A European critical raw materials' act: Shifting from extractivism to circularism

Ecological Transition cluster paper - March 2023

Executive Summary

The **imperative climate-neutral and just transition** leaves no choice but to swiftly switch from fossil-based to renewable-based energy sources, while drastically reducing overall energy and resources demand. For physical reasons, this implies **a shift from emission-intensive to metal-intensive technologies**, such as solar PV, wind energy, electric vehicles, battery storage, and renewables-based hydrogen technologies. Hence, **demand for metals** like cobalt, lithium, graphite, nickel, rare earth elements (REE) or platinum group metals (PGM) **is expected to surge**, while other sectors like defence or digital are also competing for some of these.

Shifting from extractivism to circularism is the only path to promote our climate and geopolitical priorities, and to adhere to our human and environmental rights commitments, but it is also the one, which makes the most economic sense. **A credible EU strategy on critical raw materials is an absolute first step to develop innovative and sustainable EU industries, which can be competitive internationally and lead us in the global transition** to a climate-neutral, resource-efficient and socially just circular economy. It is not just environmentally and geopolitically necessary, it would be economically counterproductive in the long-term not to engage in this path.

Similarly to fossil fuels, **metals are non-renewable elements obtained from extractive industry**. Their supply causes **very high environmental and social impacts**, which differ from material to material, depending on their respective concentration in the ground. However, the generation of waste from primary raw materials increases more rapidly than the metal production does. **Hence, we should introduce the concept of limit into our policies to curb the demand and then our needs, to secure primacy of nature and society over industrial interests.**

Similarly to fossil fuels, **metals are unevenly distributed across the globe.** Due to geological conditions and to the concentration of processing capacities, the production of strategic metals presents a level **of known concentration in some countries** (predominantly China, DRC, Chile, Australia, South Africa) **even higher than fossil fuels. We should not merely swap unwanted existing dependencies for new ones**. Hence, we must **shift from a free trade to a sustainable trade and investment paradigm**, and **build our competitiveness and leadership on our perceived current weakness**: a high level of dependence for strategic materials.

On the contrary to fossil fuels, **metals can be reused and recycled, making them a good fit for a circular economy**. However, for the time being, in the current throw-away society, the level of recycling of most metals is extremely low (below 10%), and their expected lifetime in our economy is extremely short (only a few months for some technology metals). **We must urgently close the loop of strategic materials to improve our resilience and sovereignty and reinforce our industrial leadership for a climate neutral and fair society.**

Extractivism inevitably results in irreversible consequences on nature. In turn, prospection, extraction and mines greatly affect local and indigenous communities **as well as human right and environmental defenders**.

In Sweden and Finland for example, where a major share of Europe's domestic supply of critical raw materials will come, extractivism causes grave consequences for the last European indigenous communities, the Sami people. The Sami culture is closely linked to reindeer husbandry and extractivism on Sami land (Sápmi) blocks migration routes for the reindeers and generally degrades the nature that Sami culture and their reindeers depend on. To adhere to our human and environmental rights commitments and social principles, an EU strategy on critical raw materials must ensure that extractivism in the EU and critical raw materials imported to the EU are compliant with the principle of free, prior and informed consent for indigenous communities.

Finally, COVID pandemic, Russian war of aggression on Ukraine, extraordinary inflation hitting people hard and exacerbating energy, mobility and food poverties, and bold public intervention in other parts of the world could represent **a fertile ground for conservative voices to put a halt on climate neutral, environmentally sound and fair transition.**

Against this backdrop, the Green position on an EU approach for **strategic materials should rely on the following set of four interlinked principles**:

