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Critical raw materials: Is Europe ready to go back to the future?

Executive summary

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The future will be powered by metals, but fenced in by iron curtains. Metals and critical minerals such as lithium, cobalt and nickel are crucial for the green transition, used for everything from electric vehicles to wind turbines. The market has doubled in size over the past five years, reaching USD320bn in 2022, according to latest IEA estimates, and is set to at least double by 2040 amid surging demand from EVs and battery storage, as well low-emission power generation and electricity networks. But competition for critical raw materials and their concentration among a small number of countries could create geopolitical risks, including potential cartelization

From OPEC to OMEC? China dominates the field of critical raw materials, controlling nearly all of heavy rare earth elements, 91% of magnesium and 76% of silicon metal supplies worldwide. Similarly, the Democratic Republic of the Congo commands over 60% of the global cobalt market, while South Africa holds a share of 71% for platinum and Russia 40% of palladium. Should these mineral-rich countries decide to form an Organization of Metal-Exporting Countries, it could manipulate prices, disrupt supply and further restrain international trade, posing risks to countries highly dependent on imports, including the EU, Japan and South Korea. Production concentration around leading supply-chain firms, in which Europe is less present compared to the US or China, could also create dependencies and expose Europe to trade wars between third countries.

In this context, can Europe's Critical Raw Materials Act close the gap? Ensuring a stable supply of critical raw materials and diversifying import dependencies is crucial for Europe. The CRM Act proposes a 10% target for EU sourcing, but we find that seven out of the 18 materials listed do not meet the requirement at the mining stage (antimony, borate, manganese, natural graphite, rare-earth elements, tantalum and titanium). For all of these, the EU27 is highly dependent on sourcing from third countries (more than 94%). Moreover, 21 out of 24 materials do not meet the requirement that at least 40% of the EU27 annual consumption has to stem from EU refining. Third-country sourcing shares of the EU range from 61% for aluminium to 100% for baryte, beryllium or niobium. The CRM Act also targets at meeting at least 15% of annual consumption via recycling. However, out of 16 strategic raw materials, only four meet the target. Half of the remaining 12 will not be able to meet the target as they are either consumed or converted in the industrial process, or there are simply no meaningful scrap quantities available for the quickly growing demand, as is the case for lithium.

To increase independence, the EU should support a favorable trade-policy environment and diversify global supply chains through strategic partnerships with resource-rich countries. They way forward should also focus on sustainable extraction practices, becoming the critical shareholder of industry frontrunners and reinforcing recycling.

A future powered by metals but fenced in with iron curtains

The EU's concerns regarding raw-material supply date back to the 1977 Council's second Environment Action Programme, highlighting dependence on imports. Two decades later, the European Commission introduced the Raw Material Initiative, an integrated strategy to improve access to raw materials, and established a list of critical raw materials (CRMs) based on their economic importance, supply risk and lack of substitutes. While subsequent EU strategies emphasized the need for secure access to raw materials, recent supply-chain disruptions due to Covid-19 and the Ukraine war have intensified the challenge.

Metals, including critical minerals, play a key role in the ongoing energy transition due to their unique properties and their importance in numerous clean-energy technologies. Lithium, nickel and cobalt are essential components of lithium-ion batteries, which are widely used in electric vehicles (EVs) and energy-storage systems. Although there are emerging technologies that try to reduce or cut entirely the use of lithium, it remains key as the world moves towards more renewables and demand for energy-storage systems booms. Not to mention the fact that global demand for EVs is skyrocketing as more and more countries aim to reduce their greenhouse-gas (GHG) emissions. Rare earth elements such as neodymium and dysprosium, key components of wind turbines and electric vehicles, are another set of highly sought-after metals. Thanks to its excellent conductivity, copper is also widely used in electrical applications, though it is categorized as strategic, not critical, given its key role in electric vehicles, wind turbines and solar photovoltaics. Finally, silver and platinum group metals (PGMs) are also critical in photovoltaic solar cells and fuel cells, respectively (see Table 1 for a summary).

The critical minerals market has doubled in size over the past five years, reaching USD320bn in 2022, according to latest IEA estimates. Investment in the sector jumped by +30% rise in 2022, following a +20% increase in 2021. And the EU is not alone in recognizing the strategic value of CRMs: In fact, Canada, the US and UK established their respective lists of CRMs in 2021 and 2022. This underlines the risk of potential tensions ahead between large advanced economies. Indeed, out of the 32 minerals that the US and the EU consider as critical, 21 are deemed critical by both regions. Competition for these minerals might disrupt geopolitics and alliances.

Table 1: Summary of selected CRM and their main uses

Material	Main uses	US CRM list	EU CRM list	Economic importance	Supply risk	Leading producing country and %	Primary import source for the US
Aluminum	Transportation, packaging, construction	✓	✓	5.8	1.2	Australia (28%)	Jamaica
Antimony	Flame retardants, metals, defense, construction	✓	✗	5.4	1.8	China (56%)	China
Arsenic	Herbicides and insecticides, wood preservatives, semiconductors	✓	✗	2.9	1.9	China (44%)	China
Baryte	Drilling applications, mechanics	✓	✓	3.5	1.3	China (44%)	China
Beryllium	Satellites, medical equipment, automotive, defense	✓	✓	5.4	1.8	US (88%)	Kazakhstan
Bismuth	Pharma, grinding, semiconductors	✓	✓	5.7	1.9	China (70%)	China

