation, equipment related to renewable energy generation, aircrafts, traction motors, heat pumps, data transmission and storage, mobile electronic devices, equipment related to additive manufacturing, robotics, drones, rocket launchers, satellites or advanced chips.

1.4 Circularity and sustainability

Circularity aspects of the ECRMA relate mostly to the achievement of the Regulation's recycling target, namely that by 2030, 25% of the EU's annual consumption of SRMs should be met by EU recycling capacity. Accordingly, the ECRMA highlights the need to enhance the circularity and sustainability of CRMs to ensure a high level of environmental protection and outlines provisions to achieve this objective, including provisions on due diligence certification schemes and environmental footprint declaration.

Considering the EU has several existing legislations[5] on the treatment of raw materials, the ECRMA provisions on circularity establish a new baseline for the treatment of products with high potential for CRM recovery rather than setting targets for the recovery or use of recycled content. To this end, the Commission will adopt implementing acts to define a list of products, components and waste streams that are considered to have high CRM recovery potential. Subsequently, the increase in collection rates and improvement of the treatment processes to maximise CRM recovery will be left to the MS. The MS are also required to identify and report on the quantities of CRM-embedded products and CRMs recovered.

The ECRMA places new requirements for the recovery of CRMs from extractive waste and permanent magnets. Operators of extractive waste-generating facilities are expected to assess and submit plans on the potential for CRM recovery in their facilities. Regarding permanent magnets[6], the new requirements aim to facilitate their recyclability and establish a minimum recycled content obligation. Moreover, products containing these permanent magnets must include a data carrier[7] with information on the responsible manufacturer, the weight, location, and chemical composition of the magnet(s) in the product, and instructions on how to access or remove the magnets from the product.

Overall, the circularity elements in the ECRMA focus on leveraging post-consumer waste. This includes improving recycling processes and capacity, increasing the use of secondary CRMs with minimum recycled content requirements, and encouraging waste prevention by increasing reuse and repair of CRM products.

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[5] E.g., the Extractive Waste Directive, the Waste Framework Directive, the Waste Electrical and Electronic Equipment (WEEE) Directive, the End-of-Life Vehicles (ELV) Regulation and the EU Batteries Regulation.

[6] Products containing one or more permanent magnets belonging to the following types: Neodymium-Iron-Boron, Samarium-Cobalt, Aluminium-Nickel-Cobalt, or Ferrite.

[7] The information on this data carrier will be carried over onto the digital products passport for products also covered by the Ecodesign for Sustainable Products Regulation.

2. GAPS LIMITING A RESPONSIBLE AND JUST CLEAN ENERGY TRANSITION

This section provides an overview of the gaps this project has identified relating to the responsible and just implementation of the EU's clean energy transition. It focuses on gaps identified in the ECRMA related to circularity, the sourcing of CRMs abroad, and plans for domestic extraction.

2.1 Gaps related to circularity

The first briefing of this project considers how circularity can support the targets proposed in the ECRMA, and proposes recommendations for measures that could help to realistically achieve these targets while promoting a more circular economy (Watkins, Bergeling, & Blot, 2023).

This briefing was published before the Trilogues, meaning that it accounts for the initial proposed recycling target of 15%, rather than the revised target of 25%. Regardless, the recommendations of the briefing remain unchanged as the average end-of-life recycling input rate (EoL-RIR) across the 34 CRMs identified for the EU is only 8.3% (with some higher but many at 0%). There is therefore still a significant gap to bridge to improve the circularity of CRMs – and in particular, recovery and recycling – to achieve the ECRMA's recycling objective. The briefing identifies five circularity gaps, assesses how well the ECRMA addresses them, and suggests what more could or should be done to make a more significant contribution to circularity.

The first gap identified is **inadequate product design for circularity**, with products still often not designed with longevity in mind or facilitating the access, removal and recovery of CRMs at the end of the product's life. The ECRMA notes that the requirements developed under the Ecodesign for Sustainable Products Regulation (ESPR) must be in line with the ECRMA's domestic recycling capacity target, and include specific provisions related to improving the circularity of permanent magnets. To further address this gap, the briefing recommends that: (i) the ECRMA text, or implementing acts or guidance, provide more clarity on how to consider recovery potential for CRMs in Ecodesign, (ii) the implementation of the ECRMA should include mechanisms to account for technological developments over time to ensure they don't act as a barrier to CRMs' circularity, and (iii) coherence should be ensured between the ECRMA and product and waste legislations with regards to promoting circularity (including regarding collection, recovery and recycling targets and design-related aspects).

The lack of information on product composition and materials is a second circularity gap of the Regulation, which can lead to the loss of CRMs at the EoL stage. The ECRMA requires labelling and online information on CRM content to be provided for products containing permanent magnets. To further address this gap, the briefing highlights the need for (i) clear product labelling and product passports to enable improved CRM circularity, and (ii) requirements for labelling and product passports for all products containing viable recoverable amounts of CRMs.

The EU's current **low collection and recycling rates for many CRMs** is a third circularity gap, which contributes to missed opportunities to improve CRM circularity through recycling. The ECRMA requires MS to adopt and implement national programmes to help increase collection and recycling rates of wastes with high CRM recovery potential, to promote CRM recovery from extractive and mined waste, and to report quantities of CRM-containing components removed and recovered from WEEE. To further address this gap, the briefing recommends that: (i) the recycling target (of 15% at the time) be broken down into individual targets for specific SRMs, (ii) the Commission assess whether adequate EU funds are available to support MS in the required actions, and (iii) there is coherence concerning product collection targets set in other product and waste legislations to support the ECRMA's recycling target.

A fourth gap is the **lack of adequate recycling facilities, technologies, and economic viability of recycling**, which can reduce both the quantity and quality of CRM recycling, thereby hampering circularity. The ECRMA notes the need to strengthen EU recycling capacities and improve recycling technologies and allows recycling projects to be categorised as Strategic Projects, as well as requiring MS national programmes to aim to increase the technological maturity of CRM recycling technologies. To further address this gap, the briefing recommends that: (i) the Commission assess whether adequate EU funds are available to support MS in the required actions, (ii) Best Available Techniques reference documents (BREFS) or other EU-level guidance should be developed on CRM recycling technologies, and (iii) market-based instruments should be promoted as a tool to send price signals in support of recycling and the use of secondary CRMs.

The EU's current **overall high levels of material use** is the fifth and final identified circularity gap. Section 3 of this policy report dives further into the EU's material footprint and the role of circular economy strategies in achieving the EU's climate and clean energy ambitions.

2.2 Gaps related to the external supply of CRMs

The second briefing of this project examines the EU's existing frameworks for trade and cooperation on CRMs with key partners such as Chile, Canada, Kazakhstan, Namibia and the US. It highlights the role of trade and cooperation approaches to achieve a global just and clean energy transition (Blot, 2024).

As highlighted in Section 2.1 of this report, despite the EU's endeavours to increase its sourcing of CRMs from recycling, demand for primary inputs of CRMs will increase to meet the expected rise in demand for the clean energy transition before it can decrease. Therefore, in the short term, the role of EU trade and cooperation frameworks to secure a reliable, responsible and circular supply of CRMs from third countries is especially critical.