1. **Emphasize sufficiency**, in order to drastically slash the demand: we live in a finite world, so that before suffering the impacts of scarcity, we must introduce the concept of limit into our policies to protect the achievement of societal ambitions while reducing social and environmental inequalities, via binding EU targets for reduction of material consumption, democratically agreed hierarchy of uses to avoid that non-essential applications compromise societal goals, scenarios based on profound changes of consumption patterns, and the promotion of substitution strategy. A first step to support going into this direction could be by establishing an independent EU body modelled after the European Scientific Advisory Board on Climate Change, in charge of monitoring resources, and formulating science-based recommendations on the management and allocation of materials, in order to anticipate and cope with potential scarcities and ensure social climate and environmental justice;

2. **Prioritise circularity & the use of and access to secondary materials**, to close the loop of (strategic) materials and develop their secondary use: we must prioritise the extension of the expected lifetime of materials in our economy (reuse, repair, repurpose, refurbish), rethink design of products for multifunctional and interoperable use and recycling (to drastically reduce dissipative losses), limit material flows leaving the EU as "waste", and impose smart collection and recycling targets per material and not based on the weight of products. In addition, we must urgently unleash the development of secondary raw materials in the EU by regulating to create such markets (e.g. through taxing virgin materials, subsidising secondary materials, setting targets of minimum recycled content into final products) and by improving the recovery of materials from already extracted streams (reprocessing waste and systematic recovery of companion metals);

3. **Planet and people first**, establishing the primacy of protecting communities, nature and biodiversity in EU industrial policies: EU's immediate need for metals cannot be satisfied without access to virgin materials, so that we must promote the paradigm of sustainable and fair trade for higher environmental and social standards, and develop robust and science-based criteria to establish Europe as a front-runner with best environmental and social standards for most sustainable mining; the EU must take advantage of its internal market, to regulate sustainability of materials within and beyond the EU (extraction, transformation, recycling) and foster a "global race to the top" based on environmental, social and human rights due diligence obligations when placing products on the EU market. The EU batteries legislation is a blueprint in that regard and should be used as inspiration for the CRM proposal, to prevent the import of goods made with raw materials mined and transformed in highly destructive ways. Where necessary and possible, we should support countries in the Global South which adhere to the same principles as the EU. The Global Gateway Initiative should be used as one possible funding tool in this regard, enabling resource-rich countries to extract, process and

recycle raw materials. The EU can be a partner by their side and support them to set up their own capacities;

4. **Excavation last everywhere, and exemplary domestic supply:** we must prioritise the development of processing and recycling capacities for strategic materials, and in a spirit of global and climate justice and to lead by example in a global context, if extraction in the EU proves to be unavoidable after the drastic rethinking of our societal needs and the curb of demand in all concerned industries, we must impose the highest environmental and social standards: no ground for exemption of any EU legislation or human and environmental rights conditions, full compliance with ILO 169, strict and irreversible "no-mining" areas, continuous effort to improve mining techniques and corresponding working conditions (including safety and health coverage), and ban of most harmful ones, early information, participation, consent and fair compensation of local and indigenous communities for appropriation of common resources. Extraction in countries in the Global South should be done according to the same condition and EU mineral and metals needs **should not further exacerbate the existing inequalities, nor climate and environmental injustice within the EU or with the Global South**.

This set of guiding principles should notably be reflected into the upcoming EU legislative framework dedicated to strategic materials, in particular with the following elements:

- the **primacy of planet and people over industrial interests** must be reflected in this piece of legislation, which must **not consider access to strategic materials as an imperative reason of overriding public interest** leading to any exemption or derogation from the existing EU acquis;
- absolute criteria for a human and environmental rights-based approach in mining that ensures **the respect and meaningful participation of indigenous peoples at all levels of decision-making**, complying with ILO 169, and provides for strong mechanisms to **secure their access to remedies**. The principle of free, prior and informed consent (FPIC) to large-scale land acquisitions should systematically be applied, while the right of local forest-dependent communities and of indigenous peoples to customary ownership and control of their lands and natural resources shall be protected;
- science-based and robust specifications must be developed, leveraging EU R&I programmes, for **the highest environmental and social standards of mining activities**, to be applied in the EU and in trade relationships;
- the selection of **European strategic projects** must grant a **priority to closing the loop of materials** (development of recycling facilities) over other segments of the value chain, should favour **exploration and reprocessing of mine waste over new mines**, and apply the **excavation last principle**;
- the Commission must use scenarios that take into consideration **profound changes in the metabolism of our societies**, based on sufficiency. Our dependency on phosphate rock, a critical raw material, can for instance be reduced with the implementation of the Farm to Fork Strategy which requires both a reduction of nutrient losses (50% by 2030) and a reduction of the use of fertilisers (20% by 2030).