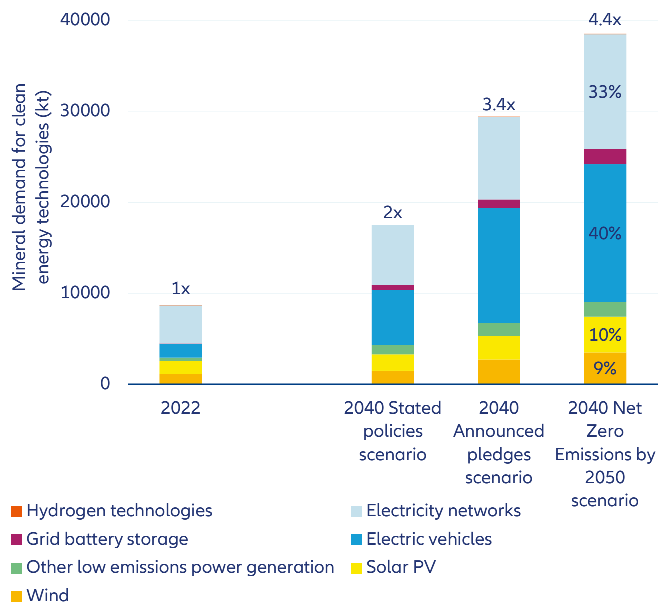
Material	Main uses	US CRM list	EU CRM list	Economic importance	Supply risk	Leading producing country and %	Primary import source for the US
Chromium	Stainless steel and heat-resisting alloys	✓	✗	7.2	0.7	South Africa (44%)	South Africa
Cobalt	Batteries, superalloys, engines	✓	✓	6.8	2.8	DRC (63%)	Norway
Copper	Cables, construction, electrical products	✗	✓	4.0	0.1	Chile (28%)	Chile
Fluorspar	Metals, nuclear industry, construction	✓	✓	3.8	1.1	China (56%)	Mexico
Gallium	Optics, integrated circuits, light-emitting diodes (LEDs)	✓	✓	3.7	3.9	China (94%)	China
Germanium	Electronics and solar applications, pharma, metals	✓	✓	3.6	1.8	China (83%)	China
Graphite	Batteries, steelmaking, lubricants	✓	✓	3.4	1.8	China (65%)	China
Hafnium	Superalloys, nuclear industry	✓	✓	4.3	1.5	France (49%)	Germany
Helium	MRI machines, scientific research	✗	✓	2.9	1.2	USA (56%)	Qatar
Indium	LCD screens, semiconductors	✓	✗	2.6	0.6	China (59%)	South Korea
Lithium	Electric vehicle batteries, smartphones	✓	✓	3.9	1.9	Australia (53%)	Argentina
Magnesium	Metals, chemicals, agriculture	✓	✓	7.4	4.1	China (91%)	Israel
Manganese	Steel and metals, batteries, animal feed, fertilizers	✓	✓	6.9	1.2	South Africa (29%)	Gabon
Nickel	Alloys and steels, chemicals	✓	✓	5.7	0.5	China (33%)	Canada
Niobium	Aerospace, superalloys, MRI machines	✓	✓	6.5	4.4	Brazil (92%)	Brazil
PGMs	Catalysts, electronics, medicine	✓	✓	7.1	2.7	South Africa (75%)	South Africa
Rare earths	Catalysts, magnets, alloys	✓	✓	5.9	3.7	China (85%)	China
Rubidium	Defense, biomedical research, electronics	✓	✗	N/A	N/A	N/A	Germany
Silicon metal	Alloys, chemicals, semiconductors, solar industry	✗	✓	4.9	1.4	China (76%)	Brazil
Tantalum	Aerospace, drilling, lenses, automotive	✓	✓	4.8	1.3	DRC (35%)	China
Tellurium	Cooling, energy generation, metals, solar industry	✓	✗	3.8	0.3	China (53%)	Canada
Tin	Chemicals, tinplate, alloys	✓	✗	4.5	0.9	China (31%)	Peru
Titanium	Aerospace, defense, medical implants, power generation	✓	✓	5.4	0.5	China (43%)	Japan
Tungsten	Construction, drilling, electronics	✓	✓	8.7	1.2	China (86%)	China
Vanadium	Steel alloys, catalysts, batteries	✓	✓	3.9	2.3	China (62%)	Canada
Zinc	Galvanized steel, metals	✓	✗	4.8	0.2	China (33%)	Canada
Zirconium	Ceramics, abrasives, nuclear industry	✓	✗	3.5	0.8	Australia (36%)	South Africa

Source: USGS, EU Commission, Allianz Research

Figure 1 shows the expected development of mineral demand for clean energy technologies under three IEA scenarios. The Stated Policies Scenario (STEPS) outlines a course based on existing and developing governmental policies worldwide. The Announced Pledges Scenario (APS): presumes all energy and emission targets, including net-zero commitments, will be achieved punctually and fully, even without current policy support. The Net Zero Emissions by 2050 (NZE) Scenario presents a roadmap for the energy sector to achieve net-zero CO2 emissions by 2050. All three scenarios predict a swift rise in the demand for critical minerals used in clean-energy technologies. By 2040, the demand doubles in the STEPS scenario, while it increases by 3.4 times in the APS scenario and by 4.4 times in the NZE Scenario. This increase is primarily driven by EVs and battery storage, but low-emission power generation and electricity networks also significantly contribute[1].

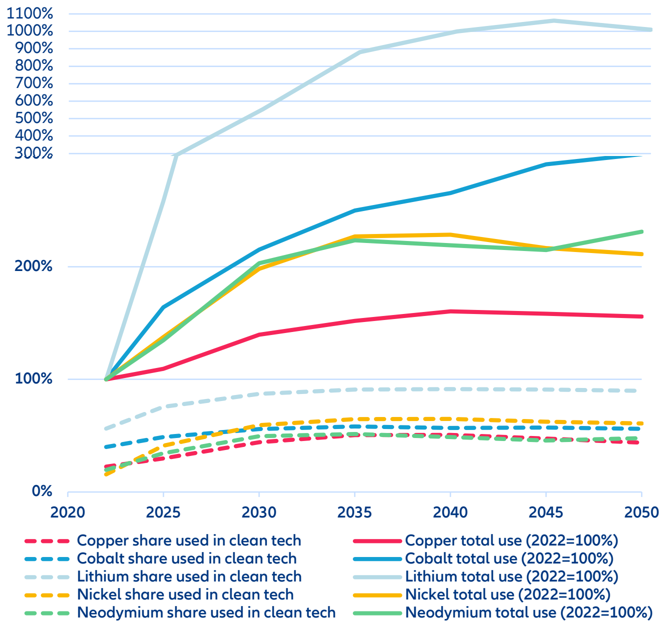
In the Paris Agreement aligned NZ 2050 scenario, the share of demand from clean-energy technologies' rises substantially in the next decade, reaching 50% for copper and rare-earth elements, around 60% for nickel and cobalt and about 90% for lithium. By 2040, the total global use of these minerals, including uses related to clean technologies, is expected to rise by +60% for copper, between +100%-200% for neodymium, nickel and cobalt and by +900% for lithium.

Figure 1: Expected development of mineral demand for clean energy technologies by IEA scenarios



Source: IEA [1], Allianz Research

Figure 2: Minerals demand for clean technologies in the Net Zero 2050 Scenario (total demand normalized to 100% in 2022)



Source: IEA[2]

[1] See also: IEA (2023): Critical Minerals Market Review 2023

[2] IEA Critical Minerals Data Explorer

Looking ahead, all planned critical mineral projects by 2030 could potentially meet various governments' climate pledges. In contrast to traditional oil and gas markets, critical minerals are seeing increased exploration investment, with a notable +20% growth in 2022, led by lithium. The production of EVs is prompting manufacturers to strategically invest in the raw material sector to ensure the necessary supplies. EV battery manufacturers are adopting a similar approach. Another positive trend is the mainstreaming of recycling, especially of batteries, with significant capacity planning and development occurring predominantly in China, Europe, and the US. This is crucial to both meet material demand and mitigate environmental impact.

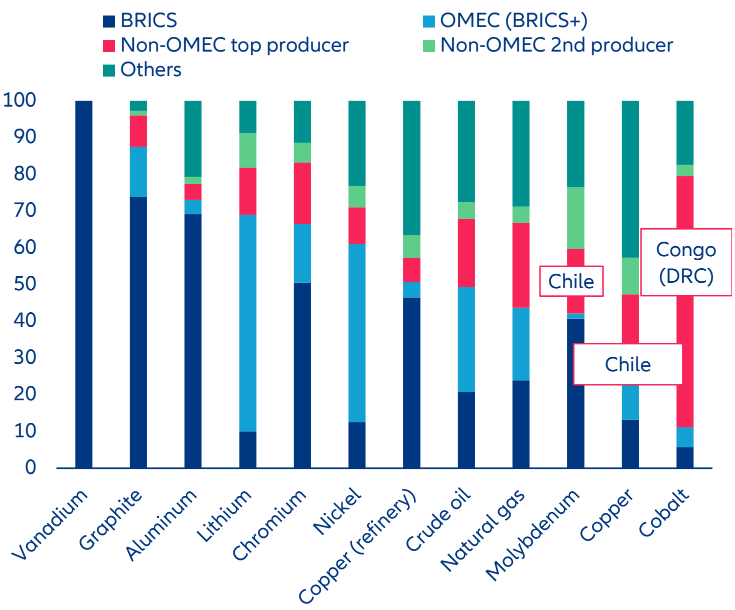
Nevertheless, the risk of delays and other hurdles calls for more initiatives by 2030, with an aim to limit global warming to 1.5°C. Diversification of supply remains a concern. In fact, the market share of the top three critical-mineral producers, especially in the nickel and cobalt sectors, has either remained constant or increased over the last three years. At the same time, critical-mineral production has seen uneven progress in environmental, social, and governance (ESG) practices. While notable improvements have been made in community investment, fair working conditions and prevention of forced and child labour and gender balance, challenges persist, with high greenhouse-gas emissions and a significant surge in water use.

