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The geopolitics of critical minerals for the energy transition

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Abstract:

The energy and digital transitions are driving up demand for minerals containing lithium, cobalt, rare earth elements, nickel, and copper, among others. The imbalance between supply and demand for these minerals—as well as their processed products—is creating a new geopolitic of resources where control and supply of these materials are becoming key factors in economic power, strategic competition, and national security.

Access to these critical minerals is becoming increasingly complex. China's dominance in production and processing, the rise of protectionism, and export controls are contributing to the profound geopolitical disruption of these mineral markets. In this context, in addition to encouraging the opening of new mines, it is essential to reconfigure industrial policies and foster international alliances with like-minded countries to ensure resilient and diversified supply chains for these critical minerals.

Regarding a potential disruption in the supply of raw materials in the energy sector, although it would not have immediate short-term consequences, its effects would be felt in the long term, impacting the future development of clean energy and the achievement of decarbonization goals.

Keywords:

Critical minerals, lithium, rare earth elements, descarbonization.

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GEOPOLITICS OF CRITICAL MINERALS IN THE ENERGY TRANSITION

THE ENERGY TRANSITION IS AN EXTRACTIVE TRANSITION

- THE ENERGY TRANSITION IS NOT ONLY TECHNOLOGICAL AND CLIMATIC, IT IS ALSO:

GEOPOLITICAL **INDUSTRIAL** **MINING-RELATED**

- RENEWABLE ENERGIES, ELECTRIC VEHICLES, DIGITALIZATION, AND DEFENSE DEPEND ON CRITICAL MINERALS:

Li **LITHIUM** Cu **COPPER** Ni **NICKEL** Co **COBALT** C **GRAPHITE** REE **RARE EARTH ELEMENTS**

FAST-GROWING DEMAND AND CONCENTRATED SUPPLY

- DEMAND FOR MINERALS FOR CLEAN ENERGY **WILL TRIPLE** BY 2040.
- MINING PRODUCTION IS CONCENTRATED IN A FEW COUNTRIES:

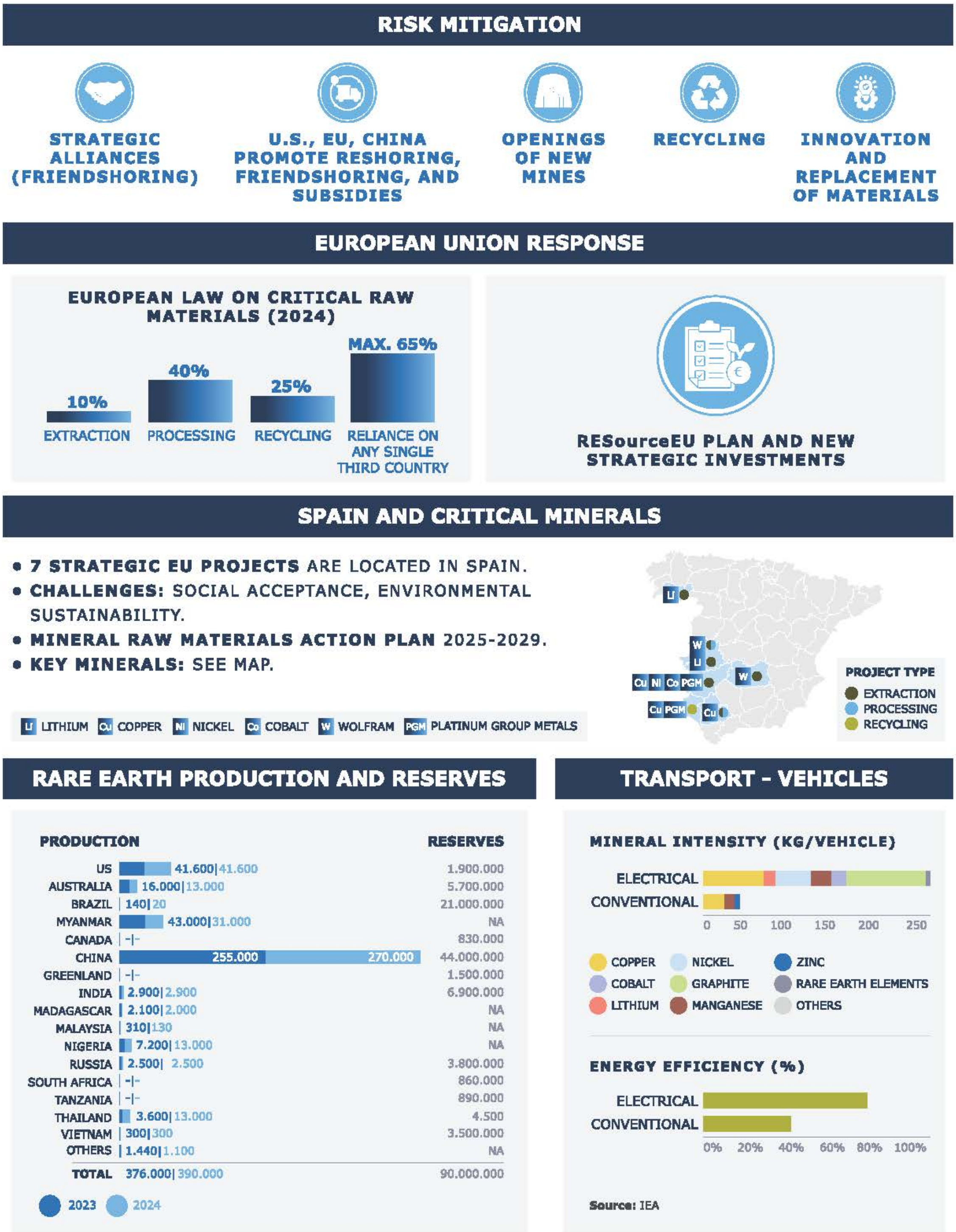
RISKS TO THE GLOBAL SUPPLY DISRUPTIONS OF CRITICAL MINERALS

1 MINERAL CONTROL = NATIONAL SECURITY

- ENERGY, DEFENCE, AI AND DIGITALISATION COMPETE FOR THE SAME MINERALS.
- CHINA-US RIVALRY REDEFINES MARKETS: LESS ECONOMICS, MORE GEOPOLITICS.
- CRITICAL MINERALS ARE NOW A STRATEGIC ASSET.

2 PROTECTIONISM AND CONTROLS

- INCREASING EXPORT BANS, TARIFFS AND NATIONALISATIONS.
- INTRODUCTION OF ACCESS TO MINERALS AS CURRENCY OF EXCHANGE IN CONFLICT RESOLUTION PROCESSES (E.G. IN UKRAINE).


RISK MITIGATION
STRATEGIC ALLIANCES (FRIENDSHORING)
U.S., EU, CHINA PROMOTE RESHORING, FRIENDSHORING, AND SUBSIDIES
OPENINGS OF NEW MINES
RECYCLING
INNOVATION AND REPLACEMENT OF MATERIALS
EUROPEAN UNION RESPONSE
EUROPEAN LAW ON CRITICAL RAW MATERIALS (2024)
10%
EXTRACTION
40%
PROCESSING
25%
RECYCLING
MAX. 65%
RELIANCE ON ANY SINGLE THIRD COUNTRY
RESourceEU PLAN AND NEW STRATEGIC INVESTMENTS
SPAIN AND CRITICAL MINERALS
• 7 STRATEGIC EU PROJECTS ARE LOCATED IN SPAIN.
• CHALLENGES: SOCIAL ACCEPTANCE, ENVIRONMENTAL SUSTAINABILITY.
• MINERAL RAW MATERIALS ACTION PLAN 2025-2029.
• KEY MINERALS: SEE MAP.
Li LITHIUM
Cu COPPER
Ni NICKEL
Co COBALT
W WOLFRAM
PGM PLATINUM GROUP METALS
PROJECT TYPE
EXTRACTION
PROCESSING
RECYCLING
RARE EARTH PRODUCTION AND RESERVES
PRODUCTION
RESERVES
US 41.600|41.600 1.900.000
AUSTRALIA 16.000|13.000 5.700.000
BRAZIL 140|20 21.000.000
MYANMAR 43.000|31.000 NA
CANADA -|- 830.000
CHINA 255.000 270.000 44.000.000
GREENLAND -|- 1.500.000
INDIA 2.900|2.900 6.900.000
MADAGASCAR 2.100|2.000 NA
MALAYSIA 310|130 NA
NIGERIA 7.200|13.000 NA
RUSSIA 2.500| 2.500 3.800.000
SOUTH AFRICA -|- 860.000
TANZANIA -|- 890.000
THAILAND 3.600|13.000 4.500
VIETNAM 300|300 3.500.000
OTHERS 1.440|1.100 NA
TOTAL 376.000|390.000 90.000.000
2023
2024
TRANSPORT - VEHICLES
MINERAL INTENSITY (KG/VEHICLE)
ELECTRICAL
CONVENTIONAL
0 50 100 150 200 250
COPPER
NICKEL
ZINC
COBALT
GRAPHITE
RARE EARTH ELEMENTS
LITHIUM
MANGANESE
OTHERS
ENERGY EFFICIENCY (%)
ELECTRICAL
CONVENTIONAL
0% 20% 40% 60% 80% 100%
Source: IEA

Introduction

Since the Industrial Revolution ushered in the era of carbon-based resources, much of the global energy supply has depended on extracting large amounts of hydrocarbons such as coal, oil, and gas. However, in the 21st century, climate policies and the quest for energy independence are making energy systems electrified, digitalised, and interconnected, with a great impact on energy security. Whereas before the debate on renewable energies focused on the costs of technology and the challenges of integration, now the debate focuses on how to promote and integrate them to be a fundamental component of the energy sovereignty and security of many nations in order to significantly reduce the risk of disruptions in energy supply.