By prioritising sufficiency and circularity, claiming primacy of planet and people, incorporating these principles in EU trade and investment agreements as well as in internal market product regulation, and adequately working with third countries, we could prevent the climate-neutral and fair transition from derailing, while improving our resilience, protecting our sovereignty and providing a salutary competitive edge to our industry in this imperative transition.

1. Background

What raw materials are

A raw material is any feedstock used to produce intermediate or finished goods. One way of categorising raw materials is to **distinguish those coming from living organisms** (biotic materials, such as biomass) **from non-renewable ones**, which can be split into three categories:

- **metals and metallic minerals**, among which we find the **ferrous** metals like iron and steel, the **non-ferrous** base metals such as aluminium, nickel, copper, lead, and zinc, the **precious** metals such as gold, silver, and the 6 PGMs (platinum group metals), and **Rare Earth Elements** (REE), grouping the light and heavy ones (LREE and HREE);
- **non-metallic minerals**, which gather **construction** materials like sand, gravel, stones and gypsum, and **industrial** minerals like natural graphite, borates, potash, limestone, silica sand or feldspar;
- **energy-related materials** (fossil fuels and uranium).

As shown by *Figure* 1, the overall material extraction has almost quadrupled since 1970, and is now dominated by non-metallic minerals (construction) and biomass. These different categories of raw materials are commonly addressed separately from a policy angle, notably because they are involved in different industrial dynamics and ecosystems, and they present distinct challenges, such as in terms of international trade, or strategic autonomy.

In particular, while representing the smallest amount of extracted materials (*Figure* 2), **metals and metallic minerals are of specific interest**, due to their close links to all industries, their ubiquity in key strategic sectors and technologies, and their predominance among elements considered as critical nowadays (see section on criticality below).

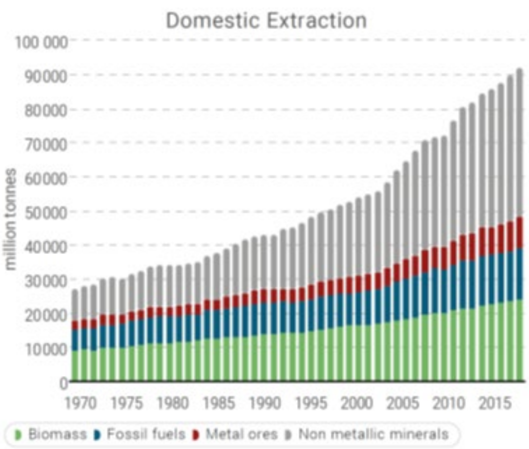


Figure 1 - Evolution of global domestic extraction from 1970 to 2017[1]

Figure 2 - Distribution of global domestic extraction in 2019 by material group

[1] Oberle, B., Bringezu, S., Hatfield-Dodds, S., Hellweg, S., Schandl, H., & Clement, J. (2019). Global resources outlook: 2019.

Impacts of primary raw materials' recovery

Metals being mainly obtained from open surface mining, **excavation industry is at the roots of metal production**. Very few metals exist in sufficiently high concentration for an economical mining as primary output (so-called base metals). Most metals are by-products (so-called companions), and thus depend on the dynamic of their host metals.