Considering the global distribution of CRM reserves, the EU has sought to conclude free trade agreements (FTA) with like-minded countries such as Australia, Canada, and Chile with the introduction of chapters on raw materials to establish market principles and harmonise standards and regulatory practices. The FTA approach allows the EU to diversify its imports in exchange for commitments from the trade partner country, including on ESG issues. Import diversification is essential for the EU as it seeks to reduce import dependencies from resource behemoths such as China and Russia, both housing reserves and/or processing facilities, particularly for CRMs most essential for the clean energy transition.

However, FTAs often take several years to negotiate, therefore the EU is now leveraging a new framework to meet its urgent need for CRMs. Specifically, by rolling out Strategic Projects under the framework of Strategic Partnerships which set the terms of cooperation on CRMs with a third country. The mineral-focused approach is favourable in terms of time sensitivity, yet it does not adequately embed responsible mining and sustainability practices at its core. Our second briefing finds three main gaps concerning the EU's Strategic Partnership and Projects approach (Blot, 2024):

Strategic Partnerships and Projects do not uphold a sufficiently high level of ESG standards to ensure that projects and third countries' regulatory frameworks are aligned with international agreements and standards. The Memorandums of Understanding utilise general language to describe "improving sustainability along the CRM value chain" and "elevating ESG standards". Yet with only a few publicly available roadmaps to evaluate how this bolstering of sustainability is planned, the issue of embedded sustainability into the EU Strategic Partnership approach remains under-addressed. Strategic Projects must also adhere to ESG criteria; however, the EU relies on third-party certification schemes, deemed insufficient to ensure compliance with human rights and environmental regulations.

There is a lack of concrete definitions or initiatives to foster value addition in the trade partner country. Rather than approaching resource-rich countries with the primary objective of securing the EU's supply of CRMs, the overall aim of the Strategic Partnerships – and, by extension, the Projects – should be to create an environment to advance the clean energy and digital transitions in the EU and the third country while maintaining alignment with the SDGs (with particular focus on SDG 3 Good Health and 6 Access to Water for All). Examples of value-addition green industrialisation could include assisting the shift away from third countries' primary raw materials towards developing their industrial capacities to produce inputs or final products for the global green transition, supporting technological developments by investing in R&D, encouraging technology transfers through joint venture partnerships or licensing, capacity building and knowledge sharing.

Failure to prioritise the roll-out of circular projects and business models, such as recycling or processing projects employing circular best practices. The Strategic Partnerships and Projects are an opportunity to accelerate not only the clean energy and digital transitions on a global scale but also to accelerate the transition to a more global circular economy for CRMs. Some examples include the prioritisation of high-material efficiency projects for CRMs, especially those finding value in waste and by-products. There is more opportunity for increasing material efficiency along the product value chain such as the uptake of sharing platforms, products-as-a-service applications, and increasing product longevity (design for repair, refurbishment, and facilitating recycling).

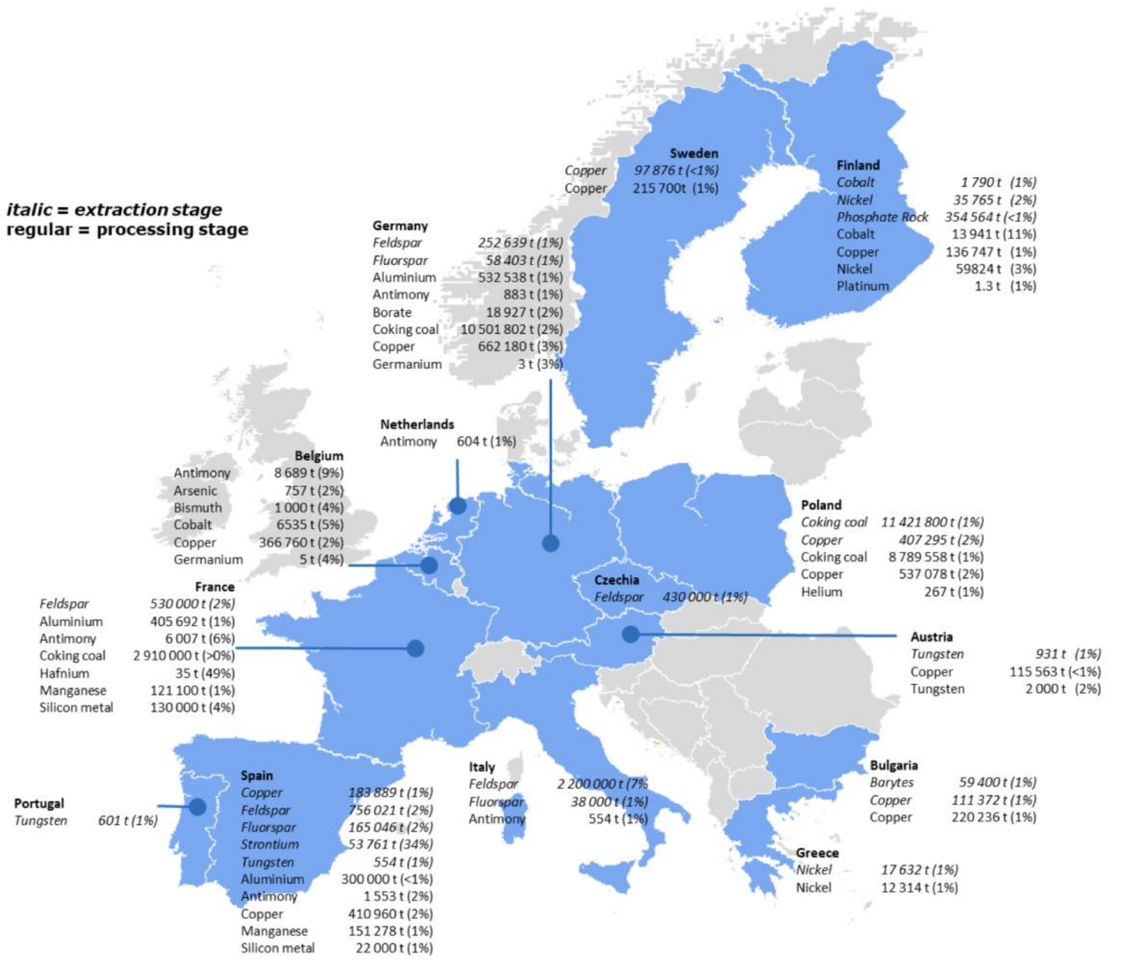
To conclude this section, neither the EU's trade nor cooperation approaches are likely to spur a wave of green industrialisation in third countries. Yet, both types of frameworks consist of solid elements to build a new type of partnership which prioritises a global just and clean energy transition. Such a partnership agreement could incorporate the binding nature of labour and environmental commitments, regulatory cooperation from FTAs with a focus on accelerating the clean energy transition, and financing capacity of the raw materials Strategic Partnerships.

2.3 Gaps related to the extraction of CRMs

The ECRMA introduces a 2030 target for 10% of EU consumption of SRMs to originate from domestic mining. Yet, despite its long history of industrial mining, the EU's current production of CRMs accounts for only 9% of the global supply (European Commission, 2014).