From electric vehicles to solar panels and wind turbines, the deployment of clean energy technologies is advancing rapidly and is heavily dependent on critical minerals such as copper, lithium, nickel, cobalt, and rare earth elements[1]. This boom in renewable energy sources - which are developing at a faster rate than any other fuel in history - means that we are witnessing not only an energy transition but also an extractive transition.

The imbalance between their supply and demand, the high concentration of their production and processing, as well as the possible disruption of their supply chains mean that some of these minerals -or more precisely certain metals contained in mineral forms- are considered critical because they are also essential not only for the energy and digital transition, but also for the defence and aerospace sector.

Mineral markets are being affected by the adoption of policies imposed for reasons of national security. The main consequence is that access to these critical minerals is altering the economic and geopolitical balance worldwide, helping to shape a very complex landscape framed in the strategic rivalry between China and the US. In this context, minerals and their supply chains have become a geopolitical weapon.

In the specific field of renewable energies, the International Renewable Energy Agency (IRENA) considers that although critical minerals could potentially become weapons, the effect of such disruption would be limited. It could slow the deployment of clean energy

[1] Rare earth elements are a group of 17 metals that are essential to modern technology. They are used from smartphones and electric vehicles to wind turbines, fighter jets, and missile guidance systems. Their unique magnetic, luminescent, and conductive properties make them irreplaceable in high-performance electronics and clean energy applications.

technologies, but it is unlikely to cripple entire energy systems. However, this view is only part of the reality as continued access to strategic minerals has become a matter of national security due to their use in emerging technologies in the digital and defence fields.

Many of the minerals needed by the energy, digital, and defence sectors are common and this opens up great uncertainties both from a supply and demand standpoint. By becoming the centre of commerce and hegemonic disputes between China and the United States, the renewable energies sector may be the one that is most affected in the long term.

In this context, it is necessary to analyse the challenges of the energy transition from the point of view of the requirements for the use of critical minerals. The increase in demand, the concentration of supply, protectionist and tariff policies, the exploitation of new spaces, or the social and environmental issues of mining are factors that can undermine the transition to economies away from the use of fossil fuels. Without proper management, the growing demand for critical minerals risks perpetuating dependence on raw materials, exacerbating geopolitical tensions and environmental and social challenges[2].

Toward an extractive transition

The dependency risks and supply dynamics of critical minerals differ fundamentally from those of fossil fuels, due to their very different characteristics and patterns.

Since 2010, there has been a 50% increase in the average amount of minerals needed for a new power generation unit, according to a report by the International Energy Agency (IEA). By 2040, demand for minerals to generate cleaner energy will have tripled. Essentially, the energy transition “means a shift from a fuel-intensive to a material-intensive system.”[3]

The current notion of energy security revolves around continuous access to energy sources. In the case of the EU, the war in Ukraine has highlighted its energy vulnerability due to its high dependence on fossil fuels from Russia and the repercussions on the economy and competitiveness of the Union. Therefore, in the short term, the repercussions of a fossil fuel disruption are much greater on energy security than the disruptions in the supply of the minerals needed to construct renewable energies since the technologies

[2] https://www.un.org/en/climatechange/critical-minerals
[3] https://www.mining-technology.com/features/mining-energy-transition-minerals/?cf-view

already built could continue to function for decades. Therefore, the risk associated with disruptions in the supply of critical materials is lower than the risk associated with disruptions in the supply of fossil fuels in the short term.

A second aspect is that trade in critical materials is many orders of magnitude lower in value than trade in fossil fossils. Fossil fuels reached a value of Generate huge rents Oil and gas exports alone represented a value of USD 2 trillion in 2021, while the market for minerals related to renewable energies (lithium, cobalt, rare earth elements, nickel, and cobalt) reached a value of 96 billions dollars[4]. Unlike oil, most critical materials are not widely traded on exchanges. Although this limits opportunities to hedge against price volatility, it allows commodity traders to play a key role in matching producers and consumers.

The third difference lies in the recycling rate. Fossil fuels are consumed while the elements incorporated in renewable energies can reach a high recycling rate. The average life is also very different, fossil fuels disappear when used while the average life of the usefulness of minerals used in energy installations is around 10-30 years.

Regarding the comparison between mineral and fossil fuel reserves, it should be mentioned that there is no shortage of reserves for energy transition minerals. From 2013 to 2022, the summaries of the US Geological Survey (USGS) reveal that, together, the known reserves of cobalt, lithium, and nickel are increasing, as are the known reserves of other critical minerals, so the global supply of critical minerals is, to some extent, elastic, but it is true that capacities for obtaining and refining are more limited compared to fossil fuels. This uncertainty in supply could slow down the transition to renewable energies due to the lack of investment in the minerals market, which is much more opaque than that of fossil fuels and much more risky.

All these factors imply that in order to move towards decarbonisation and compliance with climate objectives, progress must also be made in an updated approach to energy security, different from that used with fossil fuels. In this way, the risks associated with investing in projects to obtain the critical minerals needed for renewable energies can be minimised. In 2021, the International Energy Agency (IEA) identified an imminent lack of coordination between the demand for critical minerals and their availability. The IEA's findings helped

[4] https://www.irena.org/Digital-Report/Geopolitics-of-the-Energy-Transition-Critical-Materials

governments and companies around the world to develop strategies and investments in critical minerals.

Growing demand and concentrated supply

According to the IEA report "Renewables 2025. Analysis and forecasts 2025", renewable energy will account for almost 45% of electricity generation by 2030, going from 9,900 TWh in 2024 to 16,200 TWh in 2030. According to the aforementioned report, solar PV energy alone accounts for more than 60% of this increase, followed by wind with 32%. Regarding global AI-related electricity demand, the initial exponential growth will become more linear over time, reaching 11% of electricity demand by 2060[5].

This increase in renewable energies continues to drive growth in demand for certain metals. According to the International Energy Agency (IEA) report "Global Critical Minerals Outlook" published in 2025, lithium demand increased by almost 30%, maintaining the strong increase observed in 2023 and significantly exceeding the 10% annual growth rate recorded in the 2010s. The demand for nickel, cobalt, graphite, and rare earth elements increased by 6% to 8% in 2024. Copper also experienced solid demand growth of around 3%, surpassing the pace of the previous two years to reach 12 million tonnes. The rapid expansion of investment in power grids in China was the main driver of demand growth during those two years. Electric vehicles will also remain one of the biggest catalysts of metal demand, as they use four times more copper than their internal combustion counterparts. For this reason, for example, copper consumption in electric vehicles is expected to increase from 200,000 tonnes in 2020 to 3.4 million tonnes in 2035, representing an average annual growth rate of 14% between 2025 and 2035[6].

In the IEA's Stated Policies Scenario (STEPS), demand for lithium will quintuple by 2040, while demand for graphite and nickel will double. The demand for cobalt and rare earth elements is also growing strongly, increasing between 50% and 60% by 2040[7].

[5] https://www.dnv.com/energy-transition-outlook/2025/?utm_source=google&utm_medium=search&utm_campaign=eto_2025_download/&gad_source=1&gad_campaignid=23088436235&gclid=EAIaIQobChMI-eTPtIPtkQMVsch5BB0cyTu1EAAYASAAEgLUSPD_BwE
[6] https://www.mining.com/over-60-of-critical-minerals-demand-met-through-global-trade-ief/
[7] Global Critical Minerals Outlook 2025 – Analysis - IEA

Despite this high demand, there are probably enough critical minerals in the Earth's crust to cover the global need. But the reality is access to them can be very complex. Some critical minerals, like aluminium and palladium, have stable reserves on land that can meet global demand through 2050 and probably beyond. For others, such as copper, nickel, and cobalt, the reserves currently found may be insufficient, so a combination of more exploration, technological advances, and economic incentives will be needed to increase supply[8].

If historical growth rates in the supply of strategic minerals were increased by a factor of 3 to 4, developments in the energy sector by 2050 would remain largely unaffected. However, this increase would still be insufficient to supply the materials needed for large capacity expansions in the short term, resulting in a slower rate of electrification and greater use of fossil fuels in some sectors[9]. In particular, copper and nickel markets could face material deficits in the mid-2030s, while lithium supply remains concentrated in only a few countries[10].