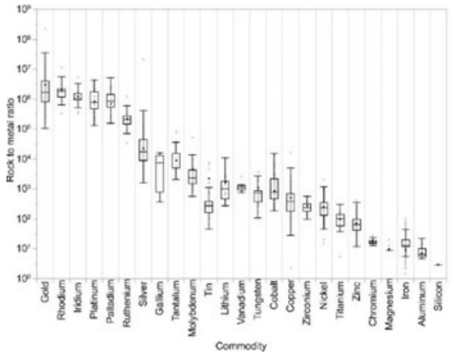
Mining to obtain raw materials causes significant risks and impacts[2,3], intrinsically linked to the underlying industrial process, which consists in extracting, crushing and grinding, separating (for e.g. by flotation, leading to the formation of a tailing), and concentrating (electro-chemical processes) the metal.

These are risks and impacts on **land and biodiversity** (changes to land, topography and landscape, erosion, risk of soil contamination, habitat changes, fragmentation and loss, loss of vegetation and deforestation), on **water** due to the high amount of water involved in the extraction and processing of minerals (eutrophication, ground and surface water impacts, changes in hydrology, increasing water scarcity, acidification), on **climate** (GHG emissions), on **air quality** (dust, smell, Fluoride and Radon gas emissions), on **noise** (blast and transport) as well as in terms of **social and human rights impacts** (displacement of communities and existential threats to indigenous lifestyles and rights to land, working conditions and child labour, violence, health…). Besides, **additional impacts** can come from the specific characteristics of the mineral recovered or the site in question, for instance with possible presence of **radioactive elements or heavy metals of toxicity** for humans and environment, that are naturally present with the mineral recovered. Mining in deep sea beds can lead to the loss of marine life.

To the first order, the **overall impact of producing a specific metal is driven by two key parameters**: firstly the **overall amount of metal produced**, and secondly the **concentration of this metal in the mineral** (ore grade). The lower the concentration, the higher the amount of rock removed and of waste generated, the higher the amount of energy involved, and the greater the terrestrial footprint and related impact on habitats and biodiversity loss. As shown on *Figure* 3, **the rock to metal ratio** (i.e. the quantity of ore mined and waste rock removed to produce a refined unit of a metal) spans from around several millions for gold, to around 5 for silicon. This means that **producing 1 gram of gold generates several tonnes of mineral wastes**. It also infers that it **does not make much sense to compare the level of production of different minerals in absolute terms**. Other impacts such as on water also vary from metal to metal due to various industrial processes involved (*Figure* 4).

[2] See for instance Social and environmental impacts of mining activities in the EU, IPOL Study of the European Parliament, PETI Committee, March 2022

[3] See for instance Bacher, J., Pohjalainen, E., Yli-Rantala, E., Boonen, K., & Nelen, D. (2020). Environmental aspects related to the use of critical raw materials in priority sectors and value chains.



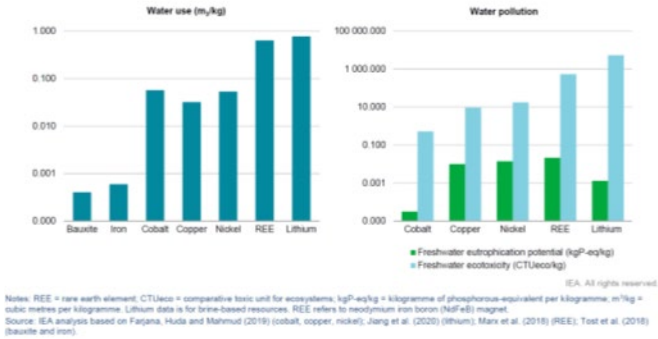


Figure 3 - *Rock-to-metal ratio of main metals (in log scale)*[4]

Figure 4 - *Water use and water pollution for selected minerals*[5]

There are also **temporal evolutions of these impacts,** driven by several factors. In particular, **most accessible minerals are extracted first, so that the ore grade decreases over time** which leads to more wastes and impacts, and **technological developments** and evolution of market price lower the economical limit of exploitability of a given deposit, **increasing further the environmental pressure**. This implies that **the generation of waste from primary raw materials increases more rapidly than the metal production does** (*Figure* 5).

