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Europe's Position on Raw Materials of the Future

Risks, Potential and Guidelines

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The EU is faced with the challenge of broadening its supply of raw materials that are essential for future technologies. This article analyses the current supply situation, assesses the areas of action identified by the EU and comes up with recommendations for a future EU raw materials policy.

Key propositions

- **The global concentration of supply** on the commodity markets means that sources of supply must be rapidly diversified, for economic, environmental and geopolitical reasons.
- **State support for the domestic mining sector** is not an appropriate response to the existing challenges.
- **Strategic partnerships** with commodity-rich third countries with a similar regulatory approach, are the best short-term means to reduce existing supply and sustainability risks.
- In the long term, **raw material recycling** is the key to a secure and sustainable supply of future raw materials for Europe. This will require a further strengthening of the circular economy.

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1 Context

The impending fossil-fuel phase-out does not simply mean giving up oil and gas, but also creates a need for new raw materials. Be they batteries, fibre optic cables or fuel cells, the technologies crucial to our future prosperity are adapted to the special properties of certain materials. These are primarily rare metals that are technically difficult or impossible to replace. Advancement of the energy transition and digitalisation is thus only partly driven by knowledge and political will; the pure and simple availability of raw materials also plays a significant role. Europe is not currently best placed in this respect. Not only are most of the relevant raw material deposits outside Europe's sphere of influence, but global markets are also currently dominated by countries that are strategic rivals or do not share the environmental and social standards that are essential to the EU's own ethos. The shift away from fossil resources thus threatens to replace old dependencies with new undesirable ones. The resulting risks are not purely economic but also involve aspects of sustainability (raw material extraction and processing as environmentally harmful process steps) and foreign policy (dependencies which squeeze diplomatic leeway). The viability of the European economic and social model is thus also being tested on the international commodity markets.

The European Union (EU) is under pressure to respond to this challenge with a coherent strategy. Individual Member States, such as most recently Germany, have already submitted plans to this effect. However, market power and an uneven distribution of resources militate in favour of a coordinated strategy across Europe. In September 2020, the European Commission took initial steps in this direction with an Action Plan on Critical Raw Materials. It identifies three main areas of action for strengthening the European market position: (Re-)building EU value chains for raw material extraction and processing; establishing strategic partnerships with reliable producer countries outside the EU; increasing the use of secondary raw materials by promoting the circular economy. However, it remains largely unclear which instruments will be used for implementation and where the priorities will be set. Then, in June 2022, the Commission raised eyebrows by announcing a draft law on critical raw materials.

This article uses the intensified debate as an opportunity to take a closer look at Europe's position on key raw materials of the future. Raw materials are selected on the basis of their relevance for future technologies; future supply risks will be analysed and Europe's chances of participating in international value chains assessed. We will then highlight the potential of strategic partnerships and secondary extraction and finally come up with a recommended course of action for a future EU raw materials policy.

2 The raw materials of the future

2.1 Choice of raw materials

Industrial resource utilisation in Europe will continue to be characterised by a broad mix of different raw materials. Not all of them deserve equal attention from a policy perspective. Thus, those raw materials for which there are large-scale, commercially viable deposits or which can be substituted using technical means in a relatively simple way, should not be considered critical. However, the situation is different for many raw materials necessary for the industrial realisation of future technologies. Not only is it virtually impossible to find substitutes for them, but they are also subject to rapidly increasing demand connected to the advancing economic transformation. These are the raw materials that our analysis will therefore focus on. They have been chosen based on the intersection of two source groups.

The first source group comes from a commissioned study on raw materials for future technologies, published in 2021 by the German Mineral Resources Agency (DERA).[1] This is a detailed evaluation of the future material requirements of technologies that are crucial for the overall innovative strength of the economy, based on the current state of technical knowledge. In their analysis, the authors focus on a total of 14 essential mineral raw materials or raw material groups. However, not all of these raw materials are necessarily in short supply or subject to supply risks for other reasons. In addition, therefore, we have used the European Commission's list of critical raw materials as the second source group. This list, first published in 2011 and updated every three years since then, defines critical raw materials from an EU perspective based on indicators of their economic importance and supply risk. We have used the current list from 2020, which includes 30 raw materials.[2] Comparing this with the DERA list provides an intersection set containing a total of twelve raw materials or raw material groups (see Figure 1). As expected, these include materials that dominate the public discussion, such as lithium, cobalt and rare earth metals[3], but also less well-known names such as scandium and tantalum.

These raw materials, which are considered to be both promising for the future and critical, in equal measure, form the subject of the following analysis. The list of their uses in future technologies shows that they cover a broad spectrum of technologies necessary for the transition to renewable power generation (wind farms, thin-film photovoltaics), the mobility transition (batteries, fuel cells, electric motors), digital networking (displays, fibre optic cables) and automated control (microchips) (see Table 1). Their sources are also diverse. Some are difficult to find because they only occur naturally in small quantities within ores that mainly contain other, more common minerals such as copper, zinc and nickel. In addition, they are often not present in pure form (native form) within the ores, but as a component of chemical compounds, and in the case of rare earth metals, they generally occur in compounds with each other, making complex separation processes necessary for the extraction of individual metals. This has a major impact on the technical requirements for smelting. This raises the

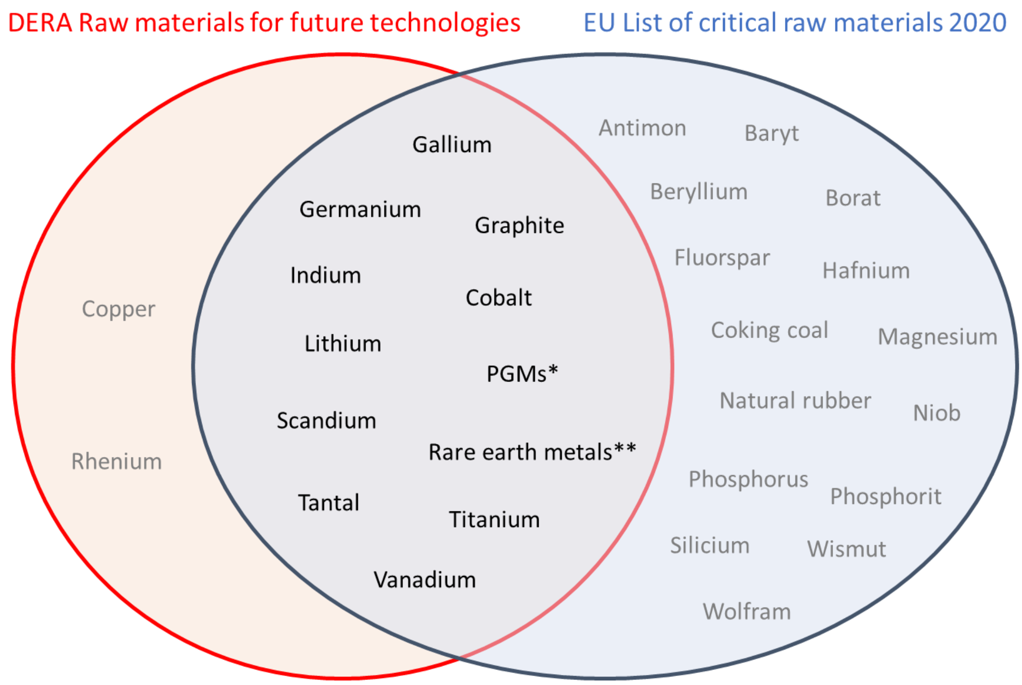
1 Marscheider-Weidemann, F.; Langkau, S.; Baur, S.-J.; Billaud, M.; Deubzer, O.; Eberling, E.; Erdmann, L.; Haendel, M.; Krail, M.; Loibl, A.; Maisel, F.; Marwede, M.; Neef, C.; Neuwirth, M.; Rostek, L.; Rückschloss, J.; Shirinzadeh, S.; Stijepic, D.; Tercero Espinoza, L.; Tippner, M. (2021). Rohstoffe für Zukunftstechnologien 2021. DERA Rohstoffinformationen 50, Berlin.

2 European Commission (2020a). Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability. Communication from the Commissions to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. COM(2020) 474 final.

3 We avoid the colloquial term "rare earths" here, as all of the materials in the group are metals and many of them, globally speaking, are not rare at all.

question of the extent to which technological dependencies could also occur not only based on the geographical distribution of deposits but also along supply chains. Due to the diversity of smelting processes, the individual raw materials or raw material groups require more nuanced consideration.