More than 60% of the global demand for critical minerals is met through international commerce, underlining the deep structural interdependence between producing and consuming economies as clean energy deployment accelerates[11]. Even in a well-supplied market, dependence on a small number of suppliers increases vulnerability to shocks and disruptions with the risk of slowing the energy transition. For example, if there were a disruption in the supply of graphite, the price would increase tenfold, the average prices of battery packs worldwide would increase by 45%, substantially reducing the competitiveness of the companies that use them[12]. Battery prices already vary considerably by region, with average prices in 2024 much higher in the United States (30%) and Europe (50%) than in China. A steep rise in graphite prices would further widen the price gap between new electric vehicles sold in the United States or Europe and those sold

[8] Qiu Y. et al. The impacts of material supply availability on a transitioning electric power sector. Cell Reports Sustainability, October 2024.
[9] Schulze K. et al. From fossil fuels to metals and minerals: Navigating global resource challenges in the energy transition, Cell Reports Sustainability, Volume 1, Issue 10, 2024,
[10] https://www.ief.org/_resources/files/reports/a-critical-minerals-enabled-energy-future.pdf
[11] Ibid.
[12] https://www.iea.org/commentaries/growing-geopolitical-tensions-underscore-the-need-for-stronger-action-on-critical-minerals-security

in China, making them nearly twice as expensive in the United States and 75% more expensive in Europe[13].

Therefore, the main current problem related to the supply of critical minerals is their high concentration - far more than fossil fuels - in both production and processing. Indonesia accounts for more than half of the world's nickel supply, the Democratic Republic of the Congo produces about 70% of cobalt. Lithium mining continues to be dominated by Australia, Chile, and China, which together accounted for more than three-quarters of global production in 2022. This concentration in production is far from ending in the short/medium term since around 75% of the projects planned for refined lithium, nickel, and cobalt, and more than 90% for battery quality graphite projects, are being developed in the three main current producers[14].

As for the rare earth element metals group, the main producers were China, the United States, and Canada. It must be highlighted the considerable increase in production from Nigeria and Thailand[15].

	Mine production[e] 2023	Mine production[e] 2024	Re
United States	41,600	45,000	1
Australia	[12]16,000	[12]13,000	13
Brazil	140	20	21
Burma	[12]43,000	[12]31,000	
Canada	—	—	
China	[14]255,000	[14]270,000	44
Greenland	—	—	1
India	2,900	2,900	6
Madagascar	[12]2,100	[12]2,000	
Malaysia	[12]310	[12]130	
Nigeria	[12]7,200	[12]13,000	
Russia	2,500	2,500	3
South Africa	—	—	
Tanzania	—	—	
Thailand	[12]3,600	[12]13,000	
Vietnam	[12]300	[12]300	3
Other	1,440	1,100	
World total (rounded)	376,000	390,000	>90

Figure 1. Principal producers and reserves of rare earth elements. Source: USGS

While the production of critical minerals may seem somewhat diversified, this advantage fades when it comes to the refining and processing of these minerals, where China occupies a clearly dominant position. China's position is based solely on scale and control throughout the supply chain, rather than on geological abundance or crude ore extraction. China refines about 90% of rare earth element group metals. It also refines 19 of the 20 key energy-related minerals, with an average global market share of around 70%. For many high-demand minerals such as lithium, nickel, and cobalt, China's extraction share is only

[13] Ibid
[14] Global Critical Minerals Outlook 2025 – Analysis - IEA
[15] https://pubs.usgs.gov/periodicals/mcs2025/mcs2025-rare-earths.pdf

10-30%, but its share in refining and processing is between 60% and 70%[16]. Currently, China produces 99% of battery graphite, over 60% of lithium chemicals, 40% of refined copper, 70% of refined cobalt, and over 80% of processed rare earth elements[17]. Currently, there are only five rare earth element refineries outside China in operation, under construction, or in the process of reactivation. These refineries are located in the USA, Malaysia, France, Estonia, and Australia.

With regard to manufactured material, China alone represents an 80% share in the different stages of solar panel manufacturing[18], including raw material processing and polysilicon production[19]. China produces two-thirds of the world's electric vehicles (EVs), 85% of battery cell productions, 90% of cathode production capacity, and 98% of anode materials globally. It leads the production of solar panels, wind turbines, and hydrogen electrolysers and dominates the entire graphite anode supply chain from start to finish[20]. The numbers are staggering.

By controlling all stages, China has built the quasi-monopoly that underpins its dominance in global clean energy manufacturing. This dominance is the result of a state policy designed with the long term in mind. Since the 1980s, Beijing has supported early investment in mineral extraction and processing, provided subsidies to both state-owned and private companies in mining, refining, and production of magnet materials or batteries, and applied more flexible environmental standards than countries such as the United States and Australia.

Specifically, China's rise as a powerhouse in the rare earth elements sector has been a product of global specialisation. China increased rare earth element production from approximately 31,000 metric tons in 1994 to 270,000 metric tons in 2024. During this period, Chinese suppliers offered lower prices than US producers thanks to state support, lower environmental standards[21], and cheaper labour[22], which led to the cessation in 2002 of the activity of the US Mountain Pass mine, which until then was recognised as the cornerstone

[16] https://www.iea.org/commentaries/with-new-export-controls-on-critical-minerals-supply-concentration-risks-become-reality
[17] https://www.mining-technology.com/features/a-deep-dive-into-chinas-role-as-critical-mineral-monolith/
[18] https://www.energynews.es/amenaza-fotovoltaica-china-controla-el-46-de-la-capacidad-mundial-y-el-80-del-mercado-de-paneles/
[19] IEA (2022), Solar PV Global Supply Chains, IEA, Paris https://www.iea.org/reports/solar-pv-global-supply-chains, License: CC BY 4.0
[20] https://www.mining-technology.com/features/a-deep-dive-into-chinas-role-as-critical-mineral-monolith/?cf-view
[21] Earth processing is very polluting as it generates radioactive waste.
[22] https://pubs.usgs.gov/periodicals/mcs2025/mcs2025-rare-earths.pdf

of global production of rare earth elements, constituting the richest and most reliable source in the world[23].

The importance of critical minerals for China has driven an acceleration of Chinese investment in the mining sector, both domestically and internationally, securing foreign mining assets in developing countries through the Belt and Road Initiative (BRI), in Africa and Latin America. Chinese-backed entities have invested nearly $57 billion in mineral projects in 19 countries[24]. China's investment in metals and mining, through its Belt and Road Initiative (BRI), reached a record $21.4 billion in 2024, a 10% increase over 2023[25]. This ensures that raw materials flow into the Chinese refining industry, reinforcing its role as a global mineral processing centre.

In recent years, China has acquired significant African mining assets, including the Khoemacau copper mine in Botswana (2023), the Goulamina lithium mine in Mali (2024), and the Ngualla rare earth element mine in Tanzania (2025). In many African countries right now, it is Chinese companies that exploit these resources, not the country itself.

In African countries, investment has focused on the creation of new lithium supply chains, where, of the seven lithium assets in Africa that are expected to start production by 2027, five have at least 50% equity ownership by Chinese companies[26]. China's BYD - the world's largest manufacturer of electric vehicles - is involved in six African lithium mines, securing enough raw materials until 2032[27].

China's advantage in critical minerals cannot be explained solely by state support to the mineral extraction and processing sector. It is the result of a vertical industrial policy developed decades ago in which an effort is made to integrate all the sectors involved from education, research, industry, and the strategic objectives of defence capabilities. In the case of electric vehicles, Beijing expanded subsidies to consumers and required foreign companies to enter into joint ventures with domestic car manufacturers.

[23] https://mpmaterials.com/history/
[24] Escobar, B., Malik, A. A., Zhang, S., Walsh, K., Joosse, A., Parks, B. C., Zimmerman, J., & R. Fedorochko. (2025). Power Playbook: Beijing's Bid to Secure Overseas Transition Minerals. Williamsburg, VA: AidData at William & Mary
[25] https://theoregongroup.com/investment-news/chinas-mining-investments-under-belt-and-road-initiative-hit-record-high-in-2024/
[26] https://www.mining-technology.com/features/a-deep-dive-into-chinas-role-as-critical-mineral-monolith/?cf-view
[27] https://africacenter.org/spotlight/china-africa-critical-minerals/

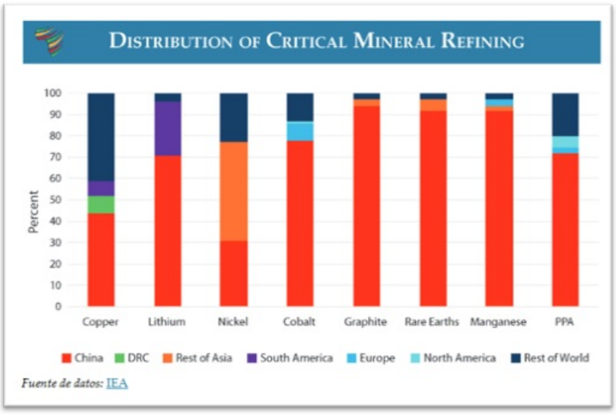


Figure 2. Distribution of refined mineral production by country.
Source: https://africacenter.org/spotlight/china-africa-critical-minerals/

This high concentration of production and processing of critical minerals from China creates vulnerabilities in the supply chain that transcend the economic realm to move into the geopolitical realm.