Figure 5 - *Evolution of waste generation and ore quality from copper and nickel mining between 2010 and 2017*[6]

Finally, whereas most industrial facilities can be set up virtually anywhere, **minerals are unevenly distributed across the globe, and their extraction is thus place-dependent**. In this regard, an analysis[7] found that in 2019, **79% of global metal ore extraction originated from five of the six most species-rich biomes,** with mining volumes doubling since 2000 in tropical moist forest ecosystems; that **half of global metal ore extraction took place at 20 km or less from protected territories**; and

[4] Nassar, N. T., Lederer, G. W., Brainard, J. L., Padilla, A. J., & Lessard, J. D. (2022). Rock-to-Metal Ratio: A Foundational Metric for Understanding Mine Wastes. Environmental science & technology, 56(10), 6710-6721.

[5] IEA, I. (2021). The role of critical minerals in clean energy transitions. World Energy Outlook Special Report.

[6] IEA, I. (2021). The role of critical minerals in clean energy transitions. World Energy Outlook Special Report.

[7] Luckeneder, S., Giljum, S., Schaffartzik, A., Maus, V., & Tost, M. (2021). Surge in global metal mining threatens vulnerable ecosystems. Global Environmental Change, 69, 102303. This analysis intersects data concerning the local and temporal distribution of 3000 sites of extraction of nine metal ores worldwide between 2000 and 2019 (bauxite, copper, gold, iron, iron, lead, manganese, nickel, silver, zinc), with data concerning terrestrial biomes, protected areas, and watersheds categorised by water availability.

that 90% of all considered extraction sites correspond to below-average relative water availability, with particularly copper and gold mining occurring in areas with significant water scarcity. In the same vein, the IEA[8] showed that around **half of global copper and lithium production was concentrated in areas already suffering from high water stress**. Additionally, a majority of current and potential excavation locations are located in rural and indigenous areas, so that expanding the mining sector also risks aggravating already existing economic, social and environmental injustices if strong economic, social and environmental justice principles are not adhered to.

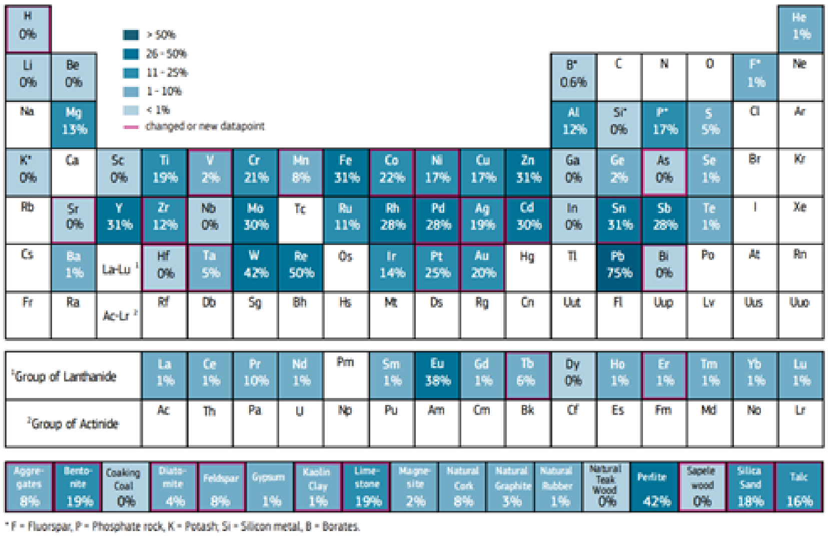
Impacts of secondary raw materials' recovery

Metal can also be produced from **secondary materials such as scrap and from recycling**, given that metals can theoretically be recycled over and over again, a metallic atom remaining stable over time. By avoiding the mining part, the environmental impact is drastically reduced, both in terms of embodied energy and in terms of water use. According to the JRC[9], **there is indeed roughly a factor of 5 to 10 between the energy and water consumptions in production of metals from scrap and ores**, which means that secondary raw materials have an environmental impact 5 to 10 times lower than primary raw materials, and negative social impacts also drastically reduced, thanks to the avoidance of the excavation process.