Fig. 1: Choice of raw materials for analysis



Sources: Marscheider-Weidemann et al. (2021); European Commission (2020a); our own diagram. *PGMs: Platinum group metals (iridium, osmium, palladium, platinum, rhodium, ruthenium). **Rare earth metals: Here we are using the DERA classification which defines a total of 16 metals as belonging to the subgroup of light (lanthanum, cerium, praseodymium, neodymium, promethium, samarium and europium) and heavy (yttrium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium and lutetium) rare earth metals.

Tab. 1: Extraction and use of the selected raw materials

No.	Raw material (group)	Use in future technologies (DERA study)	Extraction primarily from
1	Gallium	Radio frequency microchips, thin-film photovoltaics	Bauxite, zinc ores
2	Germanium	Fibre optic cable	Zinc ores
3	Graphite	Lithium-ion high-performance batteries	Metamorphic rock
4	Indium	Display technology, optoelectronics/photonics, thin-film photovoltaics	Zinc ores
5	Cobalt	Superalloys, lithium-ion high-performance batteries, solid-state batteries, synthetic fuels	Copper ores, nickel ores
6	Lithium	Lithium-ion high-performance batteries, solid-state batteries	Pegmatite rock
7	PGMs	Synthetic fuels, hydrogen electrolysis, fuel cells, data centres	Platinum-bearing ores
8	Scandium	Fuel cell, water electrolysis	The mineral thortveitite
9	Rare earth metals	Electric motors, solid-state batteries, data centres, wind farms	Metal compounds
10	Tantalum	Superalloys, capacitors, radio frequency microchips	Specific tantalum ores
11	Titanium	Alloys for lightweight construction, solid-state batteries, water electrolysis	Titanium iron ores (ilmenite), rutile
12	Vanadium	Redox flow batteries, carbon capture and storage	Titanium magnetite ores

Sources: Marscheider-Weidemann et al. (2021); various DERA raw materials reports.

2.2 Demand forecasts

To assess the future availability, we have to take a combined look at supply-side and demand-side factors. On the demand side, it is principally the raw material requirements of future technologies that will shape development. Their growing market penetration indicates increasing demand. How great this increase will turn out to be in the long term, however, substantially depends on assumptions for overall economic development and the political situation. For this purpose, Marscheider-Weidemann et al. (2021) have calculated various demand-side scenarios based on the Shared Socioeconomic Pathways (SSPs) of the Intergovernmental Panel on Climate Change for the target year 2040, which differ in their assumptions for, among other things, the development of the energy mix, vehicle markets and the market penetration of digital technologies. In light of the current tightening of EU climate and environmental policy, the "Sustainability" scenario (SSP1) is of particular interest as it envisages rapid technological development and a consistent focus on renewable energy sources. Table 2 sets out estimated global demand under this scenario, alongside the demand in 2018. There are major differences. Particularly drastic percentage increases on today's levels are projected for the platinum metals vanadium and lithium. Based on the current global production level, there will be a severe global shortage of scandium and lithium in particular, especially since these raw materials will probably still be needed for other applications in the future. Global production therefore needs to be ramped up considerably. Whether this is possible depends firstly on the availability of commercially viable deposits.

Tab. 2: Trend in global demand for raw materials

Raw material (group)	Demand by future technologies in 2018 (in t)	Sustainability Scenario 2040		
		Demand by future technologies in 2040 (in t)	% annual increase 2018-2040	Demand 2040 / Production 2020
Gallium	44	88	➔ 3%	0.2
Germanium	59	237.8	➚ 7%	1.7
Graphite	21900	1019000	➚ 19%	0.9
Indium	207	424	➔ 3%	0.3
Cobalt	49755	493272	➚ 11%	3.9
Lithium	7468	558725	➚ 22%	5.9
PGMs	0.11	180	➚ 40%	0.9
Scandium	5	72	➚ 13%	7.9
Rare earth metals	10901.8	119858	➚ 12%	0.7
Tantalum	1194	2598	➔ 4%	0.7
Titanium	74812	127960	➔ 2%	0.6
Vanadium	320	63900	➚ 27%	0.7

Sources: Marscheider-Weidemann et al. (2021); USGS Mineral Commodity Surveys (2022); own calculations.

2.3 Global deposits

Publicly available primary data on the geographical distribution of natural resource deposits are primarily provided by national statistical authorities. However, recording criteria and definitions are not subject to international standards. The U.S. Geological Survey (USGS) has established itself as a source for country comparisons, bringing information from authorities in other countries as well as results of its own research into non-official sources. In the case of deposits, it basically distinguishes between *reserves* and *resources*. *Reserves* are defined by the USGS as proven deposits that are economically viable to extract under current conditions. *Resources* also include proven deposits that are not currently economically viable, as well as deposits that are expected to exist based on geological indicators.[4] The current extent of a country's raw material reserves thus depends not only on the physical availability of deposits, but also on the level of technical development and the price situation on the raw material markets. The total resource inventory also fluctuates as a result of exploration activities, as well as due to estimation corrections. The available data thus represent a snapshot that only allows limited conclusions to be drawn about the current extent of deposits.

Nevertheless, a look at the global magnitude of deposits of future raw materials reveals a relatively clear picture (see Table 3). For the majority of raw materials, existing global reserves exceed current production levels by more than a hundred times. This also applies, at least from an overall perspective, to the group of rare earth metals. No information on reserves is available for five of the raw materials. This is either due to their rarity or to the fact that some of them are merely extracted as by-products of ores during the refining of other metals (gallium, germanium, indium). In view of the fact that demand (in absolute terms) is likely to remain low, there are no indications of a physical shortage in the near future.

However, the assessment of the supply situation depends not only on global availability, but also on its geographical distribution. For most of the raw materials under consideration, it is the case that the existing reserves are concentrated to a considerable extent in one country or a few countries (see Figure 2). In the case of cobalt, this is the Congo (Dem. Rep.), in the case of platinum group metals South Africa and in the case of vanadium and rare earth metals the People's Republic of China. These are largely the producers that already dominate today. The reported reserves of the great powers, USA and India, seem almost dwarfed in comparison.[5] Thus, in the near future, the global supply situation will continue to depend on local conditions in a few main producing countries, unless economically exploitable resources are developed on a large scale in other countries.

[4] USGS (2020). Appendices - Mineral Commodity Summaries 2020. US Geological Survey. https://pubs.usgs.gov/periodicals/mcs2020/mcs2020-appendixes.pdf

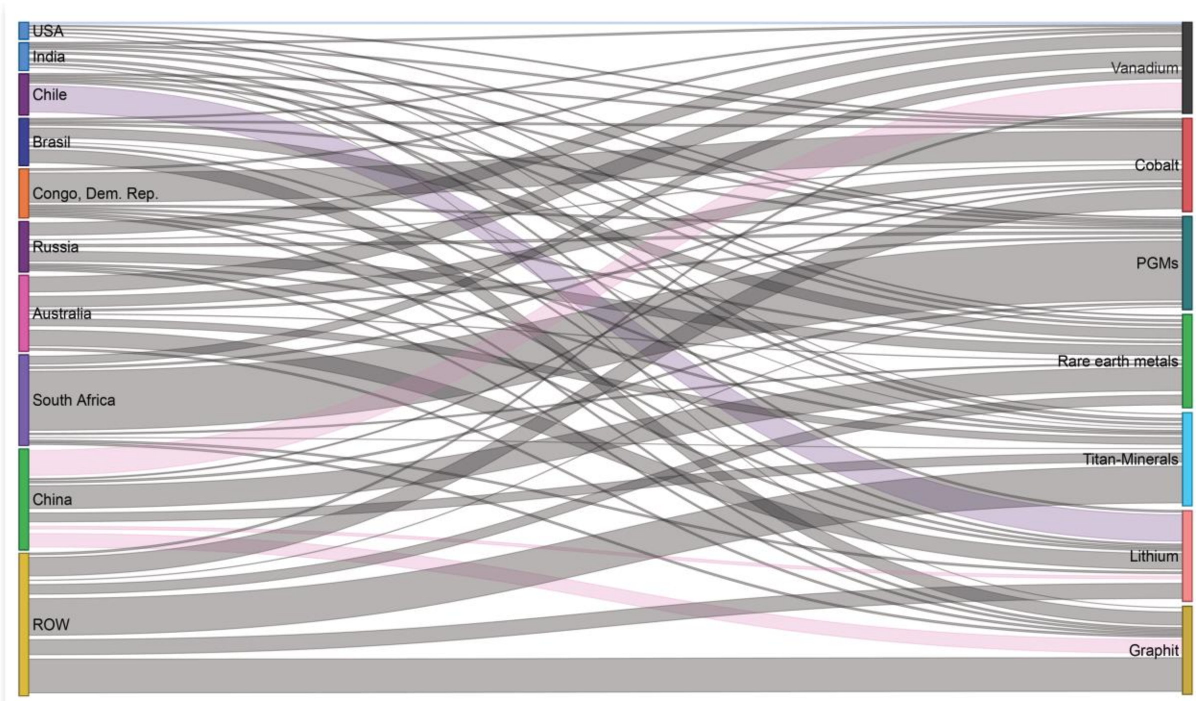
[5] Europe's specific potentials are examined in more detail in section 4.