From OPEC to OMEC (Organization of Metal Exporting Countries)?

Recent events such as the semiconductor crisis, supply difficulties brought about by pandemic-related measures and the outright war in Ukraine have highlighted the fragility of a global economy characterized by a concentration of resources that can suddenly become less accessible. In past decades, the geopolitical framework has been shaped around resources still firmly anchored in the 20th century (oil, pipelines and the grabbing of extractive or agricultural areas in exchange for easy money). Today, we may be at the beginning of the division of the world into new spheres of influence dictated by the energy reconfiguration, climate change and an overall de-democratization of the planet.

Despite sufficient global resources to support ambitious climate-mitigation plans, raw material value chains – spanning mineral extraction, refining and recycling – have become highly centralized due to geographical distribution, economic specialization and geopolitical factors. China dominates this field, controlling nearly all of heavy rare earth elements, 91% of magnesium and 76% of silicon metal supplies worldwide. Similarly, substantial market concentrations exist: The Democratic Republic of the Congo commands over 60% of the global cobalt market, while South Africa holds a share of 71% for platinum and Russia 40% of palladium. Under these near-monopolistic conditions, the EU heavily relies on these countries to satisfy its demand for raw materials. The concentration of critical-metals production and refining among a relatively small number of countries creates significant geopolitical risks (see Figure 3). Geostrategic alliances may become even more important in a highly fragmented world with potential supply risks, as well as increased chances of market, location or reputational risks.

Figure 3: Production of selected critical resources, in%



Sources: USGS, BP, Allianz Research. Note: Countries included into a simulated "BRICS+" have been selected based on their shareholding capacity in the BRICS-related New Development Bank (i.e., Bangladesh, UAE, Egypt), formal applications or interest to join the group reported by the media and/or strong affiliation to one or more countries within the bloc. Aluminum data are based on smelter production; data on lithium are based on reserves as a proxy for future production.

The risks could be further amplified if some of the countries rich in critical raw materials decide to form a cartel. The world would then have to deal with an "OMEC". What could an OMEC look like? Mineral-rich countries such as the Democratic Republic of Congo, Chile, Peru, China, Russia, South Africa and even Australia stand to benefit economically from the increasing demand and could decide to form an alliance. Although such an initiative would come with challenges related to governance and geopolitics, it would pose major risks to countries that are highly dependent on imports of these minerals, such as those in the EU, as well as Japan and South Korea, which could face supply disruptions and increased costs. The US could be somewhat cushioned from the blow as it has many mineral resources available, though not enough to fully meet its future demand. The speculative OMEC could take a set of actions to influence global markets, including:

- **Price manipulation:** An OMEC could restrict supply through production or export quotas to drive up prices, which would in turn make clean-energy technologies more expensive and eventually slow down the green transition.
- **Supply disruptions:** The cartel could strategically disrupt supply to exert (geo) political leverage over countries that are highly reliant on these metals.
- **Exclusive trade agreements:** The cartel could sign exclusive trade agreements with chosen partners, further concentrating their market power, tilting the global supply where they see fit and making it difficult for "unfriendly" countries to secure the resources they need.

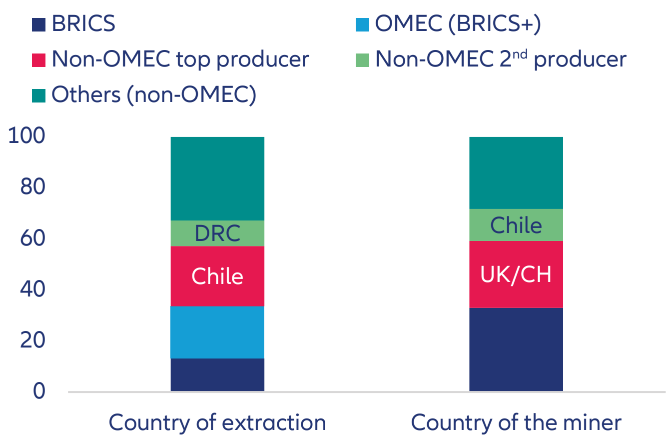
Although the above-mentioned cartel remains speculative, this trend of "cartelization" of commodities seems to be already in motion to some extent. In recent months, there has been frequent talk about the extension of the informal BRICS group of countries (Brazil, Russia, India, China and South Africa) to include several economically relevant and commodity-producing emerging markets. In the event of the formation of a metals cartel with the countries we mentioned above, we would expect many emerging markets that already hold an appeal towards the BRICS initiative to side with the cartel. We can probably make a compelling case for some South-East Asian countries (Vietnam, Malaysia, Indonesia, Laos, Sri Lanka), some African countries (Nigeria, Kenya, Angola) and some Latin American ones (Bolivia, Argentina).

From a geographical perspective, the import dependence of high-income economies on middle- to low-income suppliers is more pronounced for critical raw materials than for merchandise products, with China, Russia, Brazil, South Africa and India accounting for half of all such dependencies. As the debate on friend-shoring and de-risking progresses among commodity traders and investors, the question of finding alternative sources for the materials needed for the green and digital transformations arises. At the same time, ESG considerations should also be coupled with openness in international trade. Concrete solutions to cope with an endemic shortage of materials, costlier finance and actual bankability of projects are still experimental and could result in greater fragmentation and reliance on additional suppliers not necessarily more reliable than the previous ones.

What if the most dangerous concentrations and dependencies stem not from the geographic location of resources, but from the shareholding in the leading supply chain firms? Cobalt, for instance, is known due to its geographic concentration in the Democratic Republic of Congo (around 70% of global production), but products have shifted over time from the hands of the government and Russia into those of Chinese and South African companies. Similarly, the output of copper by country of incorporation of top producing companies sees six companies from the US, UK, Switzerland and Canada in the top 10 with about a third of global output – and only one EU company based in Poland.

An OMEC cartel that mirrors the composition of BRICS+ here is less effective, at least on paper, but political risks remain. While it is interesting to note that additional capacity would not increase significantly because the copper industry maintains substantial diversification on the mid- and downstream side, the risk of expropriatory acts or arbitrary measures against companies operating abroad (potentially leading to creeping expropriation) remains.