Figure 2 showcases CRM extraction and processing capacities by MS, including the share of global supply, presented in brackets. Although the EU hosts numerous CRM deposits, particularly in Nordic MS which could be tapped into while maintaining high sustainability standards (Eilu et al., 2021), active mining sites are limited. Cobalt deposits are found in Finland, Germany, Norway, and Sweden but are only mined in Finland (European Commission, 2023c). The same narrative applies to other CRMs, like antimony or phosphate rock. Antimony deposits exist in France, Germany, Sweden, Finland, Slovakia, Greece, Portugal, Spain and Poland, but remain unmined. Similarly, phosphate rock deposits can be found in Spain, Finland, Norway and Greece, but their extraction only occurs in Finland (Ladenberger et al., 2018). Niobium and tantalum, despite their deposits in Bulgaria, Finland, France, Germany, Norway, Portugal, and Slovakia, are not actively produced within the continent (Ladenberger et al., 2018).

Figure 2: Extraction and processing of CRMs by MS, share of global supply in brackets, 2016-2020. Source European Commission (2023d)



The long history of European mining has generated mining tailings, mostly in closed mines. The latter are considered potential sources of CRM and are now being mapped through new technological tools. However, the extent of such potential remains to be discovered due to the need for more exploration and investment across the continent (European Commission, 2023c). Most newly discovered reserves (still unexploited) are related to battery raw materials (i.e., lithium, cobalt, graphite, manganese, and nickel). Portugal ranks as the sixth global lithium producer, and France launched one of the largest European lithium mining sites (Righetti & Rizos, 2023).

Finland, Spain and Sweden are the leading MS investing in mine exploration (European Commission, 2014), with new exploration activities now occurring in eastern and northern countries. Yet, only two MS, France and Germany, have introduced ad hoc institutions to systematically monitor CRMs while other MS have advisory bodies but lack a systematic monitoring of the CRMs market and its risks CRMs (European Commission, 2023c).

Civil society has opposed the extractive components of the ECRMA due to its potential impact on local communities and insufficient environmental protection. The Raw Materials Coalition cautions that short timeframes and “overriding of public interest” for the permitting of extractive projects could come at the cost of environmental legislation or meaningful community participation and poorly conducted social and environmental impact assessments (EU Raw Materials Coalition, 2023)

A more commonly held concern regards the proximity of new extractive projects to nature sites and local communities. For example, according to an internal analysis by DG GROW, 40% of EU CRM projects are located within or less than 1 km from Natura 2000 areas, around 180 areas (European Commission, 2023a).

The potential of extractive projects affecting local communities has received media attention, especially in Sweden and Portugal. Portugal’s Barroso lithium mine was supposed to launch production in 2020, however, its start has been postponed to 2026 after opposition from the local community (Fleming, Hancock, & Wise, 2022). Similarly, in 2023, the Swedish state-owned mining company LKAB launched the discovery of rare-earth deposits in the Arctic town of Kiruna, located in a region inhabited by the Sami people (Pena, 2023). Kiruna was built in the 19th century to mine iron ore and has now become LKAB’s target for its rare earth deposits. In response, the president of the Sami parliament, Jonsson, accused the EU of targeting northern Sweden as an area to be exploited for a “black transition” rather than a green one (Pena, 2023).

Box 1: What is deep-sea mining?

Expanding from land to sea reserves

Over millions of years, the ocean floor has accumulated nodules of various metals and minerals, creating a valuable pool of resources for the clean energy and digital transition. As a result of the combination of the increased demand for CRMs and difficulties opening new mining projects on land, more attention has been drawn to the possibilities of deep-sea mining, i.e., extracting mineral resources from the seabed (Geomar, 2024).

Sea resources in international waters are subject to less stringent requirements than land resources as they are not located in a sovereign territory. They are governed by a regulatory framework outlined in the 1982 UN Convention on the Law of the Sea. The main body that deals with the management and protection of offshore assets is the International Seabed Authority (ISA) (Wiedicke, Kuhn, Ruhlemann, Vink, & Schwarz-Shampera, 2015). The ISA provides mining codes regulating marine minerals' exploration and exploitation activities in the international seabed area (International Seabad Authority, 2024).

However, the ISA has been accused by several NGOs of being unfit for its role in protecting and managing marine resources (WWF et al., n.d.). Moreover, the scientific community has expressed concerns about the unquantifiable and irreversible impacts of mining these marine resources on the deep-sea ecosystems and biodiversity. Specifically, the raw materials deposits embedded in nodules contribute to the seabed's megafaunal diversity (Reitmeier, 2023).

The European Parliament expressed its opposition by passing a resolution in 2018 calling for a temporary prohibition of deep-sea mining until the environmental effects are better understood and appropriate legislation can be put in place (Alberts, 2024). France, Spain, New Zealand and Costa Rica have called for a temporary or permanent ban, while China, Norway, and Mexico favour fast-tracking licensing for deep-sea mining projects (Stanway, 2023).

3. MATERIAL USE AND SAFEGUARDING THE CLEAN ENERGY TRANSITION

CRM extraction and use for the EU's clean energy transition is widely debated as CRMs face several complexities compared to other non-metallic resources. Specifically, CRMs are particularly susceptible to market volatilities due to their high demand, their finiteness and supply scarcity, and are often also impacted by the governance frameworks outlining their extraction. Moreover, additional narratives are often projected onto the CRM debate such as the need to secure the EU's strategic autonomy, safeguarding the clean energy transition, and calls for a more critical approach to the equity aspect of the EU's already high overall material footprint. Many EU CSOs have emphasised the need for a social and just green transition, with attention to social and environmental impacts beyond the EU's borders while accounting for the planetary boundaries (EU Raw Materials Coalition, 2023, 2024a, 2024b; González & Verbeek, 2024; Mayrhofer & Bolger, 2024).

So, what is the EU's CRM footprint?

As discussed earlier in this report, the EU's share of metallic materials makes up about 10% of the total EU's material footprint, or 1.48 tonnes per capita, with biomass (21%), fossil-energy materials (18%), and non-metallic materials (51%) making up the bulk of EU material use. As such, **the EU's CRM footprint is relatively low, equalling a share of this 10% figure, considering CRMs are utilised in relatively smaller quantities compared to steel, iron, aluminium and copper** (Eurostat, 2023).

Yet, given the centrality of CRMs in strategic sectors including defence, space and particularly for the transition away from fossil fuels to clean energy, their demand is expected to increase globally as well as in the EU over the coming decades. For the clean energy transition alone, it is estimated that up to 95% of the total global demand for CRMs is driven by EV production (50-60%) together with the expansion of electricity networks and solar PVs (35-45%). Translated into demand for metals, aluminium and copper make up the bulk volume-wise. When adding the demand for lithium, nickel and zinc, together these metals make up 80% of the global demand for CRMs for the clean energy transition (Gregoir & van Acker, 2022).