Tab. 3: Reserves, resources and production worldwide

Raw material (group)	Global reserves (in t)	Global resources (in t)	Production 2020* (in t)
Gallium	Unknown	> 1,000,000	327
Germanium	Unknown	Unknown	140
Graphite	320,000,000	> 800,000,000	966,000
Indium	Unknown	Unknown	960
Cobalt	7,600,000	25,000,000	142,000
Lithium	22,000,000	89,000,000	82,500
Platinum Group	70,000	100,000	383
Scandium	Unknown	Frequent	Unknown
Rare earth metals	120,000,000	Unknown	240,000
Tantalum	Unknown	Adequate	2,100
Titanium minerals	750,000,000	> 2,000,000,000	8,600,000
Vanadium	24,000,000	> 63,000,000	105,000

Sources: USGS Mineral Commodity Surveys (2022). * The production quantities here refer in each case to the mine production (extraction), i.e. the metal content of the respective ores. Exceptions: Gallium, germanium and indium (refined metal production).

Fig. 2: Percentage distribution of global reserves by country



Sources: USGS Mineral Commodity Surveys (2022); own diagram.

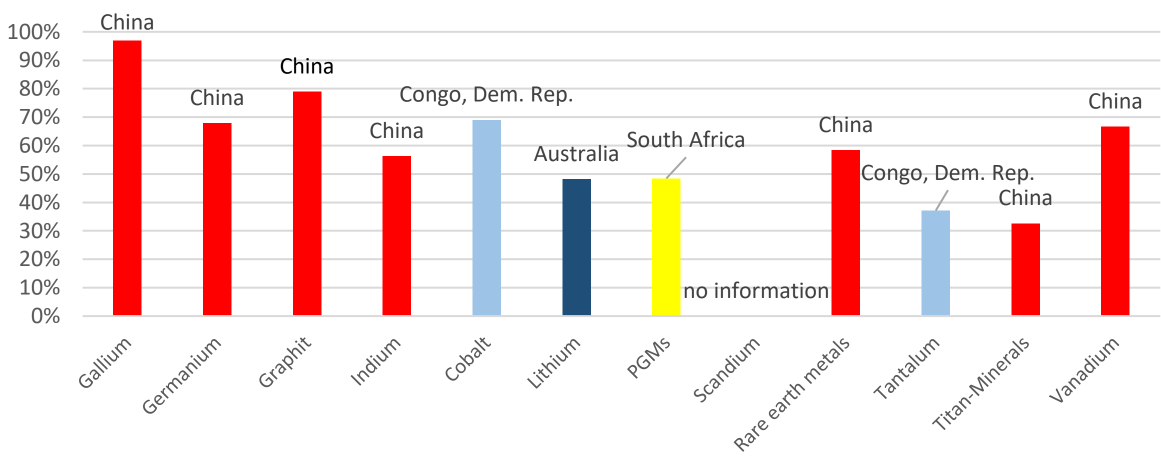
3 Current supply situation

3.1 Suppliers worldwide

In order to obtain industrially usable materials from the raw materials under consideration, they all have to pass through several process steps. This basically includes mining (i.e. extraction of the ore) and a subsequent smelting process. During smelting, the relevant concentrates are first extracted from the mixture of minerals contained in the ore. If the element sought is not present in the concentrate in pure form, but as a component of a chemical compound, the next step is to break up the compound (e.g. by methods such as electrolysis, pyrolysis). Depending on the quality requirements of the areas of application, further processing stages may be necessary to increase the purity of the raw material (e.g. gallium). Finally, the last stage of processing may also be the production of new chemical compounds (e.g. turning cobalt into lithium cobalt oxides for battery production).

The individual processing stages are not necessarily concentrated just in the country of production. Complex processes in particular can be outsourced to countries with corresponding specialised expertise or comparative cost advantages (e.g. China for cobalt processing). Thus, dependencies in the raw materials sector result not only from the physical location of the deposits, but also from the global distribution of smelting capacities. Nevertheless, international production statistics mainly focus on the primary stage of mining. Exceptions are those raw materials that are only obtained as a by-product of the smelting processes of other minerals. In the case of the future raw materials that we have selected, only a few producing countries dominate globally. China's dominance is particularly striking (see Figure 3). Not only was the People's Republic the world's most important supplier of eight of the twelve raw materials in 2020[6], but its market share was also over 50 % for six raw materials, and even over 75 % in the case of gallium and graphite. Only the Congo (Dem. Rep.) has a similarly prominent position in the field of cobalt mining. In the field of smelting, China's general dominance is likely to be even greater since in this production stage it also extends to e.g. cobalt and lithium.

Fig. 3: Market shares of the most important producers in 2020



Sources: USGS Mineral Commodity Surveys (2022); own calculations. The calculations here refer in each case to mining production (extraction). Exceptions: Gallium, germanium and indium (refined metal production).

6 There is no current information on global production of scandium, but according to the European Raw Material Alliance, China also has a dominant position here.

3.2 Risk assessment

In its criticality assessment of raw materials, the European Commission focuses on physical supply risks. In this regard, it considers three aspects. The first aspect is the degree of dependence on individual supplier countries measured by the extent to which global production is concentrated in certain countries. The second aspect is the extent to which it is technically possible to use other materials to substitute the use of a raw material in the production. The third aspect is the reliability and stability of supplier countries expressed through indicators measuring the quality of a country's institutions. In addition to these supply-side issues, other risks associated with future raw materials also play a role. These include market-related price risks as well as sustainability risks with regard to environmental and social standards in the supplier countries. The latter aspect in particular has gained relevance in light of the Commission's proposal for an EU supply chain directive.

As indicated in the previous section, with regard the physical supply risks, extraction of all future raw materials is highly concentrated in a few producing countries. However, in the case of production-related dependency, variations emerge. In its accompanying study on the list of critical raw materials 2020, the European Commission has identified a low degree of substitutability especially for lithium and cobalt as compared to the other raw materials considered. Raw materials such as vanadium and gallium, on the other hand, were assessed as easier to replace.[7] Significant differences in the reliability and stability of the main producing countries were also found to exist. The World Bank's *Worldwide Governance Indicators* (WGI) are generally used as a benchmark in international studies.[8] Figure 4 provides example results of a comparison of raw materials based on two WGI indicators, each calculated as a volume-weighted average of the top three supplier countries. Particularly problematic values in terms of both political stability and corruption control in the most important supplier countries are recorded for cobalt and tantalum. In both cases, this is due to the dominance of the Democratic Republic of Congo. A comparison with the average values of the EU members makes it clear that, for these and the other raw material, mining is largely concentrated in countries that are clearly more unstable and struggling with institutional problems.