Figure 4: Production of copper by country of extraction and country of the mining company (ultimate beneficial owner), in%

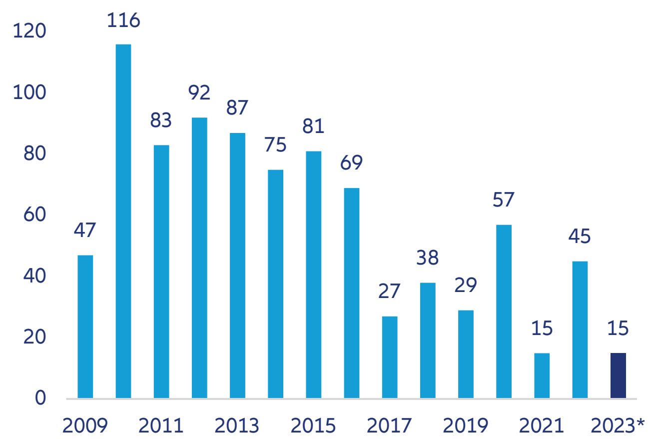


Source: USGS, PIIE, Allianz Research

Unilateral actions that may threaten the industry, whether this may be countries where CRMs are mined or private companies becoming targets of retaliatory actions in the countries where they operate, including trade restrictions. Export restrictions on CRMs have expanded by more than fivefold globally in the last decade. In recent years, around 10% of the global value of CRMs exports faced at least one export restriction measure by governments. China, India, Argentina, Russia, Vietnam and Kazakhstan were the top six countries in terms of new export restrictions from 2009 to 2020, and some also account for the largest production share of many CRMs.

Governments have imposed export restrictions for various reasons, including: monitoring export activity, protecting domestic industries, ensuring a stable domestic supply, addressing national security concerns, promoting sustainable practices, managing trade imbalances, complying with international agreements and controlling the flow of sensitive technologies or materials, as well as promoting further processing activity and value added. Between 2009 and 2022, the number of new export restrictions on critical raw materials put into place varied between the peak of 116 in 2010 and 15 new export limitations in 2021 (Figure 5). In 2022, data from the Global Trade Alerts database indicates that the top three countries applying export restrictions on critical raw materials were Pakistan, the US and Indonesia. The three most covered materials were aluminum, cobalt and helium, followed by nickel, titanium metals and platinum group metals. However, in applying export restrictions, governments risk jeopardizing the green transition.

Figure 5: Number of new export restrictions on critical raw materials, 2009-2023*



Source(s): OECD, GTA, Allianz Research[3].

3. Note: 2009-2010 from OECD, 2022 and 2023 numbers from the Global Trade Alert Database; 2023* available up to June 2023. Based on HS6 codes as outlined by the Horizon 2020 SCREEN2 factsheets for each CRM.

Box: Blackmailing with rare earths

China's export ban on rare earths to Japan in 2010 is often seen as a precedent in which China used its economic strength as leverage to achieve political goals. What happened?

China had already tried to bring the largely unregulated production and processing of rare earths under state control, with a restrictive allocation of production rights and the introduction of tariffs and taxes. Amid these efforts, export licenses were also issued and gradually reduced; in the second half of 2010, a -40% decline in exports had already been announced.

In this situation, the territorial dispute between Japan and China over the Senkaku Islands (Chinese: Diaoyu Islands) escalated into the arrest of a Chinese fishing captain in September 2010. China then stopped the export of rare earths to Japan completely. After only two weeks, the Chinese fishing captain was released and exports (slowly) resumed. But as a result of the embargo, rare earth prices exploded. The consequences of this brief episode continue to this day.

On the Chinese side, efforts to control the sector by the state were intensified because the export ban was not completely effective, but rather circumvented by "smuggling" – unsurprising given the record high prices at the time. It was not until 2021 that the government succeeded in bringing the sector completely under state control by merging the producers into the China Rare Earth Group.

On the international side, the system of export quotas eventually led to a complaint against China at the WTO, which took years to be resolved. China ended the system in 2015 but in the end this was a Pyrrhic victory: Rare-earth-based value chains had already migrated to China and the drop in prices further cemented China's supremacy in production and processing. The lack of environmental regulations and lax working conditions created an unassailable competitive advantage.

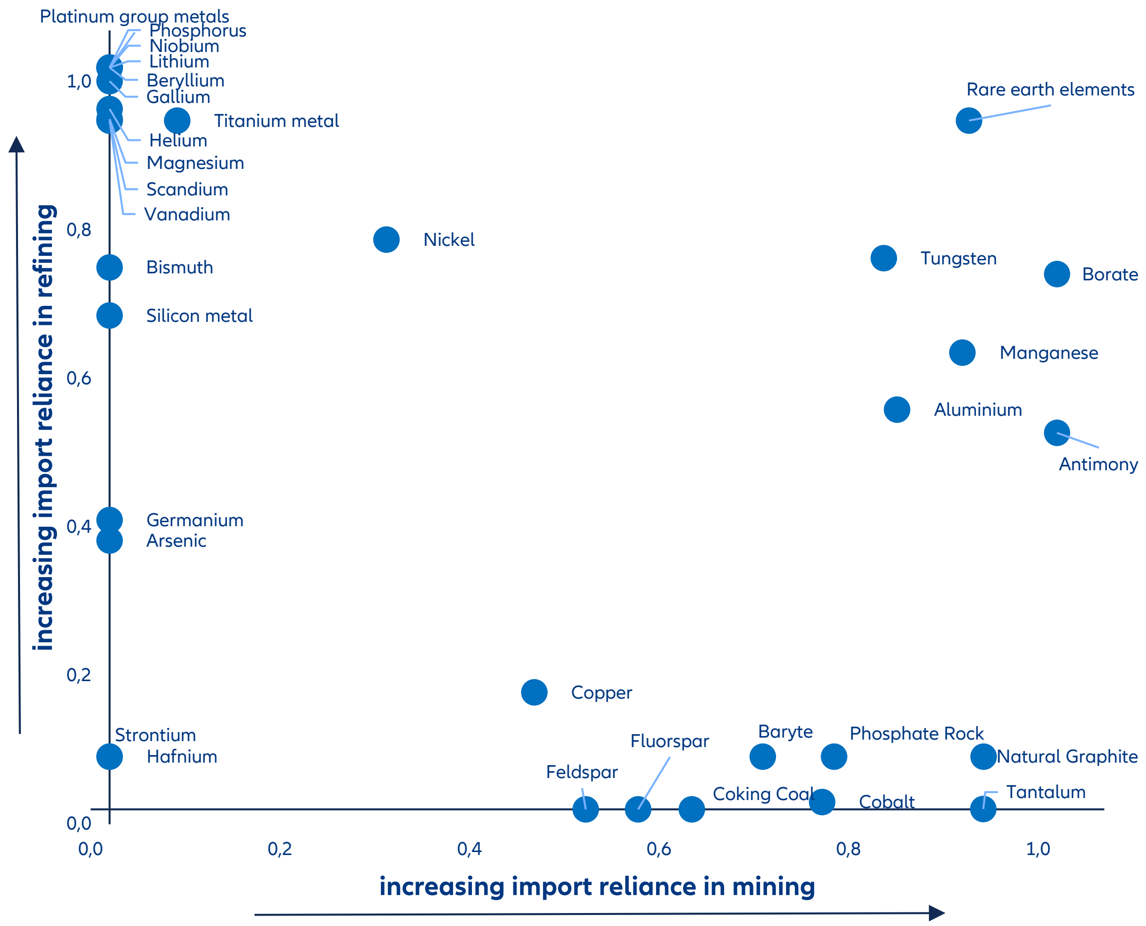
On the Japanese side, a concerted search for and securing of alternative sources began under state leadership. The Japan Oil, Gas and Metals Nation Corporation, under the control of the Japanese Ministry of Economy, Trade and Industry, acted as an anchor investor in new mining areas, primarily in Australia, thus securing new suppliers. This diversification strategy was successful: The share of Chinese imports of rare earths fell from over 90% to about 50% today. At the same time, recycling and research into alternative materials were massively increased. Japan is now a leader in "rare-earth-free" magnets and other components.