A foresight study commissioned by the European Commission presents the *additional* EU material consumption of seven CRMs essential to produce fuel cells, wind turbines, batteries, and photovoltaics *only* for the clean energy transition (i.e., renewables and e-mobility). It describes three scenarios with low (LDS), medium (MDS), and high demand (HDS) for CRMs for 2030 and 2050 respectively. The study finds that depending on the level of climate ambition, the corresponding level of CRM demand varies. Specifically, the HDS represents a high level of climate ambition for climate neutrality by 2050, while the LDS assumes a GHG reduction of 64% by 2050. Taking lithium as an example, the upper boundary for the LDS is at approximately 18 times the current use, whereas the upper boundary for the HDS is approximately 58 times the current use (European Commission, 2020).

In the short term, high climate ambition going hand in hand with higher CRM demand will inevitably mean that primary extraction remains necessary, as the EU scales up its capacity to source secondary CRMs. However, with this increase in material demand for CRMs, one must not lose sight of the overarching objective, being the transition away from fossil fuels. Though CRM demand and extraction, will increase in the years to come, **the materials required for the clean energy transition are a faction of what the current fossil-based economy consumes on an annual basis**.

> In 2022, 15 billion tonnes of fossil fuels alone were extracted while it is estimated that by 2050, clean technologies will require 0.3 billion tonnes of materials each year (Energy Transitions Commission, 2023).

Indeed, as the clean energy transition progresses, **the extraction of primary CRMs will grow before it decreases for the EU to meet its climate ambitions**. In this context, the contribution of circular economy strategies is especially important to reduce dependencies on primary extraction.

The following section highlights the role of various circular economy strategies which serve to not only increase the EU's circularity rate but also contribute to decarbonisation efforts and strengthen EU strategic autonomy.

3.1 Ensuring an ambitious circular energy transition

In 2022, the EU's circular material use rate – or circularity rate which measures the contribution of recycled materials towards the overall use of materials – is approximately 11.5% (Eurostat, 2023). Moreover, metallic materials have a higher circularity rate of 24% in 2022 compared to non-metallic minerals, biomass and fossil energy materials (Eurostat, 2023) as secondary materials are more efficiently recovered through recycling processes and have lower carbon-intensities than primary metallic materials (Gorman, Dzombak, & Frischmann, 2022).

Box 2: International dimensions of secondary raw materials

Domestic processing of scrap metals and the circular divide

The ECRMA endeavours to boost the EU's processing capacity to ensure that by 2030 it sources 40% of its SRM consumption domestically. Indeed, the capacity to process CRMs, sourced both from abroad and within the EU, internally is of great strategic importance. In particular, China has a major global market share regarding the processing of CRMs such as copper, cobalt, lithium and REOs, either domestically or through Chinese-owned enterprises in countries such as Australia, Chile and DR of Congo (IEA, 2023).

Simultaneously, the EU should seek to future-proof its CRM processing capabilities by prioritising its recycling facilities to capture the CRMs that will become available for recycling as more CRM-embedded products reach their EoL phase. If the EU's industry is not prepared to process these EoL products domestically, another strategic autonomy risk emerges as precious scrap CRMs are shipped abroad to be recycled.

Table 1 below presents percentage changes in EU exports of scrap metals by value and weight from 2017 to 2022. For all scrap metal types, the value of EU exports has grown significantly, even accounting for the slowdown in international trade caused by the pandemic. Yet, changes in exports by weight are less pronounced, indicating that the value of exported scrap metals has increased. This is most notably the case for precious and specialty scrap metals, where export in weight decreases, highlighting the price instability tied to CRMs. The value these metals retain even as scraps is significant, meaning the EU is losing valuable materials if it continues to export these metals.

Table 1: Changes in EU exports of scrap metals by value and weight from 2017 to 2022, data sourced from Chatham House (2023).

Secondary raw material	Change in exports by value	Change in exports by weight
Ferrous metal scrap	+14%	+4.9%
Aluminium scrap	+14%	+6.8%
Precious scrap metals	+13%	-45.6%
Specialty scrap metals	+5%	-4.8%

It is relevant to note that the export of scrap metals can be hindered or facilitated based on their classification in international trade. Specifically, if these metals would be classified as waste, the revised EU's Waste Shipment Regulation, which entered into force on 20 May 2024, bans the export of hazardous waste to non-OECD countries without prior consent from the receiving country (Official Journal of the EU, 2024a). However, if the EU Waste Framework Directive's End-of-Waste criteria categorises these metal scraps and to-be-disassembled CRM products for recycling as secondary materials, as is currently the case for iron, steel, aluminium and copper scrap (European Commission, 2023e), this would facilitate their ability to be exported.

The EU can rise to the occasion to secure strategic autonomy by developing both its domestic recycling capabilities and ensuring its waste treatment and shipment frameworks retain the most valuable materials for domestic processing. However, from a global equity perspective, this approach only serves to reinforce the circular divide between the Global North and South, especially in the CRM context.

The circularity divide, coined by Barrie, Anantharaman, Oyinlola, and Schröder (2022), describes how the existing inequities concerning finance, trade, development, innovation and digitalisation between the Global North and South enable the former to transition to a circular economy more rapidly than the latter. In the absence of multilateral cooperation, international policy cooperation and capacity building, the circular divide is at risk of deepening.

In the context of the race from CRMs, a greater divide will accelerate an accumulation of resource wealth in the Global North from the Global South. As the Global North continues to demand and extract primary CRMs from exporting countries, due to its increased domestic circularity, these CRMs can be recirculated back into the domestic economy (Barrie et al., 2022).

As discussed in this project's second briefing on trade and cooperation frameworks for sourcing CRMs (Blot, 2024), the EU's contribution to mutually beneficial partnerships to spur green industrialisation through capacity building and future-proof investments is of great importance to supporting a transition to a more global circular economy.

While scoring better than the global average of 7.2%[8] (Circle Economy Foundation, 2023), the EU's circularity rate has remained relatively stable over the past decade, fluctuating between 11-11.5% with the use of secondary materials providing significant contributions to this figure (Eurostat, 2023). Yet, as discussed in Section 2.1, the current circularity rate of many CRMs falls short of the both the EU's 2030 circularity rate target of 23.2% (EEA, 2024) and the ECRMA's 25% recycling target. This is due to the recycling processes of EoL CRM-embedded products being relatively more challenging compared to bulk scrap metals such as steel, aluminium and copper, as they are often still held by consumers, widely dispersed in small quantities, and therefore difficult to recover, disassemble and recycle.

Consequently, significant steps remain to be undertaken to boost the EU's circularity rate to better account for the efficient use of these finite materials as the EU decarbonises its economy. It is useful to visualise the contributions of circular economy strategies, not as an all-encompassing term but as a series of strategies with varying levels of circularity all feeding into an overall more circular economy.