To study this vulnerability, the N-1 assessment[28] used in natural gas markets and energy systems can be applied. Conducting this assessment in the context of critical minerals to examine what the system looks like when the largest supplier is excluded from global supply and demand balances, nickel, cobalt, and graphite appear to have sufficient supply globally.

However, if the largest supplier and its demand (China for lithium, cobalt, and graphite; and Indonesia for nickel) is excluded, the remaining N-1 supplies would fall significantly below the N-1 demand. For cobalt and graphite, the remaining supplies would cover only 25-30% of N-1 demand in 2035, totally insufficient to cover mineral needs in the renewable energies sector. The N-1 supply covers 55% of N-1 demand for nickel, but the proportion could be much lower if supplies of battery-grade nickel sulphate, mainly from China, are also disrupted. For lithium, the gap is less pronounced, but the remaining N-1 supply still covers only 60% of N-1 demand. This emphasises that even where the global balance is reasonably well-supplied, critical mineral supply chains can be highly vulnerable to supply shocks, whether from extreme weather events, trade disruptions, or geopolitics[29].

[28] The remaining supply after excluding the largest supplier is known as N-1 supply.
[29] https://www.iea.org/commentaries/growing-geopolitical-tensions-underscore-the-need-for-stronger-action-on-critical-minerals-security

Mineral markets: less economics and more geopolitics

China has long understood the strategic value of its dominance in rare earth elements production. As reflected in Deng Xiaoping's 1992 quote, "The Middle East has oil, China has rare earths," China recognised several decades ago the value of these minerals as geopolitical assets. Since 2017, it has gradually strengthened its control over rare earth elements and other critical minerals, imposing licensing and regulatory requirements, limiting foreign companies' access to mining, processing, and related technology.

On the other hand, the defence sector and the digitalisation of economies, where AI plays a fundamental role, need certain minerals, many of them also necessary for the energy sector. For example, electric vehicles and wind turbines require the same specialised magnets as ship propulsion systems and guided missile actuators.

This sectoral competence depends to a large extent on the priorities that certain countries have. For the US, as reflected in the National Security Strategy 2025 and the Pax Silica Initiative, the binomial of economic security-national security seems to be indissoluble. In this case, access to the strategic minerals necessary from the point of view of defence and technological development, will mark to a greater extent the policies and initiatives that the Trump Administration carries out to relocate its supply chains and minimise its dependence on China. For China, its priority is to position itself in the global market as a leader in the export of products for the energy transition, but also encouraging the development of technology in other areas such as defence and AI.

The competition between both powers to gain global hegemony constitutes a risk for the secure and sustainable access of the strategic minerals necessary to carry out the energy transition towards renewable energies. In this complex geopolitical context, preventing a power from having access to critical minerals may be prioritised over free trade, thereby contributing to mineral markets being managed by geopolitics from a national security perspective.

Increased export controls

China has repeatedly used its "quasi-monopoly" in strategic minerals as a geopolitical tool, especially in 2010, when it halted exports to Japan following the collision between a

Chinese fishing vessel and a Japanese Coast Guard vessel near the Senkaku Islands, causing the price of rare earth elements to skyrocket up to tenfold[30].

In 2023, China imposed new licensing requirements for gallium and germanium exports. Gallium exports fell from almost 6,900 kilograms in July to zero in September, and germanium shipments dropped from about 8,000 kilograms to just 1 kilogram. According to 2022 production quotas, this effectively eliminated about 60 percent of global germanium supply and 90 percent of gallium supply from international markets[31], disrupting chip and defence supply chains and demonstrating Beijing's ability to weaponise export licenses. In December 2024, China banned the export of gallium, germanium, and some other materials to the United States. Additional export control announcements followed in February 2025 on a variety of materials, including tungsten, tellurium, bismuth, indium, and molybdenum, key minerals used primarily in defence and high-tech applications. On 9 October, 2025, China expanded export controls including holmium, erbium, thulium, europium, and ytterbium as well as associated mining and processing technologies.

However, the implementation of these new restrictions and controls was suspended for a year after negotiations with Trump on 30 October. A few days later, China announced that it was suspending other long-standing restrictions, such as a ban on the export of gallium and germanium to the United States. The United States then suspended the application of the Affiliates Rule for a year[32] in addition to making other concessions related to the sale of certain chips to China. These negotiations make it clear that minerals, critical and in particular rare earth elements, are a very effective geopolitical tool.

By controlling its exports, China could thus disrupt the global supply chains of a number of strategically important sectors, such as energy and automotive, but also defence and aerospace. China's dominance in the processing of critical minerals has allowed it to reduce prices below any comparable level, increasing the rest of the world's dependence on Chinese exports of these minerals.

[30] Kang Y. et al. Navigating geopolitical risks: The impact of the Senkaku/Diaoyu Islands dispute on global rare earth markets and diversification strategies, Resources Policy, Volume 106, 2025,
[31] https://www.reuters.com/world/china/china-exported-no-germanium-gallium-aug-due-export-curbs-2023-09-20/
[32] The “Affiliates Rule” refers to a US Department of Commerce (BIS) regulation that expands the Export Administration Regulations (EAR) by subjecting non-U.S. companies that are 50% or more owned by entities included in the Entity List or MEU List to the same licensing requirements, with the goal of closing loopholes and preventing diversion of US technology.

These actions show that mineral markets are increasingly governed by geopolitics and less by the economy. This change is a reflection of the new global geopolitical paradigm in which the order established after World War II is breaking down. An example of this is the loss of multilateralism as a tool to resolve international disputes. While in 2010, the US, Japan, and the EU were able to complain to the WHO about rare earth element export restrictions following the Senkaku Islands incident, there is currently nothing that can be done when export restrictions are made on the grounds of national security. And this is the game changer.

This situation means that in recent years there has been an increase in export restrictions on certain goods, with a considerable increase in those that affect strategic minerals. Export controls pose unique challenges compared to other trade controls. Although, like tariffs, they are often part of broad diplomatic negotiations, export controls are often driven by national security concerns. Consequently, governments sometimes implement export restrictions unilaterally and immediately, generating a lot of uncertainty for companies[33].

The largest number of export restrictions between 2019 and 2023 related to the minerals needed for the energy transition were imposed by countries such as the Democratic Republic of the Congo, Mongolia, India, Burundi, and Zambia. These restrictions mainly target key minerals such as copper (notably in the Democratic Republic of the Congo, Mongolia, Zambia, and Argentina), molybdenum (Mongolia), and a group of high-tech or strategic minerals such as gallium, germanium, indium, niobium, tantalum, and vanadium (especially in Burundi and Ethiopia). Zinc has also been subject to restrictions, especially in India, Burundi, and Ethiopia[34].

[33] https://www.mckinsey.com/capabilities/geopolitics/our-insights/restricted-how-export-controls-are-reshaping-markets
[34] https://sdgpulse.unctad.org/critical-minerals

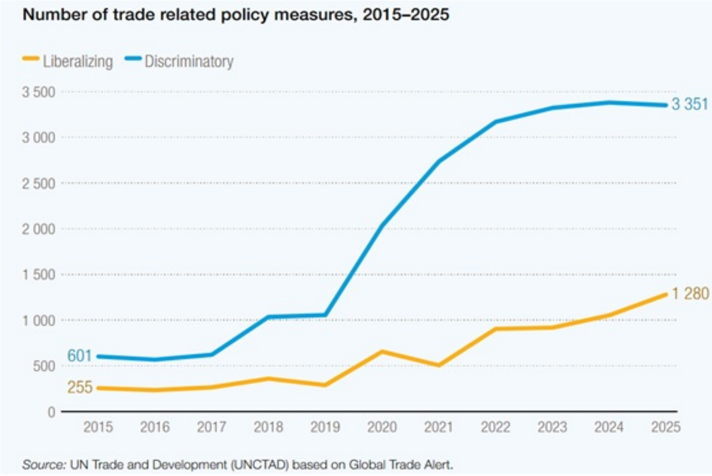


Figure 3. Number of trade policies 2015-2015. Source: UNCTAD

Promoting protectionism

Recent supply chain disruptions have led many countries and regions to seek a relocation of supply chains for greater strategic autonomy and to reduce dependence on potential adversaries. As countries move to protect their national security and energy independence, critical minerals have become the protagonists in policymaking in strategic sectors. The main objectives of these policies are to encourage strategic industries to relocate or establish new operations in their countries of origin (reshoring), in nearby regions (nearshoring), or in trusted allied nations (friendshoring)[35]. These measures disrupt global flows and are indicative of how state policy can redirect supply.