Sustainability risks associated with raw material supply chains are more difficult to detect as producer countries naturally have little interest in ensuring that there is transparency regarding mining conditions. A number of environmental issues arise with respect to the raw materials under consideration. This starts with the greenhouse gas emissions caused by extraction and smelting. These may be both direct (gases escaping from the ground) and indirect (material and energy consumption along the supply chain) in nature. In the case of some future raw materials, toxic substances frequently associated with the deposits, such as arsenic and mercury, can also pose an environmental risk, especially if contamination of the groundwater cannot be ruled out.[9] In the case of lithium, depending on the geological conditions, high water consumption may also present a problem.[10] Serious breaches of international standards are also reported with regard to the social situation of miners and safety

7 European Commission (2022). Study on the EU's list of critical raw materials. Final Report, Brussels.

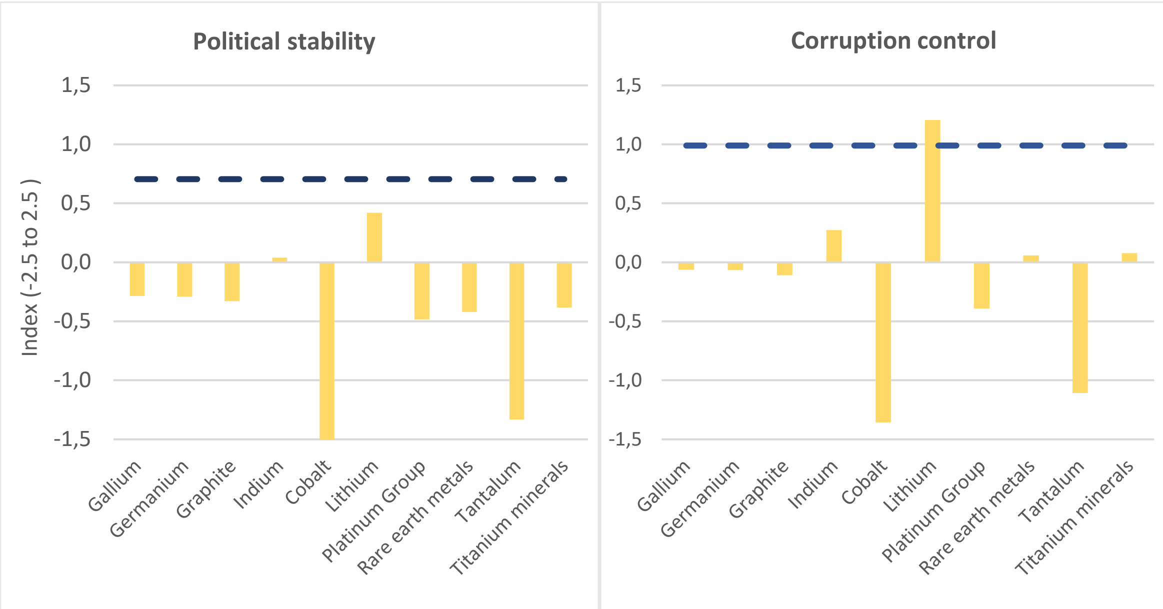
8 World Bank (2022). Worldwide Governance Indicators.

9 Kaunda, R. B. (2020). Potential environmental impacts of lithium mining. Journal of energy & natural resources law, 38(3), 237-244.
Huang, X., Zhang, G., Pan, A., Chen, F., & Zheng, C. (2016). Protecting the environment and public health from rare earth mining. Earth's Future, 4(11), 532-535.

10 Bustos-Gallardo, B., Bridge, G., & Prieto, M. (2021). Harvesting Lithium: water, brine and the industrial dynamics of production in the Salar de Atacama. Geoforum, 119, 177-189.

standards of mining.[11] Although differences in mining conditions between countries cannot be measured directly, a look at general country indicators on social security and environmental protection provides some indication. Figure 5 compares our future raw materials based on the situation in the most important producer countries regarding social security (ILO estimate of the proportion of the population with access to at least one social security measure[12]) and environmental protection (Environmental Performance Index[13]), again calculated as a weighted average of the top three supplier countries. This shows that cobalt and tantalum also score particularly poorly in terms of minimum social standards in the producer countries. The worst performers in terms of environmental protection are gallium and germanium.

Fig. 4: Raw material comparison - Governance in the producing countries



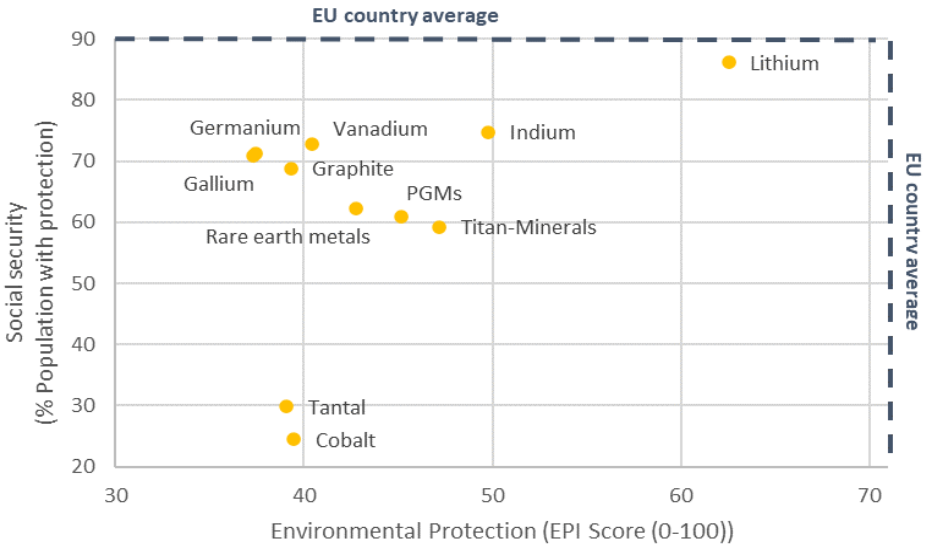
Sources: World Bank (2022); USGS Mineral Commodity Surveys (2022); own calculations. Yellow bar: Average Top 3 suppliers. Dotted line: EU country average.

[11] Sovacool, B. K. (2021). When subterranean slavery supports sustainability transitions? Power, patriarchy, and child labor in artisanal Congolese cobalt mining. The Extractive Industries and Society, 8(1), 271-293.

[12] ILO (2022). Sustainable Development Goal indicators. SDG indicator 1.3.1 - Proportion of population covered by social protection floors/systems (%) in 2020. International Labour Organization.

[13] Wolf, M. J., Emerson, J. W., Esty, D. C., de Sherbinin, A., Wendling, Z. A., et al. (2022). 2022 Environmental Performance Index. New Haven, CT: Yale Center for Environmental Law & Policy. epi.yale.edu

Fig. 5: Comparison of raw materials - environmental protection and social security in the producer countries



Sources: ILO (2022); Wolf et al. (2022); USGS Mineral Commodity Summaries (2022); own calculations

4 Potential from an EU perspective

4.1 Potential for EU-internal raw material extraction

Europe currently plays either no role at all or only a very minor role as a supplier on the global raw materials markets for the vast majority of the future raw materials we are looking at. The exception is indium, a material that in the field of future technologies is mainly used for the production of flat-screen displays, light emitting and laser diodes as well as thin-film solar modules. France is an important producer country in this regard. Based on that, the Critical Raw Materials Alliance considers the EU to be largely indium-autonomous.[14] However, this relates to production of the refined metal: Indium is obtained as a by-product from zinc smelting. The zinc ores used in this process do not come from European deposits but from US mines.[15] Among the other minerals, graphite, cobalt, lithium, platinum group metals and tantalum are currently mined within the EU, each at very low levels on a global scale.

Information on raw material deposits in the EU area is patchy and sometimes varies depending on the source. However, existing information indicates that the current low level of self-sufficiency is not due to a lack of geological resources. The Joint Research Center (JRC) of the European Commission has documented the existence of large or very large deposits for almost all future raw materials in its *Mineral Inventory*.[16] Observations show these to be concentrated in a few regions, especially the south of France, the Alpine region and Finland. At the same time, however, according to the *European Minerals Yearbook*, reserves, i.e. economically viable resources, have only been declared for a fraction of the raw materials.[17] Information on their extent is only very scattered and incomplete. For some

14 Critical Raw Materials Alliance (2022). Critical Raw Materials - Indium. https://www.crmalliance.eu/indium
15 https://www.nyrstar.com/operations/mining
16 European Commission (2022a). EU Science Hub - Raw Materials Information System (RMIS). https://rmis.jrc.ec.europa.eu/?page=geological-data-157d8a
17 Minerals4EU (2022). European Minerals Yearbook.

countries, the Yearbook generally states a lack of data, so that the true extent of EU reserves is probably underestimated. The delay in reporting new deposits must also be taken into account. The huge lithium deposits discovered only recently in Germany, in the Upper Rhine Graben[18] and in the Erz Mountains, for example, are not yet included in the Europe-wide statistics. In general, it is to be expected that, even outside of classic mining regions, the revived interest in mineral mining in Europe will lead to a significant increase in economically exploitable resources in the near future, whether as a result of new exploration or the utilisation of existing resources by means of improved mining technologies.