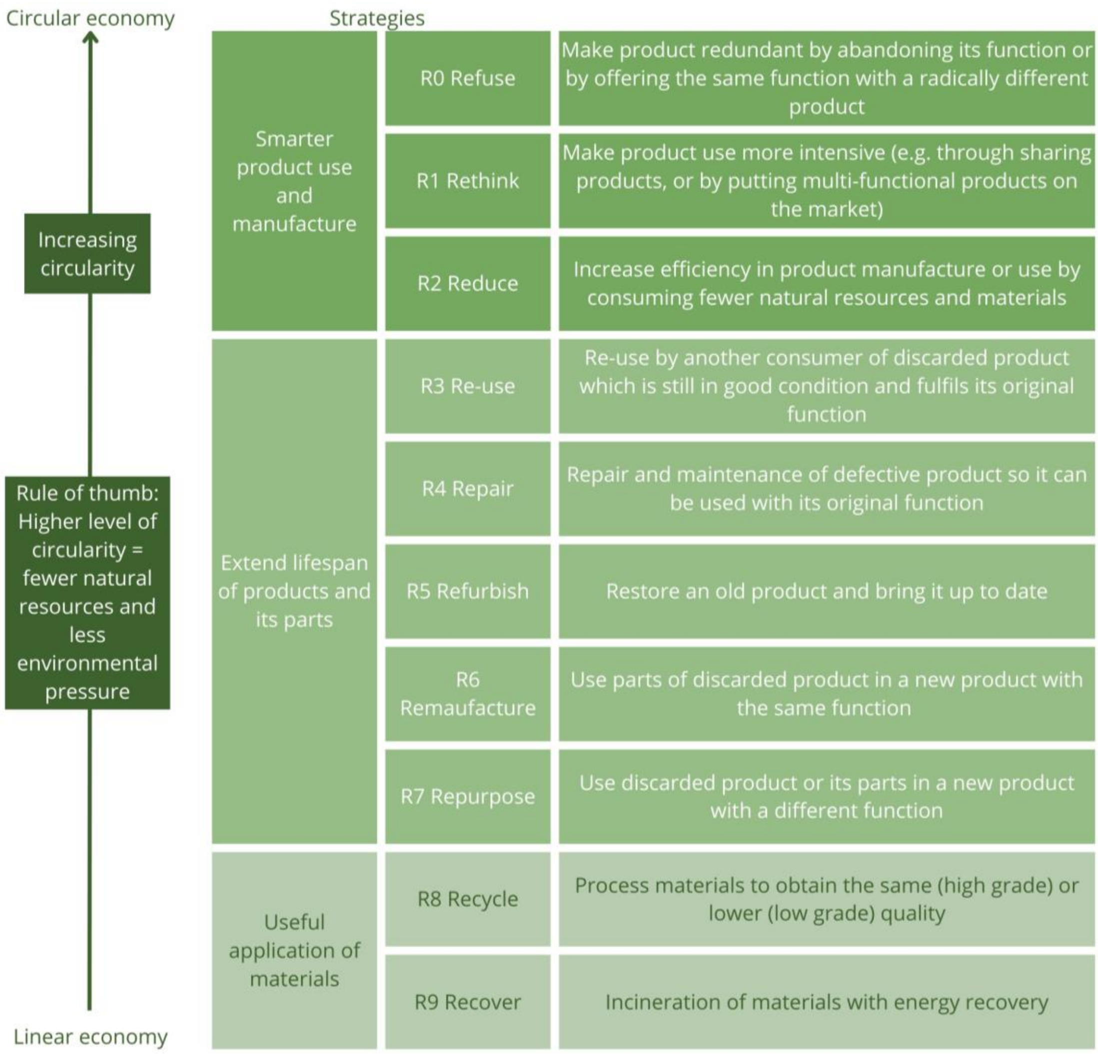
Figure 3 below presents the 9Rs list of circular economy strategies, in order of priority based on their level of circularity, with the highest levels equating to less primary material use and environmental pressures. Climbing up this ladder of circular economy strategies, it becomes clear that the recycling (R8) and recovery (R9) **approaches to extend material usefulness** are currently the most widely employed strategies in the linear economy.

As discussed above, recycling metals is an economic and environmental option as they often retain their quality while being significantly less carbon-intensive. Specifically, the production of secondary aluminium emits only 0.5 tonnes of CO_2 per tonne of production compared to the European average of 6.7 tonnes of CO_2 per tonne (European Aluminium, 2020). However, the EoL rates of four of the ECRMA's 34 categorised CRMs exceed the 25% recycling target (Watkins et al., 2023). The recycling rates of these CRMs could be advanced by guaranteeing recycling capabilities, improving collection rates through extended producer

[8] Note that Eurostat's (2023) circular material use rate is based on Domestic Material Consumption which focuses on the actual weight of materials consumed. Circularity Gap (2023) calculates the circularity metric based on Raw Material Consumption which focuses on the entire life cycle of products, capturing the full environmental impact from extraction to production. As a result, Eurostat's circular material use rate may underestimate the full environmental impact as it does not account for the upstream resources required to produce imported goods.

responsibility (EPR) schemes and ensuring policy coherence between relevant EU legislations concerning raw material use and the clean energy transition.

Figure 3: Circularity strategies in order of priority based on their level of circularity. Source Watkins et al. (2023) adapted from Potting, Hekkert, Worrell, and Hanemaaijer (2017) and RLI (2015).



Specifically, the EU's flagship policy for circular products, the ESPR, aims to enhance a product's durability, reusability, repairability, recyclability, upgradability, and environmental impact, while other legislation such as the EU Batteries and the End-of-Life Vehicles Regulations set targets for minimum recycled content and EoL handling of raw materials. The ECRMA also proposes to improve material efficiencies, by increasing the use of secondary CRMs, the reuse of CRMs with high recovery potential, and the substitution of certain CRMs where possible (European Commission, 2020, 2023c).

It is clear that these legislations anticipate applying strategies from further up the circular economy strategies ladder – re-use, repair, refurbish, remanufacture (R3-R6) – to **extend a product's lifecycle**. For example, a particularly innovative manner of remanufacturing and extending a car's lifespan involves converting petrol cars to electric ones (see e.g., e-Revolt, a German start-up with plans to enter the market in 2025). Yet another creative strategy, repurposing (R7) is not as common throughout these legislative proposals though it serves to further extend a product's lifecycle and reduce environmental impacts. One study finds that substituting a household storage battery to increase the rate of PV self-consumption with a repurposed EV battery yielded significant environmental gains, especially when the energy mix is more carbon intensive (Bobba et al., 2018).

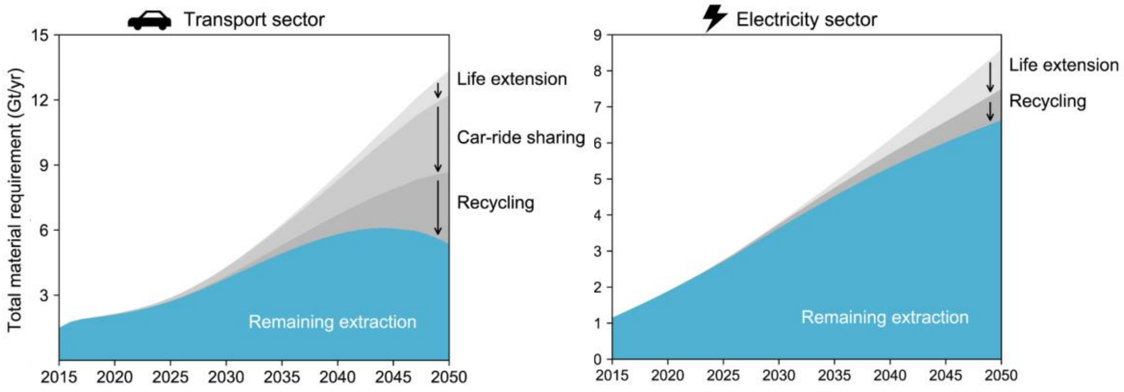
Finally, well-informed policy decisions can facilitate the uptake of the final strategies for **smarter product use and manufacturing**. For example, reducing (R2) the overall quantity of materials used for production can be encouraged by setting a minimum recycled content rate and by providing incentives for businesses to innovate their production method to increase their material efficiencies and product longevity.