According to estimates from the International Energy Forum (IEF), the number of critical minerals policies issued since 2020 nearly doubled the combined total of the previous two decades, with countries increasingly turning to strategic planning, export controls, and domestic processing mandates to protect supply chains. To cite some examples, Indonesia, with 21% of the world's nickel reserves and 37% of the mining production of this metal, has been progressively restricting exports. In 2020 it banned the export of nickel ore to force local smelting, attracting heavy investment in refineries. Zimbabwe has restricted chromium exports to boost processing in the country and the Philippines has passed a bill to ban the export of unprocessed nickel ore by 2030 to promote domestic processing[36].

[35] https://www.irena.org/Digital-Report/Geopolitics-of-the-Energy-Transition-Critical-Materials#page-4
[36] https://legacy.senate.gov.ph/press_release/2025/0203_escudero1.asp

And in Latin America, Chilean President Gabriel Boric has taken steps to nationalise his country's lithium industry, which accounts for 26% of global reserves[37].

In recent months, the Trump Administration has made efforts to reduce US dependence on Chinese supply, launching initiatives to fund domestic mining projects, streamlining permits, and partnering with allies to diversify the supply chain. Within months, the Trump Administration has rewritten the rules of US trade policy. It has imposed general tariffs on almost all countries, starting at 10% and increasing to 50%. Taxes on a number of products, such as steel, aluminium, cars, and auto parts, have further raised these trade barriers. At an average effective rate of about 18%, US import taxes are now the highest in nearly a century[38]. These actions will change the position of the United States in the world economy, detaching the country, at least in part, from global supply chains.

In recent years, support for new critical mineral projects in the US has been carried out based on purchase agreements between car manufacturers and national mineral extraction companies. General Motors (GM), for example, made a $650 million equity investment in Lithium Americas, gaining exclusive access to Phase 1 production from a new mine in Thacker Pass, Nevada[39]. This agreement would have supported GM's choice to receive consumer tax incentives for domestically produced electric vehicles.

The Trump Administration has taken another step and focused its attention on policies to increase mineral supply, including import tariffs, deregulation, and direct federal investment through the Department of Defence. The March 2025 Executive Order on “Immediate Measures to Increase American Mineral Production”[40] established the “National Energy Dominance Council,[41]” expanded the list of critical minerals to include uranium, copper, potash, and gold, and directed agencies to expedite permits and mobilise funding. In April 2025, a second Executive Order launched a marine minerals strategy, directing the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration (NOAA) to inventory deposits of nickel, cobalt, copper, manganese, titanium, and rare earth elements, and apply for fast-track permits for exploration and

[37] https://cncls.cl/estrategia-nacional-del-litio-impulso-para-chile/
[38] https://www.infobae.com/america/mundo/2025/08/07/los-impuestos-a-las-importaciones-en-estados-unidos-alcanzaron-el-mayor-nivel-en-casi-cien-anos/
[39] https://www.greencars.com/es-us/noticias/gm-invierte-650-millones-de-dolares-en-la-produccion-de-litio
[40] https://www.whitehouse.gov/presidential-actions/2025/03/immediate-measures-to-increase-american-mineral-production/
[41] Among the Council's functions is to advise the President on improving permit gaining, production, generation, distribution, regulation, transportation, and export processes for all forms of US energy, including critical minerals.

mining on the US outer continental shelf. It also calls for strengthening national refining capacity, integrating seabed minerals into national security planning, and partnering with allies to develop seabed resources responsibly, countering Chinese influence.

In mid-July 2025, the US Department of Commerce intervened in the natural graphite market, imposing a 160% tariff on Chinese graphite anode active material[42]. On 30 July, the Administration announced a 50% tariff on imports of copper products and copper-intensive products, with additional actions to require that 25% of copper ores, scrap, and concentrates produced in the United States be sold domestically[43].

In addition to tariffs, Trump's strategy also includes subsidies for the production and processing of strategic minerals. This would be especially important in industries where markets have failed, such as the battery industry where Chinese subsidies have increased battery manufacturing capacity to the point of far exceeding total global demand. It seems that Trump seeks to play by the same rules using an unusual pragmatism in Western democracies. In addition, the Mine of the Future initiative provides nearly $100 million in funding to accelerate research, innovative mining technologies, and commercialisation44. Also, Donald Trump, using the Defence Production Act of 1950, signed in March 2025 an executive order aimed at immediately increasing US production of critical minerals such as uranium, copper, potash, and gold, among others.

In July, the Department of Defence (DOD) signed a collaboration agreement with MP Materials for a vertically integrated operation from rare earth element extraction to magnet production, known as a “mine to magnet” strategy. The agreement includes capital investment by the DOD; a guaranteed agreement to purchase 7,000 metric tons of rare earth element magnets per year, just over 40 percent of US demand for these materials in 2020, and at a guaranteed price approximately twice the 2025 market price. This action should reduce the United States' dependence on China when the plant comes into operation in 2028[45].

[42] https://source.benchmarkminerals.com/article/chinese-aam-imports-into-the-us-face-160-tariff-following-antidumping-investigation-ruling
[43] https://www.whitehouse.gov/presidential-actions/2025/07/adjusting-imports-of-copper-into-the-united-states/
[44] https://www.energy.gov/articles/energy-department-announces-actions-secure-american-critical-minerals-and-materials-supply
[45] https://mpmaterials.com/news/mp-materials-announces-transformational-public-private-partnership-with-the-department-of-defense-to-accelerate-u-s-rare-earth-magnet-independence

For its part, the EU is also moving towards greater protectionism with the approval of the Critical Raw Materials Act with the aim of establishing a secure and reliable value chain of critical minerals for the bloc. It establishes dependency on a single supplier country at 65% percent and encourages mining, processing, and recycling in Europe.

International initiatives of like-minded geopolitical groups: friendshoring

China's partnerships through its Belt and Road Initiative, which supports infrastructure development primarily in developing and emerging economies, have been instrumental in dominating mineral processing[46].

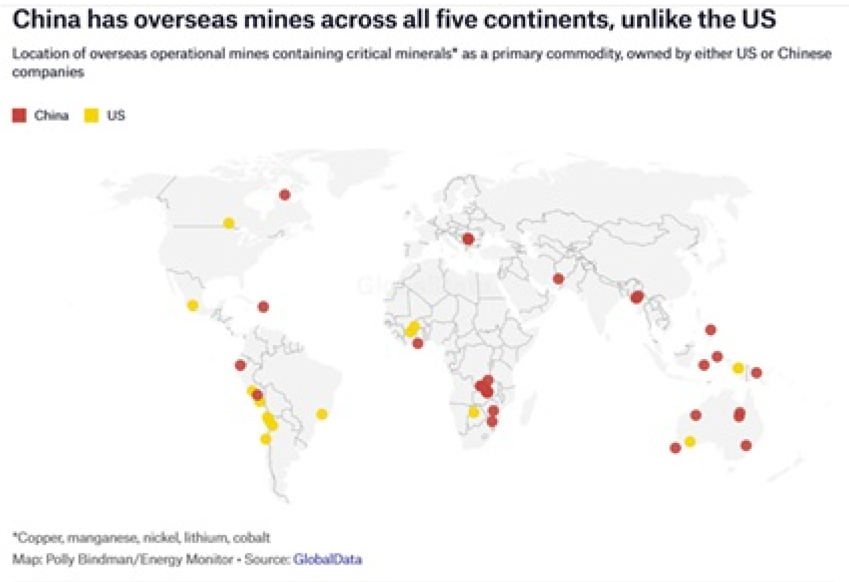


Figure 4. Location of operational mines abroad that contain critical minerals as a main product, owned by US or Chinese companies. 2023. Source: https://mine.nridigital.com

That's why the United States and its allies are turning to friendshoring, which consists of building supply chains through trusted partners. This approach is being promoted through a series of alliances and agreements at the multilateral and bilateral levels. These agreements between governments provide positive signals in the marketplace and

[46] https://www.wri.org/insights/critical-minerals-explained

leverage political support that catalyse more private investment and ensure projects get from announcement to production.

From the multilateral point of view, the initiatives framed in the G7[47] and the G20[48] stand out, as well as the Minerals Security Partnership (MSP) created in 2022. This initiative is an international cooperation mechanism to expand diversification and trade in mineral supply. Much of the MSP's focus has been on promoting corporate and political transparency in mineral-rich developing countries, including policies in support of environmentally and socially sustainable mining practices. Proof of this is the Lobito corridor initiative in West Africa.