The contribution of recycling to meet the demand is **limited by the amount of metal extracted and produced for the first time**, and is **further constrained** by other aspects such as the **collection rate** of end-of-life devices and equipment, the **required energy or chemical processes** to separate some materials from each other (in case of alloys for instance) which can make the process uneconomical, and **miniaturisation and diffused uses** (making the process of sorting and collecting metals practically impossible). The periodic table on *Figure 6* provides the **end-of-life recycling input rates (EOL-RIR) of most materials**, which correspond to the share of scrap and reintroduced material in the total amount of material used. As an illustration, 19% of silver (Ag) and 22% of cobalt (Co) come from scrap or recycled metals, and **most of the materials have end-of-life recycling input rates (EOL-RIR) below 10%.**

[8] IEA, I. (2021). The role of critical minerals in clean energy transitions. World Energy Outlook Special Report., page 128.

[9] Mathieux, F., Ardente, F., Bobba, S., Nuss, P., Blengini, G. A., Dias, P. A., ... & Solar, S. (2017). Critical raw materials and the circular economy. Publications Office of the European Union: Bruxelles, Belgium



<u>Figure 6</u> - End-of-life recycling input rates (EOL-RIR) in the EU [10]

Criticality of raw materials

The dedicated work of the Commission on raw materials has been initiated with the publication of a Communication entitled "The raw materials initiative — meeting our critical needs for growth and jobs in Europe" in November 2008. This strategy was built around 3 pillars: to ensure access to raw materials from international markets, to set the framework conditions within the EU to foster sustainable supply of raw materials from European sources, and to reduce the EU's consumption of primary raw materials via resource efficiency and recycling.

This document also suggested drawing the **first list of critical raw materials (CRM).** The methodology used by the Commission to assess the **criticality of a given raw material** is built on the combination of **two factors: the economic importance and the risk of supply disruption of this raw material.** The former relies on the computation of the economic value added by the end sectors dependent on this raw material, while the latter factors in the concentration of supply, the quality of governance of import countries, the import reliance, the trade restrictions, and supply chain bottlenecks. The methodology also takes into account recycling (based on the EOL-RIR already described) and existing substitutes, which both mitigate criticality by reducing exposure to supply disruptions.

This assessment provides a **picture of the criticality at a given time based on present and past data.**It**is not made to anticipate upcoming bottlenecks and constraints on the supply side of materials**, nor to support social and environmental sustainability assessments of industrial and economic policies, and it does not provide any meaningful element about impacts on communities and indigenous peoples of our materiality

This first list of CRM has been established in 2011, and is updated at least every 3 years since then by the Commission to reflect the evolution on market, production and technological grounds. The

[10] European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, (2021). 3rd Raw Materials Scoreboard: European innovation partnership on raw materials, Publications Office. https://data.europa.eu/doi/10.2873/567799

last edition has been released in 2020 together with an action plan on CRM[11]. The next one is supposed to be released in 2023.

While the first assessment of critical raw materials established a list of 14 materials considered as critical out of 41 raw materials included in this assessment, the length of this list increased over time, with 20 materials (out of 54 candidates) in 2014, 27 materials (out of 78 candidates) in 2017, and 30 materials (out of 83 candidates) populating this list in 2020 (*Figure 7*). There is a **clear trend towards the extension of this list over time**, due to the **rising use of materials**, and further fed by **geopolitical tensions and disruptions of supply chains**.