The role of **circular business models** in reducing overall material use is particularly relevant in this context. For example, by rethinking (R1) how certain goods are bought and used, the product use intensity can significantly increase. Some examples include product-as-a-service models, in which a consumer pays a recurring fee to make use of a supplier's service product such as a washing machine. As ownership of the product remains with the supplier, they are responsible for providing adequate customer service as well as the repairs, return and eventual EoL management of the product.

Another example of circular business models includes sharing platforms. These sharing models are most commonly known in the transport sector (bike-, car- and ride-sharing), though businesses or non-profits exist for sharing common household appliances and tools such as blenders, drills, and ladders. The effectiveness of these strategies depends on how well they contribute to reduced primary input (IPCC, 2022).

One study estimates that resource extraction for metal production used in the transport sector could be reduced by up to 60% by 2050 compared to the baseline scenario where no circularity strategies were implemented. Figure 4 below presents how car- and ride-sharing platforms, recycling, and product life extension through repair and reuse contributed 27%, 25% and 8% to the total 60% decrease by 2050 (Watari, Nansai, Nakajima, & Giurco, 2021).

Figure 4: Potential impact of some circular economy strategies to reduce the increase in demand for primary extraction. Source Watari et al. (2021)



Watari et al. (2021) find that circular economy strategies will reduce metal extraction in the electricity sector by approximately 23% by 2050 (i.e., 13% through product life extension and 10% from recycling). Due to the continuous expected growth in material demand of the expanding electricity sector, the impact of circular economy strategies in reducing metal extraction is lower than compared to the transport sector. As a result, primary CRM extraction will be necessary to continue electrification efforts. Therefore, it is crucial to complement these strategies with initiatives for the responsible sourcing of primary CRMs to support the clean energy transition effectively.

It's important to note that not all circular business models can run as a for-profit business in a linear economy. For instance, small-scale repair cafés may not turn a profit running solely on their repair facilities and complement their activities by offering beverages to customers as they wait for their repairs. The trade-off between reduced environmental impact through increased circularity and profitability should be weighed and potentially compensated by measures such as tax incentives or subsidies.

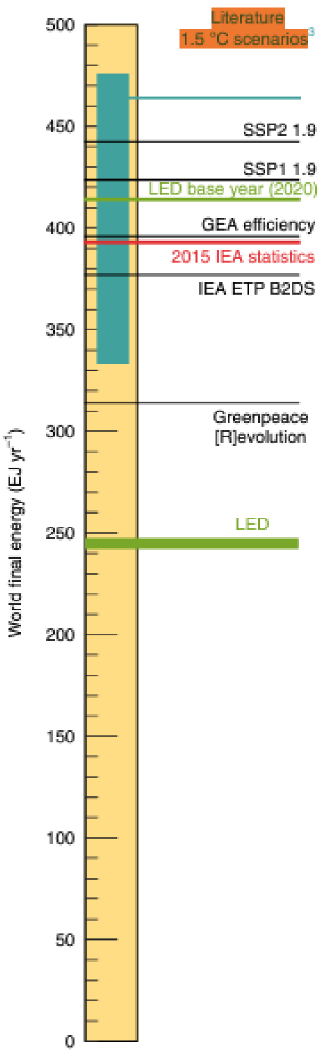
Finally, the highest circularity strategy, refuse (R0) is strongly linked to further solutions to reduce demand. The IPCC highlights the untapped potential of demand-side solutions that maintain or increase well-being levels while decreasing pressure on planetary boundaries (Pathak et al., 2022). Equity is a key aspect here and demand-side solutions differ between groups, globally and within the EU. Indeed, much potential lies in reducing the resource intensity of meeting human needs and wants. In the ECRMA public consultation, many stakeholders highlighted the need to assess the assumptions underlying the projected increase in demand and consider further the potential of demand-side mitigation efforts (European Commission, 2023a).

Demand-side measures are defined as “policies and programmes for influencing the demand for goods and/or services” (p. 457) (IPCC, 2018). Although a significant increase in demand for electricity and CRMs for the energy transition is widely accepted in the literature, the size of this increase varies between scenarios and their underlying assumptions. Figure 5 illustrates the range for final energy demand in 2050 between five scenarios with stringent climate mitigation.

The points above are aligned with the idea that individuals and businesses should not be made responsible for change in an economy that is not yet designed for circularity, regeneration, and distribution. Rather, it is a collaborative effort at a massive scale. In addition to the significant role of EU legislation, actors at different governance levels such as cities and governments play a key role in incentivising new ways of living, such as designing 15-minute cities which dissuade car reliance and promote alternative forms of transportation (walking, cycling, public transportation).

Indeed, **a systemic approach is essential to create prerequisites for sustainable material use and consumption**. A recent study finds that a large majority of the global population wants action on climate change mitigation, with 89% demanding intensified political action and 86% endorsing pro-climate social norms (Andre, Boneva, Chopra, & Falk, 2024). However, to effectively overcome social (Stoknes & Randers, 2015) and structural barriers, a systemic perspective is needed that aligns incentive structures and social norms with the goal of resource consumption within planetary boundaries (Grabbe, Potočnik, & Dixson-Declève, 2022; Greene, Hobson, & Jaeger-Erben, 2024). It is beyond the scope of this report to dive into the systemic changes required but a useful point of departure can be found in the Systems Change Compass (Systemiq & The Club of Rome, 2020).

Figure 5: Comparison between scenarios of global final energy demand in 2050. Source Grubler et al. (2018)



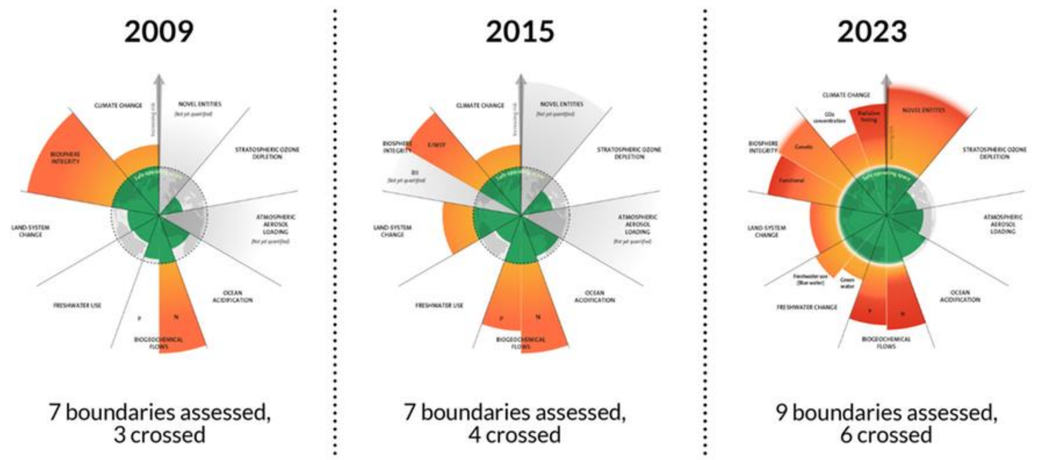
3.2 Zooming out: A sustainable EU material footprint level