But it is the bilateral framework where more progress is being made among like-minded countries to secure critical mineral supply chains and counter China's dependence. Although it involves global diversification on a smaller scale, these bilateral partnerships can bring mutual benefits in a more agile and efficient way. For example, in 2010, prices for some rare earth elements rose significantly for fear that China was restricting its supplies due to an unrelated dispute with Japan. Japan contracted Australia for additional extraction of these materials, established an agreement with Malaysia for new processing capacity, promoted mineral recycling, and funded research on rare earth element alternatives. Over the past decade, Japan's dependence on Chinese rare earth elements has fallen from 90 to 60 percent[49].

In this regard, it is worth mentioning the agreement between the US and Australia and those recently signed with Japan, Malaysia, and Thailand. We must also mention the peace agreements that Trump is reaching with certain countries in the resolution of conflicts that, although not like-minded, have critical mineral resources. Such is the case with Ukraine or the Republic of the Congo.

But perhaps Trump's most promising bet is the recently announced Pax Silica Initiative, with which he aims to establish partnerships with countries that contribute to strengthening their independence from China in certain strategic materials and advance technological development. At the moment, the initiative is a statement of shared principles-still without an implementation mechanism-on which future cooperation will be based. The first to join

[47] https://www.consilium.europa.eu/media/rwkj3dls/minerals-en.pdf
[48] https://www.iied.org/critical-minerals-reflections-g20-leaders-summit
[49] https://www.rusi.org/explore-our-research/publications/commentary/japans-responses-chinas-supply-chain-dominance#:~:text=Japan%20empowered%20the%20Japan%20Organization,from%2095%25%20to%2060%25.

the initiative were: Japan, Australia, Singapore, South Korea, United Kingdom, and Israel. Qatar and the United Arab Emirates have since joined, and India is likely to join in the coming weeks. It cannot be ruled out that in the future Trump will invite other countries to become part of it. What is most significant about this Initiative is that it is the first time that countries are organised around computing, semiconductors, minerals, and energy as shared strategic assets.

Both the EU and Canada have been left out of this initiative for now, despite the fact that Canada has deposits of more than half of the minerals on the US critical list. including lithium, graphite, nickel, cobalt, copper, and rare earth elements. It is the only western nation with all the raw materials needed for advanced electric vehicle batteries. Canada is proactively expanding its capacity for mining and processing. For example, its 2022 Critical Minerals Strategy seeks to accelerate exploration, streamline the granting of permits, and expand domestic processing.

All these multilateral agreements are reinforced by collaborations that move between the government and business sectors. These include, for example, the new joint venture between the US Department of War, the company MP Materials, and the company Maaden, which is 67% owned by the Public Investment Fund of Saudi Arabia. The aim is to build a rare earth element refinery in Saudi Arabia. This partnership represents a critical step toward balancing the global rare earth element supply chain and is aligned with US economic and national security interests. Under the agreement, the Department of War will fully fund 49% of the US side, while MP Materials will provide the technical expertise; Maaden will retain the remaining 51% of the stake[50].

Saudi Arabia offers a very favourable regulatory landscape. It has introduced a modern regulatory framework to accelerate the development of its mining sector and support its broader ambitions in critical minerals set out in Vision 2030. In 2021, Saudi Arabia enacted the Mining Investment Law, a set of sweeping reforms aimed at attracting investment and streamlining processes in the mining industry. Mining licenses in Saudi Arabia can be obtained in 180 days, in stark contrast to the United States, where it normally takes between 7 and 10 years to obtain the necessary permits to put a mine into operation[51].

[50] https://es.marketscreener.com/noticias/mp-materials-y-el-departamento-de-guerra-de-ee-uu-se-asocian-con-maaden-para-desarrollar-una-refine-ce7d5ed9d98ff325
[51] https://www.arabnews.com/node/2223726/business-economy

For its part, the EU under its Global Gateway strategy[52] has launched projects related to access to critical minerals, among which it is worth highlighting those signed with several countries such as Zambia, Namibia, Ghana, Kazakhstan, and the Democratic Republic of the Congo with its contribution to the development of the Lobito corridor[53].

In view of all these initiatives, what is perceived is a mosaic of government and business relations with similar geopolitical objectives and interests. However, some authors point out that what is missing is an institution capable of coordinating policies, mediating disputes, and promoting responsible resource management. The idea of an International Materials Agency (IMA) — proposed by the UN's International Resource Panel and, more recently, by the Global Investor Commission on Mining 2030 — offers precisely that mechanism. Just as the International Energy Agency (IEA) was created in response to the oil shocks of the 1970s, an IMA would offer a platform for cooperation between governments and industry, reinforcing data transparency and equitable access to mineral resources crucial to the energy and digital transition[54].

New exploitations vs. recycling

Increasing the supply of materials is vital to meet the future demand for materials in the energy sector. This increase can be done by expanding the primary or secondary supply. Primary supply could be increased by expanding the extraction and processing of critical minerals. Regarding secondary sources, recycling could contribute significantly to diversifying sources of supply to prevent the vulnerabilities generated by the excessive dependence on exporting countries.

[52] This initiative was launched in 2021 to compete with China's New Silk Road and boost infrastructure development in Latin America, Southeast Asia, and Africa. In four years, more than €306 billion has been mobilised, and it is likely to exceed €400 billion by 2027.
[53] https://international-partnerships.ec.europa.eu/policies/global-gateway/climate-and-energy_en?page=2
[54] https://www.theparliamentmagazine.eu/news/article/europes-chance-to-lead-on-critical-minerals

Primary supply of critical minerals

In terms of primary supply, resources are classified based on geologists' confidence in the existence and size of deposits. They become reserves when economic extraction is possible under current technical and market conditions. The border between the two is fluid, as it is subject to many factors, including raw material prices, infrastructure, regulatory frameworks, political decisions, technological innovation, and even the existence of security and conflict situations that may affect the extraction zone**.**

Ten years ago, 50% of all known rare earth element deposits were in China. Today, that figure has dropped to 34%[55], indicating the interest placed in the exploration of new ones in recent years. Earlier this year, Sweden discovered the largest rare earth element deposits in Europe[56], and between 20 and 40 million tonnes of lithium was recently found in a volcanic crater along the Nevada-Oregon border[57], making it potentially the largest deposit in the world. And regarding cobalt, for example, Australia has the second largest reserves, with around 15% of the world's total, with a production to date of only 2%.

By the end of the next decade, there is reason to expect additional discoveries that deepen the understanding of the various potential sources of supply[58]. However, explorations to find new deposits are very expensive and can be considered a lost fund if satisfactory results are not obtained, constituting the first barrier to encourage investments in the mining sector.

Although the demand for critical minerals can increase dramatically in just a few years, increasing supply by putting a new mine into operation usually takes a decade or more. This gap between rapid technological adoption and slow resource development puts governments and businesses under constant pressure to secure new sources of supply. Addressing these risks requires both short-term responses and long-term industrial planning.

The main problem for the opening of new deposits is the great uncertainty surrounding their profitability. In this regard, public-private collaboration and the support of state financing is

[55] https://www.goldmansachs.com/insights/articles/resource-realism-the-geopolitics-of-critical-mineral-supply-chains
[56] https://lkab.com/en/press/europes-largest-deposit-of-rare-earth-metals-is-located-in-the-kiruna-area/
[57] https://www.earth.com/news/worlds-largest-lithium-deposit-lies-under-a-supervolcano-in-the-us/
[58] https://www.goldmansachs.com/insights/articles/resource-realism-the-geopolitics-of-critical-mineral-supply-chains

essential if we are to move towards a secure supply chain related to renewable energies and avoid dependencies on third countries and especially China.

Prices of some minerals have swung sharply over the past decade, driven less by supply and demand fundamentals than by strategic behaviours, whether by China's dominance in supply chains or by export controls and protectionist measures. Price should not be the engine used to start up new deposits. If this is the only factor, diversification of supply will not be possible for certain minerals.

For example, in 2022, Jervois opened the only US cobalt mine in Idaho, only to close it the following year when prices plummeted. Between May 2022 and May 2025, cobalt prices fell by 59.5%. This sharp drop coincided with China Molybdenum Company Limited (CMOC) nearly doubling its annual cobalt production in 2024, reaching record production levels even as market prices fell more than 60 percent[59].

This situation indicates that government investment in shares provides an avenue for the necessary capital and reduces risks for companies. Price support mechanisms and other policy tools will also be able to make strategic mining projects viable for national security.

With regard to investments in developing and mineral-rich countries, foreign direct investment plays a key role in helping resource-rich countries build local refining and processing capacities and move up the mineral value chain. The energy transition offers developing economies a great opportunity to boost development by moving up the value chain of critical minerals[60].

Recently, new regions are emerging as hotspots in the competition for mineral resources. They have large underdeveloped reserves and are attracting geopolitical interest. Their importance as sources of critical minerals gives these areas additional strategic importance. This is the case of the Arctic, deepwaters, or space mining.