2020 Critical Raw Materials (30)			
Antimony	Fluorspar	Magnesium	Silicon Metal
Baryte	Gallium	Natural Graphite	Tantalum
Bauxite	Germanium	Natural Rubber	Titanium
Beryllium	Hafnium	Niobium	Vanadium
Bismuth	HREEs	PGMs	Tungsten
Borates	Indium	Phosphate rock	Strontium
Cobalt	Lithium	Phosphorus	
Coking Coal	LREEs	Scandium	

Figure 7 - List of Critical Raw Materials established in 2020[12]

2. The future needs of materials

Materiality of the energy transition

The number of different raw materials extracted from earth's crust for industrial applications, and notably for the energy system as sketched on *Figure 8*, has constantly risen since the first industrial revolution, thanks to abundant and affordable energy for extraction, and to progress in chemistry for separation and refinement of materials. This gave **access to most of the elements from the periodic table**, reaching a point where technologies use a significant share of these chemical elements. As illustrated by *Figure 9*, **a smartphone requires 56 out of the 94 elements of the periodic table** that exist in nature.

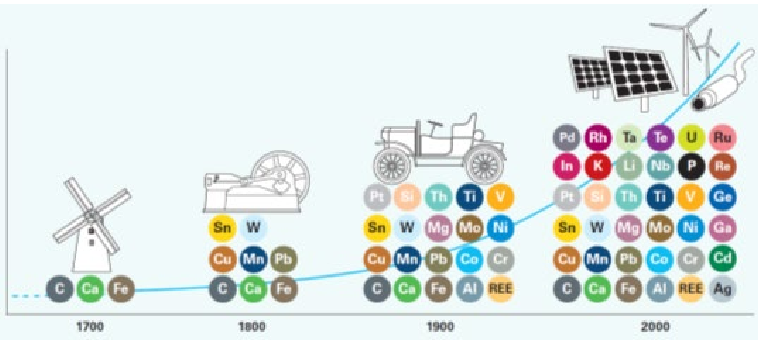


Figure 8 - Elements widely used in energy pathways[13]

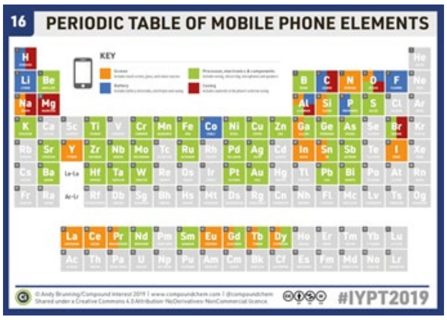


Figure 9 - chemical elements necessary to smartphones

[11] European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs. (2020). Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability. COM/2020/474 final.

[12] European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Blengini, G., El Latunussa, C., Eynard, U. (2020). Study on the EU's list of critical raw materials (2020) : final report, Publications Office.

[13] Zepf, V., Simmons, J., & Universität Augsburg. (2014). Materials critical to the energy industry: an introduction. BP plc.

Metals are essential to the shift to a climate neutral society, while reinforcing social and environmental justice, fighting inequalities, and maintaining our modern way of life. Indeed, beyond the basic principle that a more electrified society requires *de facto* more copper, literature[14, 15, 16] shows that **clean energy technologies require many different metals,** and **are more intense in and require a broader variety of minerals than their fossil and fissile versions** (see *Figure* 10).

Below, is provided the list of concerned metals and the corresponding technologies (in **bold**, metals that are base metals, ie not a by-product of another metal, and current CRM in pink):