What lessons can be learned from this? First, Chinese export embargos are likely to be far more effective today: The times when the private sector still had some (even illegal) leeway are over. The government can easily enforce its orders, not only in the rare-earth sector. Second, de-risking can be successful, but it requires time and government support as alternative sources are usually not profitable in purely economic terms. However, this only applies if supplies continue to run "normally". For thirdly, in a crisis, the price mechanism will ensure that alternatives – be it other suppliers or new technologies – become available much faster. Last year's "gas crisis" proved this impressively.

Implications of the EU Critical Raw Materials Act and missing pieces

At the mining stage, the EU is completely import dependent for antimony and borate and more than 80% import dependent for another six materials (Figure 6). At the refining stage, this is true for six materials with 100% import dependence and seven more with an import reliance of more than 80%.

Figure 6: EU27 import reliance, 2008-2021 average in%



Sources: EU Prodcom, BGS, WMD, Allianz Research. Note: EU27 import reliance calculated as (import – export)/(domestic production + imports – exports) in tons.

Europe is dependent mainly on a single supplier for magnesium, germanium, or rare earth elements (China), as well as borate (Turkey). In this context, there is always a looming risk of supply chains running dry. So ensuring a stable supply is a crucial challenge that Europe needs to tackle.

The EU Critical Raw Materials Act places a lot of attention on increasing the mining and refining of raw materials in Europe by strengthening all stages of the European value chain for critical raw materials and diversifying EU imports to reduce strategic dependencies. However, this inward-looking response misses the fact that most of the action will take place outside of the EU.

Below, we analyze how many materials currently meet the requirements outlined in the EU CRM Act:

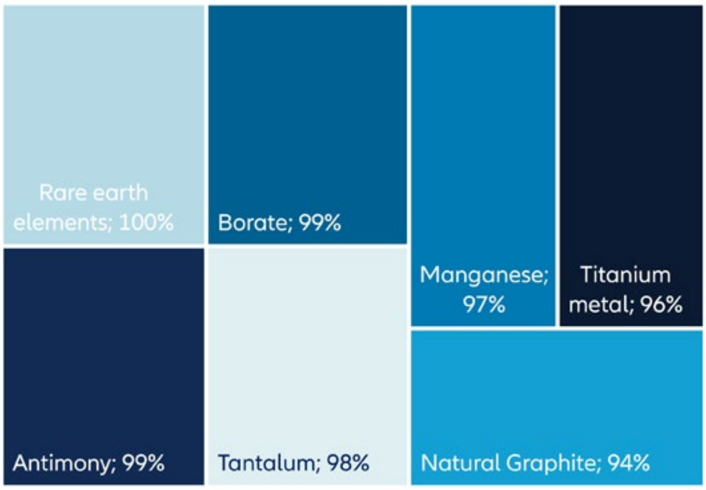
1. At least 10% of the EU's annual consumption to come from EU extraction.

A natural response to raw-material supply pressures is to consider unexploited domestic resources. The CRM Act proposes a 10% target for EU sourcing of these materials. Looking at the sourcing shares of the EU27 by material, seven out of 18 materials do not meet the requirement at the mining stage (antimony, borate, manganese, natural graphite, rare-earth elements, tantalum and titanium). For all of these, the EU27 is highly dependent on sourcing from third countries (more than 94%, Figure 7).

However, the European continent does have significant potential for battery raw materials such as lithium, cobalt, nickel, graphite and manganese. France, Germany and Portugal are rich in lithium, and France is even preparing to open a large lithium mine. Substantial unexploited cobalt resources also exist throughout Europe, and rare-earth elements have also been discovered. However, due to insufficient monitoring and technical or geological constraints, a comprehensive assessment of EU geological potential is missing. Nevertheless, advancements in mining technologies and coordinated exploration efforts under the CRM Act could provide greater clarity on the EU's untapped mining potential.

Turning mining potential into production depends on the technical and economic feasibility of extraction and time-consuming permit procedures. In the EU, launching a mining project typically takes 10-15 years, making significant contributions to raw materials needs by 2030 unlikely. While EU intervention is limited, the CRM Act aims to expedite strategic projects that meet specific criteria through streamlined permitting and facilitated finance, with permits to be issued within two years, although this has sparked mixed responses.

Figure 7: Sourcing shares of materials that do not meet the CRM guidelines in mining, by material in%



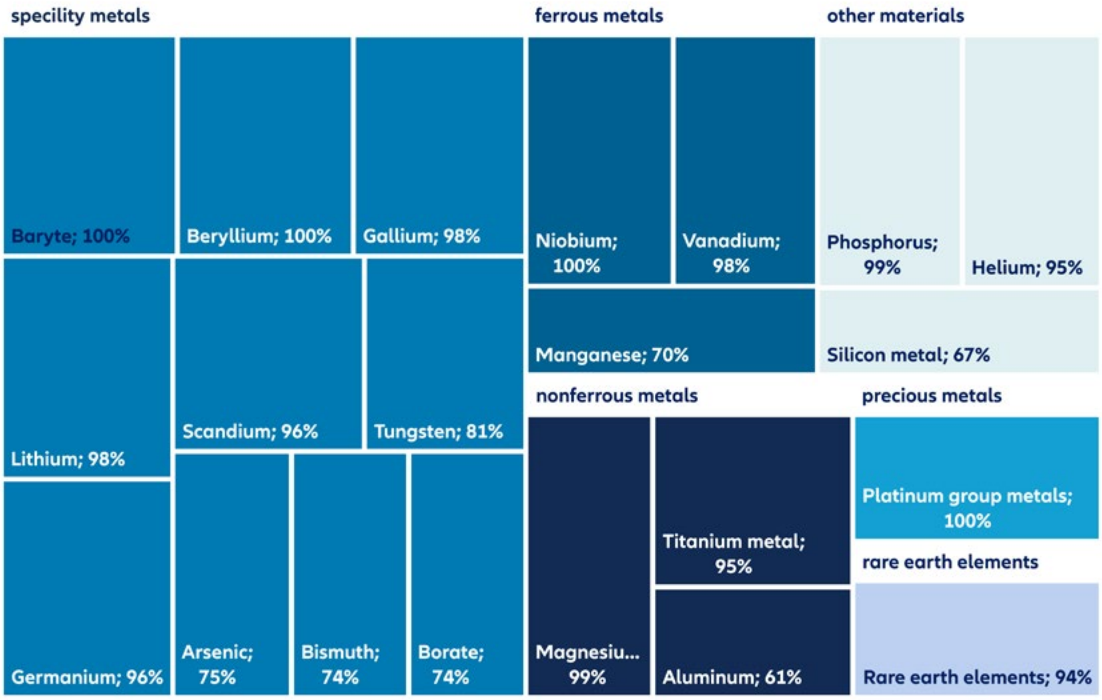
Sources: EU Prodcom, BGS, WMD, Allianz Research.