Greenland has deposits of 39 of the 50 minerals included in the US critical minerals list. These include earth elements, graphite, platinum group metals, and niobium. Greenland's REE reserves are approximately 1.5 million metric tons, close to the US total. If developed, these reserves could cover a large portion of global demand[61]. Both the United States and

[59] https://source.benchmarkminerals.com/article/cobalt-price-slump-hits-first-new-us-cobalt-mine-in-decades
[60] https://sdgpulse.unctad.org/critical-minerals/
[61] https://www.csis.org/analysis/greenland-rare-earths-and-arctic-security

China have shown interest in Greenland's resources in recent years, but now Trump has gone a step further by seeking to annex this huge island.

Secondary supply

Emerging technologies for recycling and recovering critical raw materials are not yet sufficiently developed to meet current demand. Their large-scale industrial implementation requires technological, environmental, and economic validation.

Current recycling levels vary significantly by material. Steel, aluminium, and copper are commonly recycled, with average rates above 60%, so there could be large volumes of secondary supplies of these materials available to replace a portion of their primary production and relieve pressure to further expand their supply chains. In contrast, other materials, such as lithium, graphite, and rare earth elements, are rarely recycled (1% recycling rate), mainly due to the lack of considerable flows at the end of their useful life.

In the long term, there is great potential to improve recycling rates for these materials as a growing number of contemporary energy infrastructures reach the end of their useful life[62]. Therefore, proactive actions are also needed to support the R&D of waste management measures and recycling technologies for these materials, so that they are available and can be scaled up to manage the increasing volumes of energy technologies at the end of their useful life that will be needed in the future.

The most convenient thing is that the entire life of the product -from its design to the end of use- is carried out from a point of view of subsequent recycling and circularity. Many products today are not designed for easy material recovery. They are often created with functionality and production costs in mind rather than sustainability. For example, some products contain adhesives or coatings that further complicate material recovery. The lack of clear design standards for recycling exacerbates the problem, making the transition to a circular economy even more complicated[63].

[62] Yang Qiu, 1,2 et al. The impacts of material supply availability on a transitioning electric power sector https://doi.org/10.1016/j.crsus.2024.10022
[63] Ries, Lena & Wartzack, Sandro & Zipse, Oliver. (2023). Creating Sustainable Products: The Road to Circularity. 10.1007/978-3-031-42224-9_5.

Replacement

Technological advances can drive the reduction of the intensity of the use of critical minerals and their replacement, thus alleviating the impacts of a possible shortage of materials supply in the future related to strategic minerals. Technological innovation that reduces the intensity of material use in energy technologies such as solar PV, wind, and battery storage is already underway. Replacements of materials and technologies are also being carried out, such as the abandonment of permanent magnet-based wind turbines and the adoption of vanadium redox flow batteries. While these strategies could reduce the demand for supply-constrained materials such as Li, Co, and rare earth elements, they could increase the demand for other materials due to replacement of technologies and materials (e.g., increased demand for Na or V due to replacement of lithium ion batteries for sodium or vanadium ion redox flow batteries, or replacement of Cu for Al in wires). Thorough assessments of these trade-offs are essential to ensure a sufficient supply of alternative materials should such replacements occur[64].

EU's response to critical minerals

The EU is gradually trying to strengthen its autonomy in strategic sectors such as clean energy and artificial intelligence through a strategy of diversification and reduction of the risks of excessive interdependence with other countries (de-risking), but avoiding commercial decoupling with them (decoupling), which would imply deglobalisation with enormous economic costs for member states.

To this end, the European Critical Raw Materials Act, approved by the EU in 2024, sets the goal of achieving the local extraction of 10% of the critical materials that the bloc needs by 2030 and reaching 40% of the processing, in addition to covering 25% of the demand with recycling and not depending on a single supplier by more than 65%.

In compliance with this law, the EU has approved 47 projects of interest that will have advantages for their implementation, mainly in the streamlining of the permits necessary to carry them out. Of these, 7 are in Spain.

[64] Yang Qiu et al. The impacts of material supply availability on a transitioning electric power sector, Cell Reports Sustainability. Volume 1, Issue 10, 2024, https://doi.org/10.1016/j.crsus.2024.10022

Recently, the Commission has proposed a new Action Plan called RESourceEU to accelerate the diversification of supply through concrete financing, market monitoring, and risk mitigation instruments. The RESourceEU Action Plan will accelerate the deployment of raw materials projects in Europe and partner countries.

The Commission is prioritising strategic projects with the potential to rapidly reduce EU dependencies. To achieve this, the Commission is mobilising close to €3 billion in EU funding over the next 12 months for critical raw materials projects. The Commission is also expected to propose simpler permits for critical raw materials in order to enable the rapid deployment of the projects, while respecting EU environmental, social, and governance standards.

Funding remains an important bottleneck for projects along the entire value chain of critical raw materials. In recent years, the Commission and Member States have supported critical raw materials projects, for example through the Innovation Fund or the Just Transition Fund. Neo Performance Materials' rare earth element magnet plant in Narva, Estonia - construction of which began in 2023 - has been one of the first beneficiaries of the EU's Just Transition Fund. Its production capacity in Phase 1 is 2,000 annual tonnes, with plans to subsequently expand it to 5,000 annual tons[65].

The InvestEU guarantee has also helped implementing partners such as the EIB to finance projects. Some Member States have also started to create specific funds for critical raw materials. But more action is needed and that is why the RESourceEU Plan is fundamentally focused on funding. The Commission will unlock support through direct aid through EU grants and mobilise support by channelling investments.

Within this RESourceEU Plan, the EU aims to create the European Critical Raw Materials Centre in 2026. This centre will provide strategic oversight that will enable the EU to ensure European industries' access to critical raw materials, while ensuring resilience and sustainability. It will develop robust information on critical raw material value chains and primary and secondary markets, which will serve as a basis for national and EU strategies on investment, storage, and joint procurement.

[65] https://ec.europa.eu/regional_policy/whats-new/panorama/2025/09/17-09-2025-green-jobs-local-roots-global-reach-the-baltic-sea-region-road-to-innovation_en

A Raw Materials Mechanism will also be established within the framework of the EU Energy and Raw Materials Platform, which will act as a contact search tool, allowing the aggregation of demand and facilitating the joint private purchase of strategic raw materials.

In addition, the Commission, together with Member States, will also launch a pilot project for the storage of critical raw materials to create an effective approach to raw material reserves, focusing on logistical and financing challenges to improve industrial resilience.

The RESourceEU Plan will also accelerate raw material diplomacy by deepening and expanding the EU's strategic partnerships with resource-rich and related countries, and strengthening cooperation in multilateral fora. The Commission, Member States, and partner countries will continue to implement the already existing strategic partnerships established through the Global Gateway strategy by accelerating support to projects in third countries through technical assistance, guarantee, and blended financing instruments. Following the Memorandum of Understanding with South Africa, the Commission will also initiate negotiations with Brazil to support joint projects, local value creation and employment, and stricter ESG (Environmental, Social, and Governance), research, and innovation standards throughout the value chain[66].

The RESourceEU Plan urges Member States that have not yet done so to establish one-stop contact points and ensure that they function efficiently, in order to help set clear deadlines for the granting of permits and reduce risks for project promoters. With a view to improving the regulatory framework, the Commission will present a proposal on accelerating the granting of environmental permits, which will include provisions to accelerate the granting of permits for critical raw material projects.

A very important aspect is that the EU must ensure that foreign investment brings real added value to the single market and is in line with our economic security objectives. Taking into account the strategic nature of the value chain of critical raw materials, the Commission will integrate the strategic projects as 'projects or programmes of Union interest' under the Foreign Direct Investment Regulation, which will provide greater control over foreign investment in the EU critical raw material value chain for security reasons. To further safeguard strategic projects, the Commission will also restrict the participation of non-reciprocal foreign entities, including Chinese-controlled entities, in EU-funded research.

[66] https://ec.europa.eu/commission/presscorner/detail/es/ip_25_2755

Mining in Spain and critical minerals

As demand for renewable energies continues to rise, the mining sector faces significant challenges and opportunities to meet the demand for critical minerals needed while addressing environmental concerns and adopting technological advancements.

Spain is a country with a mining tradition and can play a prominent role due to its geodiversity and the existence of minerals considered critical. In this context, Spain can contribute extractive and mineral processing capacity to the domestic market and the EU. In fact, 7 of the 45 EU priority projects have been awarded to Spain. Seven of these projects have been awarded to Spain, with mines located in Extremadura, Galicia, Andalusia, and Castilla-La Mancha. In Extremadura, the mines of Aguablanca (Badajoz) and Las Navas (Cáceres) will be used to extract minerals for batteries, while tungsten, a key mineral for the aerospace and defence industry, will be extracted in La Parrilla (Cáceres), an activity that will also take place in Abenójar (Ciudad Real). In Doade (Ourense) lithium will be extracted, and in Andalusia projects will be developed to obtain minerals through circular economy.

Selected projects will be able to benefit from financial support from the European Commission, Member States, and various institutions, in addition to a more streamlined permit processing process. In this regard, the maximum period for the granting of mining permits will be reduced to 27 months, while that of transformation and recycling will be 15 months, compared to the five or ten years that the process used to last.