As previously mentioned, though CRMs are generally used in relatively small quantities (European Commission, 2023a), their use is often coupled with larger quantities of other material use. For example, producing an EV requires CRMs for the battery and internal technologies but also other materials steel, glass, rubber and plastic for the body and wheels (Blot & Stainforth, 2022). As a result, the clean energy transition can easily lead to an overall increase in material use if not offset by the deployment of circular economy strategies as discussed in Section 3.1. Therefore, it is important to observe the potential consequences of unlimited material use as the EU attempts to decarbonise its economy with finite materials.

Sustainability impacts of EU material use

According to the International Resource Panel's (IRP) definition, sustainable resource management means ensuring that (i) consumption does not exceed levels of sustainable supply, and (ii) the Earth's systems can perform their natural functions (UNEP, 2024). One way of quantifying and illustrating the latter point is the planetary boundaries framework, presented in **Figure 6** which was introduced by Rockström et al. (2009) with updates by Steffen et al. (2015) and Richardson and al. (2023). The framework identifies nine planetary boundaries within which "humanity has the freedom to pursue long-term social and economic development" with stable and resilient Earth systems.

Figure 6: The evolution of the planetary boundary framework by Azote for Stockholm Resilience Centre, Stockholm University. Based on (Richardson & al., 2023; Rockström et al., 2009; Steffen et al., 2015)



In 2022, the EU's material demand totalled 14.8 tonnes per capita, with significant variations between EU member states (EEA, 2023), while the European Commission estimates that the EU has "clearly transgressed the planetary boundaries for five impacts" including the use of mineral and metal resources (European Commission, 2023b, p. 8).

Indeed, for numerous impact categories, the average EU citizen's consumption is beyond the safe operating space for humanity (Sala et al., 2019). Most European countries currently use the resources of three Earths (Global Footprint Network, 2024). Global resource use is at an all-time high, and excessive use of material resources is at the heart of the triple planetary crisis of climate change, biodiversity loss, and pollution (UNEP, 2024). At the same time, society is dependent on well-functioning Earth systems.

Figure 7: The linkages between natural resource consumption, the triple planetary crisis, and the SDGs. Source UNEP (2024)

Figure 7 illustrates how material use is directly or indirectly linked to all SDGs. Material overuse is associated with significant adverse environmental and social impacts throughout the value chain. This includes emissions to air and water (e.g., SGDs 6 and 13), waste creation (SDG 12), acidification impacts (SDG 14), land use competition (SDG 2), and mining conflicts (SDG 16) (European Commission, 2023a). UNEP (2017) provides additional examples of the direct and indirect linkages between material overuse and the SDGs.

Fundamental issues for humanity like democracy, health, poverty, inequality, power, justice, human rights, security, and peace all rest on the life-support capacity and resilience of the biosphere. – Folke, Biggs, Norström, Reyers, and Rockström (2016)

Sustainable management of materials

The totality of materials required for the energy transition, combined with the global nature of the transition, highlights the need for efficient and effective use of these valuable resources. Consequently, a more holistic approach is required to achieve both decarbonisation and a reduction of the EU's material footprint to get within planetary boundaries.

> *Concerted action to decrease material requirements for transitions to renewable energy systems – including by applying sustainable consumption and production, resource efficiency and circular economy strategies – can help facilitate the transition to clean energy for all countries, while minimizing the socioeconomic impacts. – IRP, 2024*

One option could be the **design of a long-term sustainable resource management strategy**, an idea that has received more attention as a solution to the triple planetary crises of climate change, biodiversity loss, and pollution. Sustainable resource management means departing from Earth's systems and functioning, translating this into what can be sustainably supplied, and making sure that demand does not exceed these levels. Such a strategy could outline required actions to be undertaken by governments to facilitate not only an industry-wide shift to more circular practices (recalling the 9Rs list) but also induce society-wide systemic changes.

Box 3: Potential benefits of a long-term material use strategy include

The **anticipation and management of rebound effects** to ensure that the efficiency gains are not outpaced or lowered by increases in consumption.

Mitigating "problem shifting" (Parrique, 2019), i.e., when attempts to resolve one environmental problem give rise to new ones or exacerbate others.

Ensuring disruptiveness of innovation and technological development. An overarching framework setting science-based targets for reduced primary resource use can mitigate the risk that the linear economy remains the status quo with a select few circular "plug-ins", thus undermining the circular economy's benefits (Johansson, 2021). As highlighted in the Global Resources Outlook Report, equally as important as enabling sustainable resource management is "actively phasing out unsustainable practices and overcoming lock-ins and barriers".

Enhanced policy coherence, creating synergies, and leveraging existing EU legislation such as the ESPR, the End-of-Life Vehicles Regulation, the Batteries Regulation , and the Right to Repair.

Contribute to EU strategic autonomy as a lower demand for materials can coincide with a reduction in material import reliance.

Considering the challenges of setting a broadly agreed-upon science-based target for sustainable levels of resource use, especially in a limited timeframe, this strategy could include ambitious but amenable targets for material footprint reduction. This target should also consider the impacts of material use varying between types of materials and over time with changing practices and innovation. For example, recalling the EU's material footprint equals 14.8 tonnes per capita, based on the best available data, a potential target could strive for a 40% reduction by 2040, and a 66% reduction by 2050, or five tonnes per capita (Mayrhofer & Bolger, 2024).

Though an ambitious task, the political support increasing. In 2021, the European Parliament called for the Commission to propose science-based binding EU mid-term and long-term targets for the reduction in the use of primary raw materials and environmental impacts (European Parliament, 2021). Moreover, several MS have started acting. For example, Finland set the goal that "the total consumption of domestic primary raw materials in 2035 will not exceed the level in 2015" (Finnish Government, 2021). Austria set the goal to reduce the Material Footprint to seven tonnes per capita per year by 2050, and to reduce the Domestic Material Consumption to 14 tonnes per capita by 2030 (Federal Ministry Republic of Austria, 2022). Flanders, Belgium, also aims to reduce its material footprint by 75% by 2050 (van der Ven, Watkins, & Bondi, 2023).

4. CONCLUSION

The ECRMA was the departure point of this policy report as the Regulation aims to improve the EU's strategic autonomy by safeguarding its industrial capacity to produce key technologies for the clean energy transition in addition to defence, space and digital applications. As the EU is far from self-sufficient in the sourcing of CRMs necessary for these technologies, the ECRMA proposes several targets to strengthen the EU's position: by sourcing more primary and secondary CRMs internally through extraction, processing and recycling, and by diversifying its imports of CRMs from resource-rich countries through Strategic Partnerships.