Public opposition to mining, often due to environmental concerns, poses another challenge, as seen with Portugal's Barroso mine, and can delay or block operations. The CRM Act stipulates community engagement and plans for public acceptance for strategic projects but lacks further specifics. Additionally, attracting investment is crucial for expanding EU mining capacity. Yet, due to structural issues, high energy costs, commodity price volatility and potential skill shortages, these projects are often seen as high-risk and unattractive to investors. The CRM Act aims to mitigate this by facilitating access to public and private financing for strategic projects.

2. At least 40% of the EU's annual consumption to come from EU processing

The calculation of sourcing shares at the refining stage reveals that 21 out of 24 materials do not meet the requirement that at least 40% of the EU27 annual consumption has to stem from EU refining. Third-country sourcing shares of the EU range from 61% for aluminium to 100% for baryte, beryllium or niobium (Figure 8).

Table 8: Sourcing shares of materials that do not meet the CRM guidelines in refining, by material in%



Sources: EU Prodcom, BGS, WMD, Allianz Research.

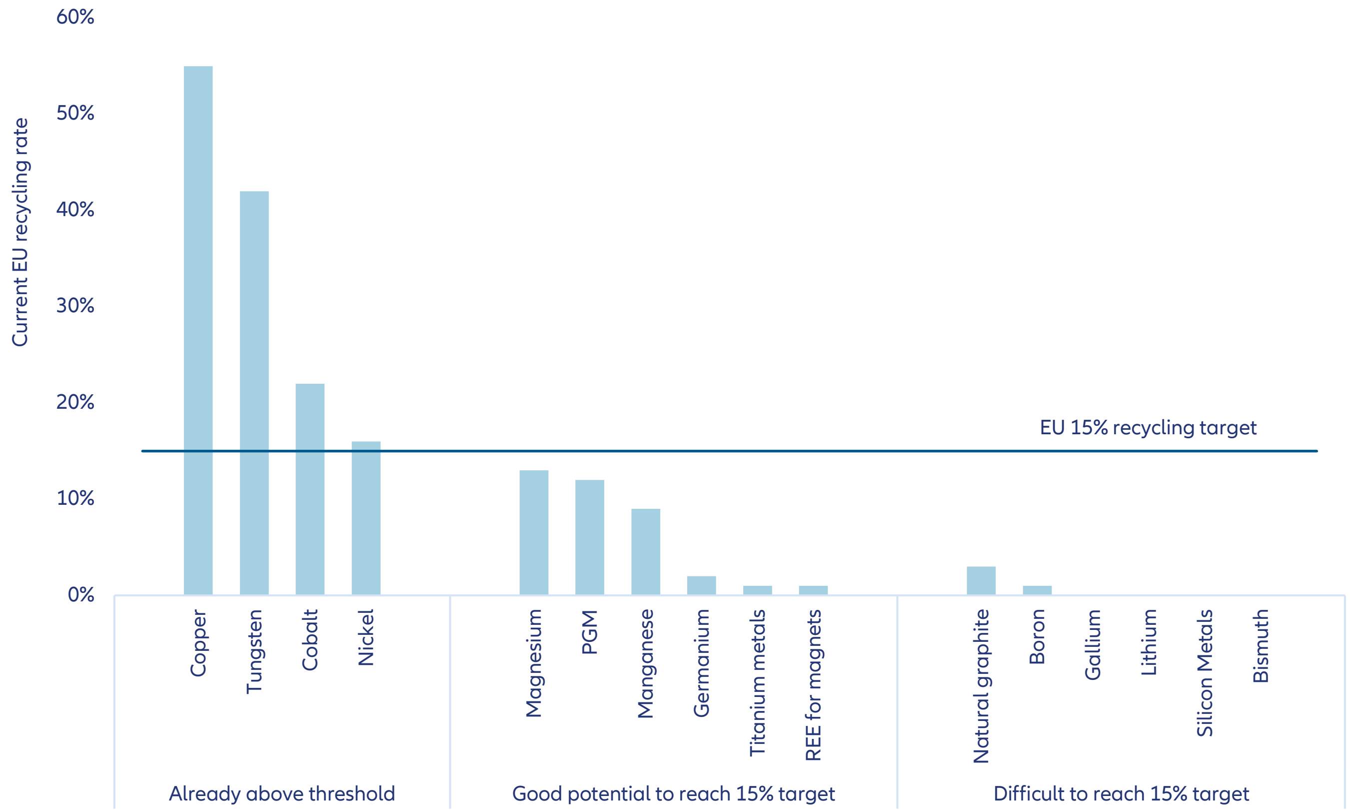
3. At least 15% of the EU's annual consumption to come from domestic recycling.

As mentioned above, the mining industry's short-term contribution to reduce the dependency on CMR imports is limited. Enhancing circularity and recycling capacities in the EU is thus vital. The CRM Act targets at least 15% of EU annual consumption of each strategic raw material (SRM, a subgroup within the CRMs that is strategically important for green, digital, space and defense applications and subject to future supply risks)[4] to be covered by Union recycling capacity by 2030. While some materials, like copper, already exceed this target, many SRMs and CRMs, including battery raw materials such as lithium, manganese, natural graphite, and rare-earth elements, have negligible or no contribution from secondary sources (Figure 9).

Recycling technologies exist for most CRMs, some promising swift commercialization and scale-up. There are also ongoing projects in the EU for recycling EV batteries and developing rare-earth magnet recycling operations, driven by EU regulations and funding. However, to make significant contributions, recycling will need to scale up faster than mining production and rely on efficient systems and sufficient end-of-life products.

4. The list of strategic raw materials from the European Commission includes: copper, tungsten, cobalt, nickel – battery grade, magnesium metal, platinum group metals, manganese – battery grade, natural graphite – battery grade, germanium, boron – metallurgy grade, rare earth elements for magnets, titanium metal, bismuth, gallium, lithium – battery grade, silicon metal. Platinum group metals include iridium, palladium, platinum, rhodium and ruthenium. Rare earth elements for magnets include neodymium, praseodymium, terbium, dysprosium, gadolinium, samarium and cerium.

Figure 9: EU recycling rates by material and target, in%



Source: EC, Allianz Research.

Several obstacles exist in the recycling chain, from product design to collection and processing. The systematic collection of certain CRMs is often lacking due to inefficient waste systems, limited infrastructure, and missing economic incentives. For example, over a third of end-of-life electric vehicles are not properly collected or are exported outside of the EU. Only 46% of waste electrical and electronic equipment is collected in the EU, resulting in the potential loss of valuable materials. Despite the importance of recycling systems, the potential contribution of recycling to future critical raw materials demand will depend on the availability of recyclable products. Consumption of these materials for low-carbon applications is set to increase exponentially until the early 2030s before stabilizing. Given the long lifetimes of these applications (12 years for EVs, over 30 for wind turbines), few products will reach the end-of-life stage in the near term, making primary materials crucial. Therefore, recycling's contribution will significantly increase only in the long term (Righetti and Rizos, 2023)[5].