Apart from the physical potential, however, Europe's prospect of participating in the value chains of raw material processing also depends on other factors. Thus, China's dominance regarding the raw materials of the future is largely based on labour cost advantages in processing, and low environmental standards.[19] The European economic area cannot and will not become competitive in this respect. In markets with a high concentration of supply, it is also to be expected that the currently dominant suppliers will react to the advance of European competition with price wars, which will make market entry even more difficult. On the other hand, the hopes for economic efficiency rest essentially on the factors of transport costs and technical know-how. European raw material extraction is expected to reduce transport costs along the supply chain due to its closer proximity to demand centres, especially for raw materials currently mined to a greater extent in peripheral regions. Technological innovations in mining and smelting could reduce existing environmental risks due to more sustainable practices. However, it is doubtful whether this will solve future acceptance problems among the population in mining regions because, even if comparatively sustainable technology is used, mining in Europe will principally take place in regions that are much more densely populated than the world's largest extraction sites.

Tab. 4: Raw material deposits and production in the EU

Raw material (group)	Deposits			Production 2020	
	Existence	Large deposits*	Declared reserves	Quantity (in t)	Global share (%)
Gallium	Yes	No	No	None	-
Germanium	Yes	1 very large, 1 large	No	None	-
Graphite	Yes	1 very large, 2 large	Yes	800	< 1%
Indium	Yes	1 very large	Yes	58	6%
Cobalt	Yes	2 large	Yes	1,420	1%
Lithium	Yes	2 very large	Yes	348	< 1%
Platinum Group	Yes	2 large	Yes	1.3	< 1%
Scandium	Unknown	No	No	None	-
Rare earth metals	Yes	1 very large	No	None	-
Tantalum	Yes	1 large	No	> 0 (no data)	< 1%
Titanium minerals	Yes	4 large	Yes	None	-
Vanadium	Yes	2 large	No	None	-

Sources: USGS Mineral Commodity Summaries (2022); European Minerals Yearbook (2022); European Commission (2020b)

[18] The designated mining company talks of just under 16 million tonnes of lithium carbonate equivalents

[19] Shen, Y., Moomy, R., & Eggert, R. G. (2020). China's public policies towards rare earths, 1975-2018. Mineral Economics, 33(1), 127-151.

In principle, consideration should also be given to the question of what a redirection of productive resources to the European mining sector would mean for the global division of labour because, despite all the existing know-how, the competitive advantage of European industry clearly lies in the downstream stages of the value chain. Setting up complete, parallel supply chains in Europe, primarily for geopolitical reasons, would in itself not only be damaging to global prosperity, but may also reinforce the trend towards isolation in other economic areas. Thus, from an economic perspective, there is little to be said for the model of an EU that is self-sufficient in raw materials.

4.2 Potential of strategic partnerships

Currently, the EU officially has two strategic partnerships in the raw materials sector: with Canada and Ukraine. The Strategic Raw Materials Partnership with Canada was launched at the EU-Canada Summit in Brussels in June 2021. The parties agreed to develop joint value chains and expand technology cooperation. This was to ensure the security of access to critical raw materials and, above all, to advance the common goal of establishing more sustainable production methods in the raw materials sector. The diversification of raw material sourcing away from countries with low environmental and social standards is an important part of the motivation.[20] The partnership with Ukraine was agreed a short time later, in July 2021. Here, too, technology cooperation and integration of the value chains are stated goals but, unlike in the case of Canada, intensive cooperation in aligning the regulatory framework for mining is considered necessary. In addition, capital for sustainable mining projects is to be mobilised in a targeted manner via investment platforms.[21] Implementation of the agreement is currently uncertain in view of the ongoing war in Ukraine. In addition, other raw material partnerships exist at the level of individual EU Member States.

Recently, the European Commission referred to other talks on new raw material partnerships, explicitly mentioning Japan, Namibia, Norway, Serbia and the USA as possible partner countries.[22] At this point, the potential of such partnerships will be briefly examined as exemplified by the countries mentioned.[23]

Japan: Japan has a lack of domestic rare metal resources. According to USGS information, only germanium and indium are currently produced domestically, both in small quantities by international standards, and no significant unexploited deposits are currently apparent. What makes the country attractive as a partner from the EU's point of view, however, is its experience in strategically dealing with resource scarcity. In recent years, in the field of rare earth metals, Japan has succeeded in significantly reducing its previously almost exclusive dependence on China. The key measures were a consistent diversification strategy through global investments in mining projects, and support for domestic recycling activities.[24]

Canada: Canada is currently a supplier of graphite, cobalt, platinum and titanium minerals. The country also has significant reserves of lithium and rare earth metals. The Canadian government plans to significantly expand domestic production of critical raw materials over the next few years through

[20] European Union / Canada (2021). European Union - Canada Summit 2021. Joint Statement.
[21] European Union / Ukraine (2021). Memorandum of Understanding between the European Union and Ukraine on a Strategic Partnership on Raw Materials.
[22] European Commission (2022). Council "Competitiveness", 9 June 2022 - Public session. Statements by EU Internal Market Commissioner Thierry Breton.
[23] Ukraine is excluded here.
[24] Quartz (2021). Japan's global rare earths quest holds lessons for the US and Europe.

government support measures such as tax incentives and infrastructure investments. The medium-term goal for Canada to gain a leadership role in international mining through global partnerships, also supported by foreign investment.[25] In terms of industrial policy, this will be followed by the establishment of regional supply chains in battery production to make the national automotive industry future-proof.[26]

Namibia: Namibia is an established mining location, but it has not yet emerged as a supplier of future raw materials on the world markets. Also, no domestic reserves of these raw materials have yet been officially documented. However, exploration projects are currently under way which suggest significant deposits of rare earth metals.[27] Deposits of tantalum and vanadium are also currently being explored. As a result of Japan's investment activity, the country is already involved in international capital flows in this sector.

Norway: Norway is currently active in the field of future raw materials as a supplier of graphite and titanium minerals. The country has extensive reserves of titanium minerals in particular. In addition, larger resources of rare earth metals and vanadium have been identified.[28] Geologically, Norway is also interesting from the point of view of future deep-sea mining in the Arctic region. The melting of the Arctic ice promises access to previously untouched reservoirs of rare metals.[29] The country is already integrated into the EU's internal market through its membership of the European Economic Area (EEA) and the European Free Trade Association (EFTA).

Serbia: Serbia is currently not yet a producer of future raw materials. The country is relevant here in view of the large lithium reserves in the Jadar Valley in western Serbia. The British-Australian mining group Rio Tinto has been operating an exploration project there for several years. The start of large-scale mining was planned for 2026. It was hoped that the region would cover a large proportion of Europe’s lithium demand. However, the project led to massive protests by local residents, as fears about possible environmental damage (including drinking water contamination) could not be allayed by the project company. As a result, the Serbian government stopped the project in January 2022. The company has not yet given up on the project, however, and is hoping for a policy reversal.[30]

USA: The USA is currently the second most important global producer of rare earth metals after China. However, this is only true of mining, not smelting or subsequent processing into industrial materials such as magnets. In refining, the US, like other countries, is heavily dependent on Chinese capacity.[31] Before China's rise in the raw materials sector, the US was a pioneer and world leader in the extraction and processing of this group of metals. Recently, the US government has intensified its efforts to bring larger parts of the supply chain back into the country.[32] Looking ahead, however, the stock of reported reserves is significantly lower than in countries such as Brazil and Russia. At the same time, the US is already active in the markets for future raw materials regarding the production of titanium minerals and vanadium.

[25] GTAI (2021). Kanada weitet Förderung kritischer Mineralien aus. Germany Trade and Invest.
[26] Markets international (2022). Kobaltgräberstimmung in Kanada.
[27] Namibia Critical Metals Inc (2022). Lofdal Heavy Rare Earths Project Under Joint Venture with JOGMEC.
[28] Nordic Innovation (2021). The Nordic supply potential of critical metals and minerals for a Green Energy Transition. Nordic Innovation Report. ISBN 978-82-8277-11
[29] Innovation News Network (2022). The potential for raw materials exploration in Norway.
[30] Balkan Insight (2022). 'It's [Not] Over': The Past, and Present, of Lithium Mining in Serbia.
[31] Reuters Commodity News (2020). American quandary: How to secure weapons-grade minerals without China.
[32] CNBC (2021). The new U.S. plan to rival China and end cornering of market in rare earth metals.