The Regulation chapters on risk monitoring and mitigation, Strategic Projects, Strategic Partnerships and circularity outline measures and approaches to be undertaken to strengthen the EU's sourcing of primary and secondary CRMs while accounting for CRM susceptibility to market volatilities due to their high demand, finiteness and supply scarcity, and applicable governance frameworks. This report also discussed social and environmental concerns linked to the expansion of domestic extractive projects and the exploration of deep-sea mining.

Yet, based on this project's previous research identified several missed opportunities for strengthening the responsible and circular sourcing of these materials. Concerning the external sourcing of CRMs, the **Strategic Projects and Partnerships**:

1. **Do not uphold a sufficiently high level of ESG standards** to ensure that projects and third countries' regulatory frameworks are aligned with international agreements and standards.

2. **Lack concrete definitions or initiatives to foster value addition** in the trade partner country. Examples of value-addition green industrialisation could be assisting the shift away from third countries' primary raw materials towards developing their industrial capacities to produce inputs or final products for the global green transition.

3. **Fail to prioritise the roll-out of circular projects and business models**, such as recycling or processing projects employing circular best practices.

This project also identified **circularity gaps** in the ECRMA, i.e., gaps between legislative ambition in the ECRMA and current levels of circularity, specifically:

1. **Inadequate attention to product design for circularity** to increase longevity and facilitate the access, removal and recovery of CRMs at the end of the product's life.

2. **A lack of information on product composition and materials**, which can lead to the loss of CRMs at the EoL stage.

3. **Low collection and recycling rates for many CRMs** in the EU which contribute to missed opportunities to improve CRM circularity through recycling.

4. **A lack of adequate recycling facilities, technologies, and economic viability of recycling**, which can reduce both the quantity and quality of CRM recycling, thereby hampering circularity.

Considering the speed at which not only the EU but all industrialised countries aim to boost their strategic autonomy and secure a stable supply of CRMs, this report highlights the intricacies of maintaining an equitable share of demand for CRMs and safeguarding the clean energy transition to remain compatible with the Paris Agreement.

Though **CRMs equal only a small share of the EU's total material footprint**, due to their price volatility and soaring demand, they receive significantly more attention than traditional metals. Moreover, their central role in the clean energy transition only further highlights existing material footprint inequities between the Global North and South as the former endeavours to achieve climate neutrality. However, it is important to keep in mind that decarbonisation and material footprint reduction are not at odds with one another and that **a decarbonised economy will require fewer materials overall than the current fossil-based economy**. Yet, until the uptake of more circular economy strategies becomes more mainstream in our economic model, **the demand for CRMs will continue to increase in the coming years before it decreases**.

In this context, significant efforts remain to be undertaken to boost the EU's overall circularity rate which has remained relatively stable over the past decade, fluctuating between 11-11.5%. Secondary metallic materials have a particularly high value-retention and low carbon footprint, though the recycling of CRMs faces several challenges compared to traditional scrap metals such as iron, steel, aluminium and copper. Arguably, the largest gains could come from applying circular economy strategies to CRMs and CRM-embedded products, as these strategies aim to not only increase material usefulness but also expand product lifecycles and encourage new ways of product utilisation.

This report presents the suggested application of the 9Rs list of circularity strategies. Starting from below, **recovery** and **recycling**, which are the most widely applied in the linear economy, are viable options to increase material usefulness. Recycling is especially important as secondary CRMs retain their value which is even more useful for a material faced with such price volatilities. Considering this value retention, the EU must consider guaranteeing its ability to process these secondary materials as opposed to exporting them for EoL treatment. However, at the same time, the EU should acknowledge the potential for CRM accumulation and global inequities as it increasingly implements these circular economy strategies.

Next on the list are circularity strategies to extend product lifecycles through **re-use, repair, refurbish, remanufacture, and repurposing**. The former four are most relevant for the ESPR which aims to enhance a product's durability, reusability, repairability, recyclability, upgradability, and environmental impact. This legislation is particularly important to address the circularity gaps discussed above, i.e., improving product information and design to facilitate its repair, re-use, and recycling. The latter strategy, repurposing, is not as common throughout these legislative proposals as it increases a product's lifecycle creatively, for example repurposing a household storage battery with an EV battery.

The remaining circularity strategies aim to encourage smarter product use and manufacturing. **Reducing** the overall quantity of materials used for production can be encouraged by setting a minimum recycled content rate and by providing incentives for businesses to innovate their production method to increase their material efficiencies and product longevity. **Rethinking** how certain goods are bought and used can significantly increase product use intensity. Here, the role of circular business models is particularly relevant, such as product-as-a-service models and sharing platforms. **Refusing** is linked to the untapped potential of demand-side solutions that maintain or increase well-being levels while decreasing pressure on planetary boundaries. However, a systemic approach is essential to create prerequisites for sustainable material use and consumption. By encompassing a collaborative effort at a massive scale, EU legislation together with actors at different governance levels such as cities and governments play a key role in incentivising new ways of living.

Finally, though CRMs are used in relatively small quantities, their use is still coupled with that of other materials to produce key defence, space, digital and clean energy technologies. Considering that the EU has transgressed the planetary boundaries for five impacts and the effect of material overuse on achieving the SDGs, civil society has begun to demand action from the EU to address its high levels of material use.

In this light, this report highlights the policy option to **design a long-term sustainable resource management strategy** as a solution to the triple planetary crises of climate change, biodiversity loss, and pollution. Such a strategy could outline required actions to be undertaken by governments to facilitate not only an industry-wide shift to more circular practices (recalling the 9Rs list) but also induce society-wide systemic changes. This strategy could include ambitious but amenable targets for material footprint reduction, considering that the impact of material use varies between types of materials and over time with changing practices and innovation.

4.1 Recommendations

This report puts forward several recommendations to ensure the EU can keep a dual focus on decarbonisation (to meet its climate goals) and reducing its material footprint (to meet its circularity goals), both of which are essential for the EU to get within planetary boundaries.

- **Address gaps in the Strategic Project and Partnership approaches** to ensure mutually beneficial economic and environmental outcomes for both Parties. These approaches should prioritise high ESG standards, circularity and add value towards global green industrialisation.
- **Tackle circularity gaps in the general approach to managing CRMs** by ensuring policy coherence between the ECRMA, ESPR, Batteries Regulation, Waste Framework Directive and the Waste Shipment Regulation. These legislations should serve to maximise CRM usefulness by lengthening product lifecycles, improving material efficiencies, and guaranteeing the appropriate management of high-value EoL CRM-products and scrap metals.
- **Encourage the uptake of the 9Rs circular economy strategies** in CRM-relevant sectors and products. This should go hand in hand with safeguarding EU secondary raw material processing, supporting innovative product design for material efficiency, and backing ambitious circular business models and societal changes.
- **Contribute to closing the circular divide by pursuing multilateral cooperation efforts**, including financing and capacity building. As both demand for CRMs and the application of circular economy strategies increase, the Global North will inevitably accumulate CRMs originally extracted in the Global South.
- **Evaluate overall material footprint levels and benefits of a long-term strategy for sustainable resource management** as a solution to the triple planetary crises of climate change, biodiversity loss, and pollution.

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