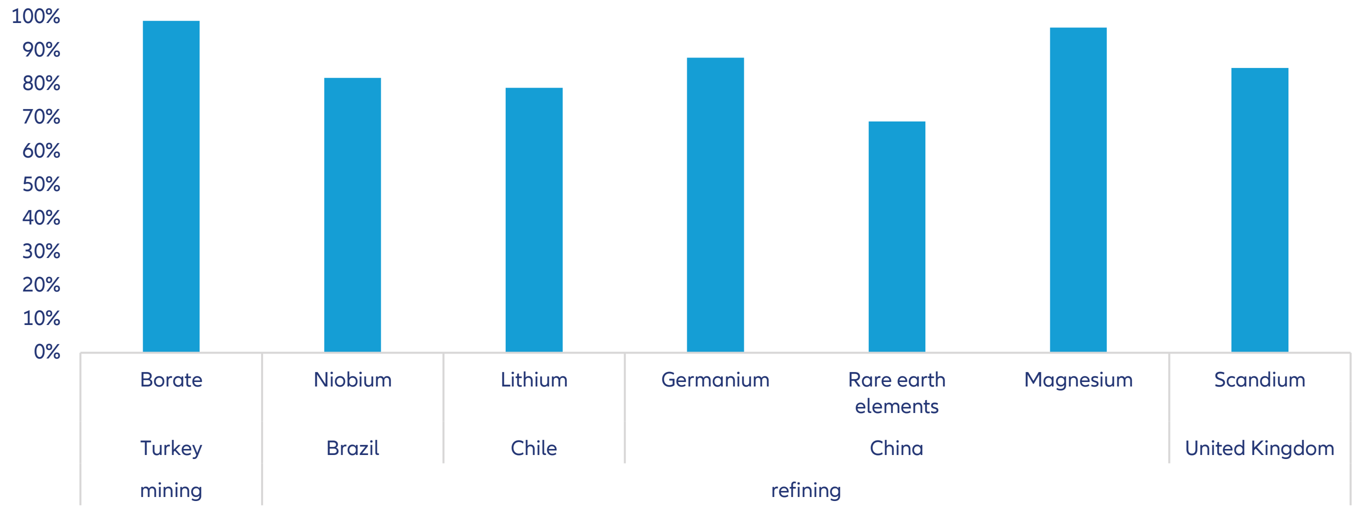
Nevertheless, by 2030, about 150 GWh of used EV batteries will be ready for recycling. Current key recycling facilities include Redux in Germany and Guangdong Brunp Group in China, with future facilities likely to use less energy-intensive hydrometallurgy for a higher recovery rate. However, given the rapid growth in EV usage, more recycling efforts are urgently needed, particularly in Europe and North America. To support this, policy measures are necessary to incentivize recycling, standardize battery design and regulate end-of-life EV battery movement. Beyond the lack of end-of-life scrap material, some CRMs are simply consumed or converted during the industrial processing, which makes their recovery impossible. Out of the 16 SRM groups shown in Figure 9, four already exceed the 15% recycling threshold and six show good potential for exceeding the threshold, but achieving the target for the remaining six could prove to be problematic.

5. Edoardo Righetti, Vasileios Rizos (2023), The EU's Quest for Strategic Raw Materials: What Role for Mining and Recycling? Intereconomics – Review of European Economic Policy.

4. Not more than 65% of the Union's annual consumption of each strategic raw material at any relevant stage of processing to come from a single third country.

The EU is highly dependent on borate from Turkey, with an import share of 99%. At the refining stage, we find it is also heavily dependent on niobium from Brazil; lithium from Chile; germanium, rare-earth elements and magnesium from China and scandium from the UK.

Figure 10: Sourcing shares of materials from single third country not meeting the requirement, by stage, material, country in%



Sources: EU Prodcom, BGS, WMD, Allianz Research.

Box: Import restrictions on critical raw materials and EU27 import losses

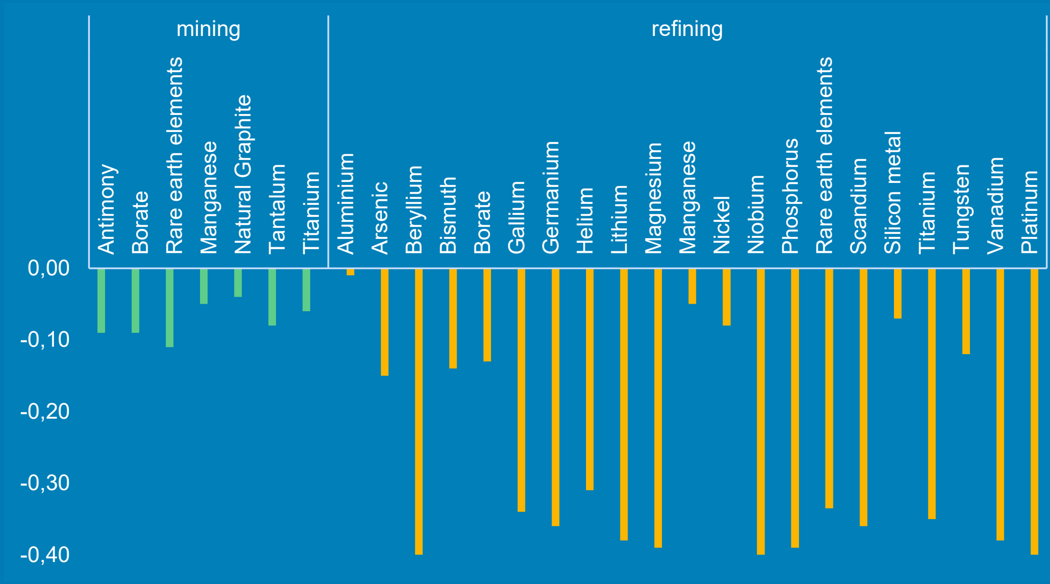
If the EU self-imposes the criteria outlined in the CRM Act, trade flows on certain materials to the EU will be reduced. We analyze the change in trade flows in a hypothetical world in which the EU applies import quotas to the materials that do not meet the outlined requirements. We define three scenarios in which the EU would impose an import quota of

1. 90% on each critical raw material in the mining stage.
2. 60% on each critical raw material in the refining stage.
3. 65% of each critical raw material in the mining or refining stage that comes from a single third country.

This does not mean that these materials cannot be imported to the EU after the quota is reached, but a higher import tariff would apply to imports beyond the quota.

We find that the EU would suffer a massive trade loss if the quotas were strictly applied. Based on 2022 numbers, the EU stands to lose EUR0.17bn of imports at the mining and EUR8.82bn of imports at the refining stages – a total loss of EUR9bn. In mining, the loss ranges between -4% in natural graphite to -11% in rare-earth elements per year (Box, Figure 1). At the refining stage, aluminium would suffer the least loss in percentage terms with -1% while phosphorus and magnesium show the highest losses with -39% of imports, followed by vanadium and lithium with -38% of imports and germanium and scandium with -36% compared to the current situation per year.

Box. Figure 1: Reduction in EU imports due to quota per year, base year is 2022 in%



Sources: EU Comext, EU Prodcom, BGS, WMD, Allianz Research. Note: Calculations based on imports in values, own production in tons, EU consumption calculated as own production + imports – exports in tons. Quota applied to % of EU consumption in own production. The base year is 2022.