The above examples show: The prospective partners differ greatly in the nature of their raw material potential, but also with regard to the stage of development reached in their extraction projects and the accompanying environment. For successful diversification, it will be important to create a good mix of strategic partners that covers Europe's needs for various future raw materials as broadly as possible. At the same time, in many cases, the EU cannot limit itself to the role of passive buyer. Putting some high-potential countries on the commodity producer map will require a high degree of regulatory cooperation.

4.3 Potentials of recycling

The existing problems in the mining of future raw materials have turned our attention to alternative sources. With increasing industrial use, the treasure trove of raw materials buried in everyday products is becoming ever more attractive. The term "urban mining" describes strategies to make this treasure economically viable through waste management and reprocessing. The advantages of such so-called "anthropogenic" raw material stores are obvious. Access is gained without the environmental risks associated with mining and free from the price fluctuations and supply risks on the world markets.[33] Moreover, anthropogenic repositories are concentrated in urban areas and thus generally in close proximity to production sites. This would reduce the EU's dependence on a small number of producer countries.

At the same time, however, the establishment of corresponding recycling chains represents a major technical and organisational challenge. As in mining, the first prerequisite is an insight into the size of existing stocks. This is particularly difficult with future raw materials which are often tied up in durable consumer goods such as mobile phones. Since a large part of the life cycle is tied up with the consumer, it is difficult to estimate material flows and changes in local stocks. Constant changes in material intensity due to short innovation cycles further complicate the accounting.[34] However, Europe-wide quantities are certainly considerable. The *Urban Mine Platform* carried out calculations on this in 2018.[35] For example, it estimates the amount of lithium contained in the European battery stock at roughly 13,000 tonnes, and cobalt at 24,000 tonnes.[36] This treasure trove is likely to have grown in the meantime.

The first practical challenge to recycling is securing the products at the end of their use phase. On the consumer side, this presupposes sufficient incentives for proper disposal. For electrical appliances, the costs to the consumer tend to be higher than for household waste, as additional knowledge is required (location of depot containers, recycling centres) and more time is needed.[37] Following this, an efficient collection and sorting system is needed that sorts the resource-rich waste according to the type of re-use and separates out non-recyclable material. And finally, the individual raw materials, which are often only present in small quantities and in the form of chemical compounds, must be extracted from the remaining mixture of substances in the largest possible proportions. With this in mind, a variety of technical solutions for rare earth metals, for example, have already been undergoing development and

33 Tercero, L., Rostek, L., Loibl, A., & Stijepic, D. (2020). The Promise and Limits of Urban Mining. Fraunhofer Institute for Systems and Innovation Research ISI.

34 Umweltbundesamt (2022). Urban Mining.

35 Urban Mine Platform (2018). Composition of batteries.

36 Here recorded as EU27+UK, Norway and Switzerland.

37 Otto, S., Henn, L., Arnold, O., Kibbe, A. (2015). Die Psychologie des Recyclingverhaltens. In: Recycling und Rohstoffe – Vol. 8. TK Verlag Karl Thomé-Kozmiensky, Neuruppin.

testing in Europe for several years.[38] One economic problem, however, is the high capital intensity of such complex, multi-stage processes. This requires major economies of scale as the use of such processes is only worthwhile in terms of costs if large quantities of recyclable materials are involved.[39] With only a low yield of recyclates, extraction costs are high, which in turn keeps demand for secondary raw materials low. With no realistic prospect of an increase in the influx of material, there is a lack of investment incentive and no capacity building is taking place.

Europe's slow progress in recycling old electrical appliances is proving to be a stumbling block here. The problem is obviously primarily one of securing access to resources. According to Eurostat, although a large part (approx. 80%) of the old devices actually collected was recycled or reused across the EU in 2019, almost all Member States failed to meet the EU's collection rate target[40] (65%). EU-wide, the actual rate was only 48.5%.[41] For Europe to take its technological capability for recycling future raw materials and turn it into global leadership, an external push will be needed. This could consist of regulatory incentives to increase recycling rates, but could also come from rising raw material prices on the world markets.

5 The EU Action Plan on Critical Raw Materials

As early as 2008, the European Commission attempted to approach the issue of raw materials from a strategic perspective with a communication entitled the "Raw Materials Initiative".[42] Even then, security of supply and dependence on imports were at the centre of the deliberations. This included, for the first time, a proposal for a definition of critical raw materials . Then, in 2011, also for the first time, the Commission published a list of 14 critical raw materials. This list has been updated every three years since then. The publication of the latest list of 30 raw materials in 2020 was accompanied by a foresight study[43] and an Action Plan on Critical Commodities[44] .

The Action Plan identifies existing EU supply problems in critical raw materials and proposes a series of measures to strengthen resilience and autonomy in this area. The Commission divides its proposals into four fields of action. The first field of action "Resilient value chains for EU industrial ecosystems" focuses on supply chains. By means of overarching alliances, raw-material-based value creation is to be strengthened in Europe and existing gaps at the various processing stages are to be closed. In this context, the Commission has initiated the establishment of a *European Raw Materials Alliance* (ERMA), a network primarily consisting of industrial companies and sector associations, which aims, among other things, to promote communication between stakeholders and create an investment platform for raw materials in Europe.[45] In addition, criteria for sustainable activities in the area of raw material extraction and processing are to be defined within the framework of the EU taxonomy.

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38 Sander, K., Zimmermann, T., Gößling-Reisemann, S., Marscheider-Weidemann, F., Wilts, H., Schebeck, L., ... & Pehlken, A. (2017). Recycling potentials of strategic raw materials (ReStra). Final report. Umweltbundesamt, Dessau.

39 KU Leuven (2022). Metals for clean energy: Pathways to solving Europe's raw materials challenge. Report for Eurometaux.

40 The collection rate is defined as the ratio of the total weight of waste electrical equipment collected in one year to the average total weight of electrical equipment brought onto the market in the three previous years.

41 Eurostat (2022). Waste statistics - electrical and electronic equipment.

42 European Commission (2008). The raw materials initiative — meeting our critical needs for growth and jobs in Europe. Communication from the Commission to the European Parliament and the Council. COM(2008) 699.

43 European Commission (2022). Critical Raw Materials for Strategic Technologies and Sectors in the EU - A Foresight Study.

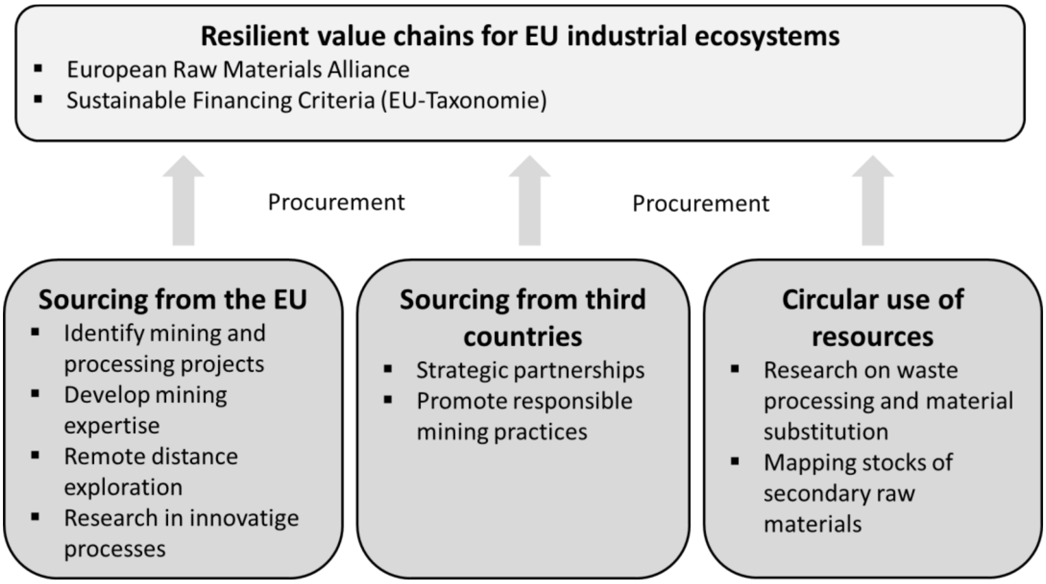
44 Cf. European Commission (2020a)

45 https://erma.eu/

The other fields of action each address different sources of raw material procurement. The Commission is pursuing a three-pronged strategy in this regard. "*Procurement from the European Union*" is seen as one source. This refers to the extraction of primary raw materials by means of mining in the EU. The Commission has its sights set on regions that have so far been strongly characterised by coal mining. In order to build capacity in critical raw materials, the Commission intends to first identify mining and processing projects that can be ready for use in the short term; develop expertise in regions in transition; use remote sensing technologies, and promote RDI projects under Horizon Europe to reduce the environmental impact of raw material extraction. Another component of the procurement strategy is the "*Diversified sourcing from third countries*". One-sided dependence on individual producing countries for the import of raw materials is to be reduced. To this end, the Commission will rely on the strategic partnership model with resource-rich countries. In addition, an international regulatory framework for responsible mining practices is to be created. The last building block is "*Circular use of resources, sustainable products and innovation*". The Commission wants to advance the extraction of secondary raw materials by increasing the circularity of the economy and at the same time improve research into the technical possibilities for substituting critical raw materials with non-critical ones. In addition to support via research funding, the mapping of possible sources of secondary raw materials is to be undertaken in order to identify the potential.