Doade mine Located in Galicia, the Doade mine is the only approved lithium mining exploitation in the region. Managed by Recursos Minerales de Galicia, S.A., the project involves the construction of an underground mine and a treatment plant for the minerals extracted in the Doade-Beariz area (Ourense).
Las Navas mine Lithium Iberia, S.L. is leading this project, which focuses on open-pit lithium extraction in the area of Dehesa Boyal de las Navas, in Cáceres. This deposit is in an ecologically sensitive location, being located between the SPAs (Special Protection Areas for Birds) of Monfragüe and Canchos de Ramiro - Ladronera, within the Natura 2000 Network.

La Parrilla mine Located between the Extremaduran municipalities of Almoharín and Miajadas, the La Parrilla mine has received the support of the European Commission for its reopening. Iberian Resources Spain seeks to extract tungsten, a critical metal with applications in the technology and defence industry, as it is used in the manufacture of components for home appliances, cars, and even military equipment. The approved exploitation model is an integrated project that will combine extraction with mineral processing, which is a strategic advantage by reducing dependence on third countries in the tungsten supply chain.
Aguablanca mine Located in Monesterio (Badajoz), the Aguablanca mine focuses on the extraction of a variety of strategic minerals such as nickel, copper, cobalt, platinum, palladium, and gold. This exploitation, managed by Rio Narcea Recursos S.A., had already operated open pit in the past, but the new project proposes an underground exploitation, with the aim of minimising its environmental impact.
El Moto mine This deposit located in Ciudad Real, managed by Abenójar Tungsten S.L., focuses on the extraction of tungsten and gold. After 14 years of research and obtaining environmental and mining permits, the project has been approved with an exploitation concession for 90 years.
CirCular Project Unlike the other projects, the CirCular Project, promoted by Atlantic Copper SLU, does not consist of a mining exploitation, but of an innovative metal recycling plant. This facility, located in Huelva, will have the capacity to process up to 60,000 tonnes of electronic and electrical waste per year, allowing the recovery of valuable materials such as copper, gold, silver, platinum, and palladium
Las Cruces PMR Project Cobre Las Cruces S.A.U. is leading this ambitious project in the Iberian Pyrite Belt, which covers areas of Badajoz, Huelva, and Seville. It is an underground mine that will exploit a new polymetallic deposit located beneath the one that was exploited between 2009 and 2020. In addition to extraction, the project includes the construction of the world's first polymetallic refinery, which will produce copper, zinc, lead, and silver using a technology patented by the company.

Figure 5. Projects of strategic interest to the EU in Spain.
Source: https://elperiodicodelaenergia.com/del-litio-al-cobre-los-siete-proyectos-mineros-que-transformaran-espana/

Spain faces a profound paradox: it has remarkable geological potential, recognised by the European Union with the designation of these seven strategic projects for the continent's autonomy, but lacks a unified state vision for its mineral resources[67].

In compliance with the European Critical Raw Materials Act, Spain has presented the National Mining Exploration Program 2025-2029. The problem is that it neither has a clear budget nor depends entirely on the Government, since the competences in mining matters are transferred to the autonomous communities. Perhaps the most relevant novelty introduced by the new action plan is the approval of a new Mining Law.

The Mining Law in force is from 1973 and was a boost for mining, addressing the need for this activity to be developed looking for a balance with some protection of environmental values. A possible reform would offer the opportunity for mining activity to be more sustainable, integrated into the circular economy, and committed to the fight against climate change[68].

Current and future mining faces social and environmental challenges in general terms and specifically in Spain. Sustainability and the reduction of environmental impact are identified as the main challenges of mining in Spain in an opinion study carried out by Knauf[69] in which it is concluded that there is a significant gap between the reality of modern mining and the perception that society has. In the study, 63% of respondents consider that mining is an industry that should be boosted in Spain, but 8 out of 10 respondents believe that it does not have enough government support.

Almost half of Spaniards (49%) do not have a clear opinion on how they would react if a mining project were developed near their locality, which shows that the perception of mining in Spain is still complex and, in many cases, there is a great lack of knowledge. 57% of Spaniards believe that it generates employment and development in these areas, while 22% consider that it has an overall economic impact. This positive view on its economic contribution, however, coexists with a significant lack of knowledge about the real scope of its labour impact, 8 out of 10 Spaniards do not know that mining generates more than 320,000 quality jobs in the Spanish mining regions.

[67] VAN DEN HURK, Arnoldus M. La Nueva Geopolítica del Siglo XXI: La Doctrina TESIS como Pilar de la Soberanía Mineral y la Seguridad Nacional de España. Documento de Opinión IEEE 102/2025.
[68] Carlos Ramírez Sánchez-Maroto | 28 November, 2023. Actualidad Jurídica Ambiental, no. 139
DOI: https://doi.org/10.56398/ajacieda.00348
[69] https://knauf.com/es-ES/knauf/sobre-knauf/noticias/estudio-mineria

Regarding the environmental impact, it is worth mentioning that solutions are being offered to make mining production compatible with sustainable environmental management. In this regard, it is worth mentioning the techniques that allow the development of exploitations with a minimum impact, even fully integrating them into the landscape, generating new ecosystems. An example of this is the UCM Geomorphological Restoration Group led by José Francisco Martin Duque.

With regard to the social impact, it is necessary to have the participation of local communities and interest groups so that the mining activity benefits the local population. It is also important that the mining project be accompanied by other projects in the value chain. From research in universities to the implementation of production systems. In this way, the generation of "clusters" contributes to improving the development of populations and generate wealth over the long term, even when mining activity has ceased.

The United Kingdom's strategy on critical minerals offers a very interesting vision since it faces the challenge of increasing its own mining capacity by associating it with its own industry, and even proposes an industrial renaissance through the mining, processing, and recycling of minerals[70].

Conclusions

The future of green technology depends on sustainable supplies of critical minerals. For this reason, the global energy transition cannot be understood only as a technological or environmental change, but as a profound geoeconomic and geopolitical transformation marked by a growing dependence on these minerals.

The shift from a fossil fuel-intensive to a mineral-intensive energy system introduces new structural vulnerabilities, stemming not so much from its geological scarcity, but from the extreme concentration of production, processing, and manufacturing in a small number of countries. In this context, energy security is no longer exclusively associated with access to energy sources and becomes dependent on complex, long mineral supply chains that are highly exposed to political and strategic risks.

[70] https://www.gov.uk/government/publications/uk-critical-minerals-strategy/vision-2035-critical-minerals-strategy

This chapter highlights that while the global supply of critical minerals might be sufficient to sustain the energy transition, the real challenge lies in stable access to these resources. The high concentration of production and, above all, refining - with China as the clearly dominant actor - turns critical minerals into instruments of geopolitical power. Although the disruption of the supply of critical minerals in the energy sector would not have short-term consequences, its long-term effects would imply slowing down the energy transition and preventing the fulfilment of climate objectives.

Export controls, trade restrictions, and state-led industrial policies are transforming traditionally economically driven markets into national security issues, weakening multilateralism and increasing geoeconomic fragmentation.

The strategic rivalry between the United States and China acts as the backbone of this new mineral geopolitics. As China consolidates its leadership through vertical integration of value chains and a long-term global investment strategy, the United States and its allies are opting for policies of reindustrialisation, selective protectionism, and friendshoring to reduce critical dependencies. These dynamics, although aimed at strengthening national resilience, run the risk of slowing the deployment of clean technologies, raising the costs of the energy transition, and generating new tensions between climate objectives and security and defence imperatives. The absence of effective global governance of critical minerals remains one of the main weaknesses of the current international system

Faced with these limitations, the document shows that no strategy based exclusively on the opening of new mining exploitations can solve the bottlenecks in the short term, due to long development times, price volatility, and regulatory and social uncertainty. In this regard, recycling, the circular economy, technological innovation, and the replacement of materials emerge as indispensable pillars to reduce the pressure on the primary supply, although their contribution will remain limited in the short term. The energy transition therefore requires far-reaching industrial planning, accompanied by public financing mechanisms, investment support, and risk management that stabilise strategic mineral markets.

The energy transition will only be viable if it is accompanied by a strategic, responsible, and cooperative management of the critical minerals that make it possible. In this regard, the European Union's response reflects an attempt to balance between strategic autonomy and economic openness, betting on diversification, de-risking, and strengthening internal capacities without resorting to a complete decoupling from global trade. Initiatives such as the European Critical Raw Materials Act and the RESourceEU Plan represent important advances.

Finally, the case of Spain illustrates both the opportunities and the challenges of this new scenario. The existence of critical mineral resources and the inclusion of several strategic projects in the European framework place the country in an important position within the EU value chain. However, the development of sustainable mining that is socially accepted and aligned with climate objectives requires a profound update of the regulatory framework, greater coordination between administrations, and a real integration of mining in a circular economy vision.

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