Moreover, based on 2022 data, borate mining imports from Turkey would need to be reduced by -34% – a total loss of imports of EUR12.3mn per year (Box, Table 1). Similarly, cutting dependence on China would have led to a loss of imports of EUR313.7mn. The EU's dependence on lithium from Chile is 79% and EU imports from Chile would have been reduced by -14% or EUR 80.2mn with an import quota as suggested. For niobium, the picture does not look much brighter: The EU is 82% import dependent on Brazil and a quota would have reduced imports by EUR74.7mn in 2022. The reduction in scandium, a material mainly imported from the UK at the refining stage, looks minor in value terms, but import dependency is elevated at 85% and imports would need to be reduced by -20% to reach the target set by the EU.

Box. Table 1: EU27 dependency in critical raw materials from single third country, 2022 in% and EUR mn

Stage	Material	Country	% of EU consumption in production	Observed imports in mn Euro	Reduction in %	Reduction in mn Euro	Counterfactual imports in mn Euro
Mining	Borate	Turkey	99%	36.2	-34%	-12.3	23.9
Refining	Gallium	China	69%	15.0	-4%	-0.6	14.4
Refining	Germanium	China	88%	93.7	-23%	-21.5	72.1
Refining	Lithium	Chile	79%	573.2	-14%	-80.2	492.9
Refining	Magnesium	China	97%	910.7	-32%	-291.4	619.3
Refining	Niobium	Brazil	82%	439.1	-17%	-74.7	364.5
Refining	Rare earth elements	China	69%	3.4	-4%	-0.1	3.3
Refining	Scandium	UK	85%	0.0002	-20%	-0.00003	0.0001

Sources: EU Comext, EU Prodcom, BGS, WMD, Allianz Research. Note: Calculations based on imports in values, own production in tons, EU consumption calculated as own production + imports – exports in tons. Quota applied to % of EU27 consumption in own production.

Support, develop, leverage and strengthen: Key takeaways for Europe

Critical raw materials have become a vector of dependency and geopolitical risk as well as a hugely important externality in international trade. CRMs are basic resources indispensable for the green and technological transition. However, there is a need to reduce dependence and diversify relationships with third countries. To achieve its objectives, the EU must adopt a multi-level approach that addresses various aspects of critical raw materials.

The green transition presents a dual challenge by increasing the demand for clean tech goods and requiring larger quantities of minerals. Extensive investments in circularity and innovation, a financing offensive for domestic projects on the extraction, processing and recycling of CRMs, and a practical implementation of the CRM Act could increase European independence.

Amid a challenging geopolitical environment, the EU can move forward by

- **Supporting a favorable trade-policy environment and concrete investments abroad that diversify global supply chains through inorganic growth to prevent larger concentration.** Given the limited presence of European companies and investors in the CRM industry's production core, increasing the plurality of shareholders in the most significant companies, whether public or private, is the fastest and most effective way to be where it counts.

- **Developing a more outward-looking approach along with the CRM Act.** Policies so far have looked rather inwards, but action will take place elsewhere so broader and long-term investment make sense aside from coalitions and the promotion of merely bilateral relationships.

- **Leveraging its foreign investment policy, the Global Gateway.** This can be achieved through strategic partnerships with resource-rich countries outside the EU (i.e., focus on existing or strategic new regional trade agreements), reducing reliance on a single supplier and enhancing supply chain resilience.

- **Strengthening domestic production and recycling capabilities for critical raw materials.** This would include promoting sustainable extraction practices and investing in the research and development of recycling technologies to reduce the environmental impact of raw material extraction and ensure a more circular economy.

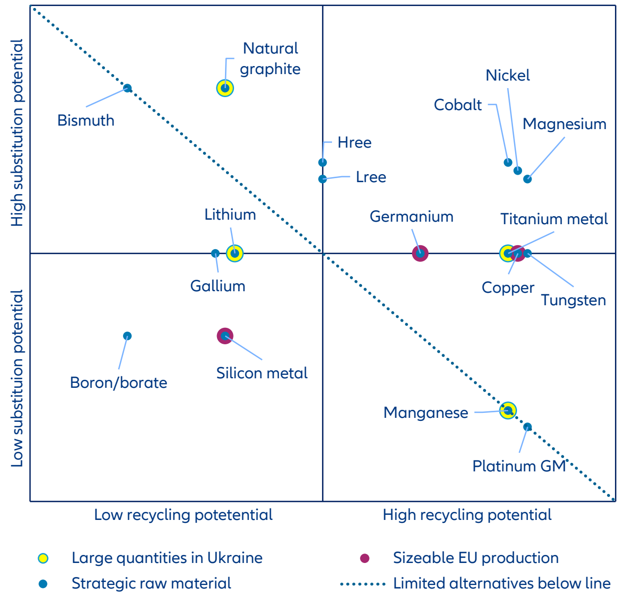
Active engagement in maturing a collective and planet-wide approach to critical raw materials is essential for Europe to reduce dependencies, strengthen its position in the global market and act as a balancing force in the CRM-related geopolitical arena.

What about the rest of the world?

Historically, supply strains prompt market responses such as demand reduction, substitution or a supply boost, but often with price volatility, time delays or efficiency losses. In clean-energy transitions, inadequate mineral supply could lead to costlier, slower or less efficient progress, hardly ideal, given the urgency to cut emissions. Market responses to previous mineral supply-demand imbalances have led to additional investment and demand-moderation measures, often causing considerable price fluctuations and time lags. These could slow down and inflate the cost of future clean-energy transitions.

Technology innovation can play a key role in reducing material intensity and promoting substitution, thereby easing supply strains and lowering costs. Figure 11 assesses the EU SRMs based on their substitution possibilities and their recycling potential. For instance, the 40-50% reduction in silver and silicon use in solar cells over the past decade has facilitated a massive rise in solar PV deployment[4]. Moreover, innovative production technologies, such as direct lithium extraction or enhanced metal recovery from waste streams or low-grade ores, could drastically increase future supply volumes. Boosting R&D for technology innovation can result in more efficient material use, enable material substitution and unlock significant new supplies, providing environmental and security benefits. Potential strategies include improving material efficiency in production, reducing material use in certain applications and substituting one material for another. However, it is worth noting that substitution can often be challenging due to the unique properties of certain materials, such as copper's unparalleled thermal and electrical conductivity. For instance, aluminium has substituted for tin in packaging due to high tin prices, but such substitution sometimes requires a significant redesign of systems and can lead to unforeseen consequences. Another caveat is that a suitable substitute for one strategic raw material is often another strategic raw material. The area under the dotted line in Figure 11 indicates SRMs that are particularly difficult to recycle or to substitute. Lithium, gallium, boron and silicon metals fall in both categories, calling for an increased awareness in addressing potential supply issues. Out of this group, lithium could be supplied by Ukraine in considerable quantities, and the country is also rich in other SMRs such as titanium, manganese and natural graphite.

Figure 11: EU SRMs based on substitution and recycling potential



Sources: EU, EC, Ukrainian Geological Survey, Allianz [7]

6. See also IEA(2021): The Role of Critical Minerals in Clean Energy Transitions
7. Systematic expert assessment of: EU Horizon 2020 SCRREEN Factsheets, EC Raw Material Foresight Study 2023, Ukrainian Geological Survey 2022: UKRAINE Investment Opportunities in Exploration & Production of Strategic and Critical Raw Materials Allianz Research.

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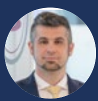

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