The European Parliament responded to the Action Plan in November 2021 with a resolution on a European Strategy for Critical Raw Materials.[46] This calls on the Commission to flesh out its ideas in the form of a more comprehensive raw materials strategy. In principle, Parliament supports the plan to diversify sources of supply. At the same time, it is emphasised that special focus should be placed on the ecological footprint and compliance with sustainability standards when importing raw materials. The important role of raw material recycling is also highlighted and, among other things, specific recycling targets for critical raw materials are called for.

Fig. 6: The EU Action Plan on Critical Raw Materials



Source: European Commission (2020a); own diagram

[46] European Parliament (2021) European Parliament resolution of 24 November 2021 on a European strategy for critical raw materials. 2021/2011(INI).

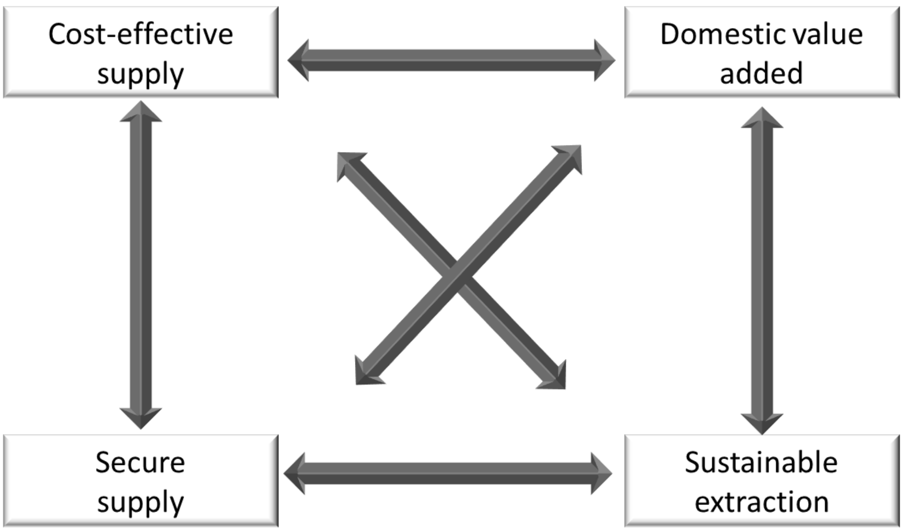
6 Strategic options for action

6.1 Objectives

The recommendations for action issued by the European Commission are based on the idea of diversification as a common guiding principle. Europe's supply of future raw materials is to be placed on a broader footing. There are several objectives behind this idea. Firstly, there is security of supply. The sourcing of raw materials is to be less exposed to the specific supply risks of individual source areas. Secondly, there is the need to boost domestic value creation: EU companies should be more involved in the supply chains for raw material extraction and refining in order to create income and jobs in Europe, especially in mining regions affected by structural change. Thirdly, diversification will be used to pursue sustainability goals by shifting some of the extraction to the EU's own regulatory area or to third countries with high environmental and social standards. There is also a fourth societal objective that is not explicitly addressed in the Action Plan: ensuring the cheapest possible supply of raw materials.

The four objectives both complement and compete with each other. This becomes most evident when comparing the objective of low-cost supply with the other three objectives: the focus on security of supply and sustainability would mean accepting cost increases, at least in the short term, as it requires moving away from current supply chains. The other three objectives are also not entirely without conflict, however. Thus, more relaxed regulatory requirements to boost domestic resource extraction could come at the expense of environmental standards, and, in light of investment uncertainty, security of supply could be better achieved through partnerships with established market players from third countries, rather than through building domestic value creation. When evaluating policy instruments, it is therefore important to look at the possible impact on the individual objectives.

Fig. 7: Coordination of raw material supply objectives



Source: own diagram

6.2 Instruments

In principle, the EU should have a wide range of instruments at its disposal to pursue the above-mentioned objectives. Some of these have been under discussion for some time, others result from the transfer of existing methods from related fields. In line with the multi-level strategy of the Action Plan, specific instruments can be identified for three fields of action: 1) Developing domestic primary procurement, 2) Strategic partnerships with third countries, 3) Expanding circular resource use. In addition, overarching instruments are under discussion. An impact assessment depends, of course, on the specific legal form. Nevertheless, it is already possible to draw conclusions about the emphasis of the instruments, the primary objectives they will address and where the risk of conflict could be lurking. Table 5 summarises a selection of possible instruments and their objectives.

The **overarching instruments** that are under discussion include the establishment of a European Raw Materials Authority as a central coordinator, point of contact and source of knowledge. The German Mineral Resources Agency (DERA) could serve as a model for this. In addition to providing commodity information and advisory services to the private sector, a European authority could go beyond DERA's remit by coordinating the research and mining activities of the Member States and developing networks with third countries. Thus, the authority could promote the strengthening of domestic value chains for primary and secondary raw materials as well as import-partnerships with third countries. As a further overarching device, it is proposed that strategic reserves of future raw materials in Europe be developed in a similar way to the national oil reserves held by many Member States. The objective is to secure domestic supply in the event of global shortages.

A broad range of measures is being discussed for **developing domestic primary procurement**. This starts with increased support for geological exploration activities, especially in areas of high potential for future raw materials. Our analysis of the data has already highlighted the deficient and inconsistent information situation in this area. In addition, there have recently been loud calls for the direct use of EU funds in capacity building via the creation of new financial instruments or the notification of projects as Important Project of Common European Interest (IPCEI).[47] As regards existing financing barriers in the private capital market, there is a lively debate on extending the EU Sustainability Taxonomy Regulation to include the mining sector.[48] Currently, instruments used to finance mining activities cannot qualify for sustainability status. Binding technical requirements would first need to be defined, and these would need to be complied with in order to show a significant contribution to the environmental goal of "climate change mitigation". A significant market intervention would be the introduction of purchase obligations for domestically produced raw materials by domestic industry According to its proponents, this would create a stable sales market in the initial phase.

For the design of **strategic partnerships with third countries**, similar instruments may be considered in some cases, especially with regard to the development of funding capacities in the partner country. Choosing the appropriate instrument here depends crucially on local conditions, as illustrated by the examples in section 4.2. In order to avoid any conflict with sustainability targets, there could be intensive regulatory cooperation before establishing joint supply chains in partner countries with low

[47] Critical Raw Materials Alliance (2021). Rare Earth Magnets and Motors: A European Call for Action. A report by the Rare Earth Magnets and Motors Cluster of the European Raw Materials Alliance. Berlin 2021

[48] European Union (2020d). Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088. See on this: Van Roosebeke (2020), cep**Adhoc**: The EU Taxonomy for Sustainability – Summary and Assessment.

environmental and safety standards. However, the extent to which a direct transfer of EU standards to local conditions is technically feasible and politically enforceable can only be assessed on a case-by-case basis. Cooperation in the form of technology transfer and exchange of knowledge is particularly attractive from an EU perspective for partners with an established position in global supply chains. Joint investment platforms could also facilitate the financing of cross-border supply chains. In order to **expand the circular use of resources** in the area of future raw materials, one of the options being discussed is to further tighten EU requirements for the design of industrial products with binding requirements for recyclability. The draft of a new Eco-design Regulation, submitted by the European Commission in March 2022, could be taking this route in the future via the planned inclusion of recyclability in the requirements and by extending the scope to almost all physical goods.[49] Minimum quotas for the use of recycled raw materials in production could also be stipulated for products resulting from future technologies, as already envisaged for traction and industrial batteries as from 2030, in the proposal currently under negotiation for an EU Battery Regulation.[50] In addition to production-side requirements, the introduction of deposit systems for high-tech consumer products, or the tightening of export controls on waste could also be considered in order to ensure recycling.

Tab. 5: Summary of instruments and addressed objectives

Instruments	**Objectives**			
	Cost-effective supply	**Sustainable extraction**	**Participation in value creation**	**Secure supply**
Overarching				
European Raw Materials Authority			blue	blue
Strategic stocks of critical raw materials				blue
Field 1: Developing domestic primary procurement				
Public funding of exploration activities			blue	blue
Public co-financing investments	red		blue	blue
Extension of EU taxonomy to mining sector		blue	blue	blue
Purchase obligation for domestic industry	red		blue	
Shortening the approval procedure		red	blue	blue
Strengthening acceptance through communication			blue	
Field 2: Strategic partnerships with third countries				
Support for exploration in partner countries				blue
Technology cooperation	blue	blue		
Regulatory cooperation		blue		
Joint investment platform			blue	blue
Field 3: Expanding circular use of resources				
Research funding for waste processing	blue	blue	blue	blue
Product design specifications		blue	light blue	blue
Minimum requirements for use of recyclates		blue	light blue	blue
Deposit refund schemes		blue	light blue	blue
Tighter export controls on waste		blue	blue	blue

Source: Own diagram; blue: Directly addressed targets; Red: Foreseeable areas of conflict

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49 European Commission (2022b). Proposal for a Regulation of the European Parliament and of the Council establishing a framework for setting ecodesign requirements for sustainable products and repealing Directive 2009/125/EC.

50 European Commission (2020d). Proposal for a Regulation of the European Parliament and of the Council concerning batteries and waste batteries, repealing Directive 2006/66/EC and amending Regulation (EU) No 2019/1020.

6.3 Recommendations

Rapid growth in demand for raw materials requires quick action to diversify sources of supply. Building and strengthening strategic partnerships with resource-rich third countries should therefore be a top priority. In the short term, priority should be given to cooperation with countries that not only score points in terms of the abundance of their resources but also due to their well-developed infrastructure and regulatory proximity to the EU, which makes them suitable for the rapid establishment of joint supply chains. On that basis, Norway, Canada and the USA are natural partners. Cooperation on raw materials with countries in which the necessary structures are still at the development stage are best regarded as long-term projects. Here, efforts should first focus on exploration and institutional cooperation before pushing ahead with economic integration. In principle, when selecting partners, care should be taken not to create new one-sided dependencies. In addition to alliances with resource-rich countries, strategic-buyer alliances with countries such as Japan are therefore also important, as they increase Europe's weight on the global commodity markets.

In contrast, efforts to achieve self-sufficiency in the form of massive state support for mining in the EU region should be viewed with scepticism from several perspectives. On the one hand, in many cases there is simply not enough time to build competitive domestic supply chains. Countries like Australia have been working for some time to end their reliance on China through domestic projects and international alliances. China, for its part, will do everything it can to maintain its current market position for as long as possible by increasing yields. Europe is lagging behind on a global comparison, and not only in terms of exploration activities. Lengthy approval procedures and low acceptance in the population also hinder roll-out of the future raw materials supply.[51]

Finally, the development of sustainability standards for the extraction of future raw materials, which are essential to the EU's own ethos, will also take time. A practical difficulty in this respect is that the positive contribution to the environmental goal of climate protection can only be of a very indirect nature. Mining itself merely provides the raw materials for the implementation of emission-reducing technologies whilst being directly associated with additional emissions. Clarification is also required as to the conditions under which mineral mining is compatible with the "do no significant harm" principle in relation to the other environmental goals, especially with regard to the prevention of air pollution and the protection of ecosystems. To assess the net impact, therefore, a scientifically sound methodology for balancing life-cycle emissions must first be specified.

In addition, market entry represents a considerable economic risk, especially in the case of particularly rare minerals where concentration of supply has so far been at a very high level. The dominant suppliers will be tempted to use their market power for price wars in response to the new competition from the EU. In the worst case, EU projects would quickly be forced out of the market again, and state funding would have been squandered. Trying to counter this risk through purchase obligations for domestic companies would mean a further cost burden for European industry. From a macroeconomic perspective, a politically induced build-up of large mining capacities would also represent a significant intervention in the international division of labour. Investment would be diverted from highly competitive industries to a traditionally low value sector of the primary economy. This would not only result directly in a form of de-specialisation that is damaging to prosperity, but would also jeopardise

[51] Graham, J. D., Rupp, J. A., & Brungard, E. (2021). Lithium in the Green Energy Transition: The Quest for Both Sustainability and Security. Sustainability, 13(20), 11274.

Europe's future competitiveness in fast-growing downstream industries as a consequence of the withdrawal of capital.

This does not mean that Europe should leave the value creation potential associated with future raw materials untapped. However, the position of EU companies in the global exploitation chain should be based on the comparative advantages of the economic area and these are principally towards the end of the chains in the case of the relevant future technologies. This refers, on the one hand, to the processing of refined products in downstream industries and, on the other, to the recovery of raw materials from end products. In this regard, Europe should direct its technological capabilities more towards the recycling of future raw materials. This would not only benefit general resource efficiency. The transition to a largely closed material cycle could, in the long term, also reduce dependence on global supply chains with their questionable mining conditions and high level of price volatility. Since the creation of such a recycling economy will take a long time, the EU should work in parallel on a strategy of stockpiling future raw materials to mitigate existing market risks. The impact of such a strategic reserve on supply costs will strongly depend on the envisaged quantity, the sources used and the timing of the reserve build-up. Here, too, staying power will be necessary. An EU reserve built up in the short term by way of massive purchases could lead to price surges on the world markets.

7 Conclusion

The success of Europe's industrial transformation is not only a question of technological capability but also very much a question of raw material availability. In order for the transition from the fossil fuel age to an era of climate-friendly, digitally connected production to succeed, secure access to a range of rare mineral raw materials is essential. These complement each other in their properties and areas of application. Securing a good competitive position in future technologies therefore requires an overarching raw materials strategy that identifies and eliminates existing dependencies. The EU is not in a good position in this respect: Extraction and smelting of the essential raw materials of the future is currently in the hands of a few non-European countries, especially China. The uneven distribution of economically viable reserves means that there is little likelihood of change in the foreseeable future for most of the raw materials. At the same time, global demand will increase by leaps and bounds in the coming years, which will intensify competition for access to raw materials. Apart from the problem of economic dependence, this also affects the credibility of the EU's value system: Mining is concentrated in countries whose environmental and social standards are far below the level applicable in the EU's internal market.

The European Commission has fundamentally recognised the strategic importance of these issues, as the 2020 Action Plan and the recent announcement of legislation on critical raw materials make clear. However, specific instruments and clear prioritisation are still lacking. This article advocates a raw materials strategy that relies heavily on strategic partnerships with third countries in the short term, and on building domestic secondary sourcing via the expansion of the circular economy in Europe in the longer term. With a good mix of strategic partners, the EU will not only be able to reduce dependencies relating to the access to raw materials; technology cooperation and joint financial instruments also offer the opportunity to anchor parts of the value chains in the EU area. The development and enforcement of generally applicable environmental standards is also best advanced in cooperation with experienced partners. In parallel, the development of capacities for the extraction of secondary raw materials should be accelerated. Further increases in the recycling of rare metals are essential for this, especially by increasing collection rates.

In contrast, massive state support for the extraction of future raw materials in the EU area would be a questionable strategy in terms of economic policy. Although the Union does have significant geological resources of some raw materials, such as lithium and rare earth metals, the dominance of players such as China is not primarily due to favourable geographical concentration, but rather the result of a long-term strategy that, in addition to state subsidies and the systematic acquisition of technological capability, is also based on labour cost advantages and low regulatory standards. The Union cannot and should not copy such a strategy. It would also entail a diversion of capital away from knowledge-intensive export sectors towards primary products with lower value-added - and thus a form of de-specialisation that is damaging to prosperity. This does not exclude the possibility that individual projects for the extraction of significant deposits, arising from private initiatives, may make economic sense. However, any future industrial policy strategy of the Union should focus on sectors where European companies have competitive advantages due to their knowledge and established market position, which, in this case, mainly involves the final utilisation of future raw materials in end applications.

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