- **Aluminium** - Al (wind, solar PV, batteries, networks, traction motors);
- Boron - B (wind, solar PV, traction motors);
- Chromium - Cr (wind, hydro, geothermal, batteries, traction motors);
- Cadmium - Cd (solar PV);
- Cobalt - Co (batteries, fuel cells);
- **Copper** - Cu (wind, solar PV, CSP, hydro, geothermal, batteries, fuel cells, networks, traction motors);
- Light and Heavy Rare Earth Elements: wind, traction motors (Dysprosium - Dy, Neodymium - Nd, Praseodymium - Pr, Terbium - Tb) and electrolysers (Lanthanum - La, Yttrium - Y);
- *Graphite* (batteries, fuel cells);
- Gallium -Ga (solar PV);
- Germanium - Ge (solar PV);
- Indium - In (solar PV);
- Platinum Group Metals (fuel cells & electrolysers) (Iridium - Ir, Palladium - Pd, **Platinum - Pt**);
- **Iron** - Fe (wind, solar PV, batteries);
- **Lead** - Pb (wind, solar PV, hydro, batteries, traction motors);
- Lithium - Li (batteries);
- Manganese - Mn (wind, hydro, geothermal, batteries);
- Molybdenum - Mo (wind, solar PV, hydro, geothermal, batteries, traction motors);
- Niobium - Nb (wind, batteries)
- **Nickel** - Ni (wind, solar PV, hydro, geothermal, batteries, fuel cells & electrolysers);
- Selenium - Se (solar PV);
- Silicon - Si (solar PV, batteries, traction motors);
- Silver - Ag (solar PV, CSP, batteries);
- Strontium - Sr (fuel cells);
- Tellurium - Te (solar PV);
- **Tin** - Sn (solar PV);
- **Titanium** - Ti (hydro, geothermal, batteries, fuel cells);
- Vanadium - V (batteries);
- **Zinc** - Zn (wind, solar PV, hydro, batteries);
- Zirconium - Zr (electrolysers)

[14] Bobba, S., Carrara, S., Huisman, J., Mathieux, F., & Pavel, C. (2020). Critical raw materials for strategic technologies and sectors in the EU—a foresight study. European Commission, 100.

[15] World Bank (2020). Minerals for climate action: The mineral intensity of the clean energy transition. Climate Smart Mining (World Bank Group Report).

[16] IEA, I. (2021). The role of critical minerals in clean energy transitions. World Energy Outlook Special Report.

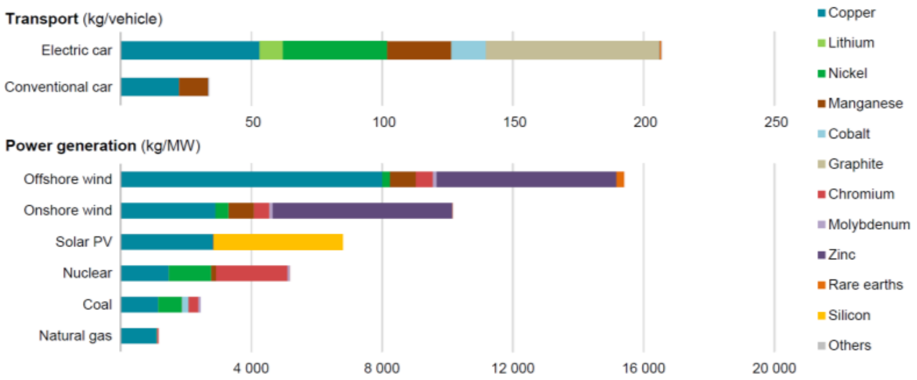


Figure 10 - Minerals used in selected renewable energy technologies, compared to fossil and fissile fuels technologies [17]

This comparison between clean energy technologies and their fossil and fissile versions from the material intensity angle **cannot be the ground of any argument to slow down this imperative transition** from the latter to the former ones. Beyond the undisputable environmental, climate and health benefits of clean electricity technologies[18], even the total material requirement of a fossil and fissile based system surpasses the corresponding figure for a system based on clean technologies when the fuels themselves are considered [19].

Uncertainties about future needs for climate neutrality

Inherent to any prospective exercise and regardless of the ability for the supply to meet the demand[20], **there are uncertainties concerning the future needs.** To the first order, this **uncertainty is driven by the actual deployment of technologies** resulting from investment decisions, public interventions (EU legislation, auctioning schemes, regulatory framework around transportation at local, national and European levels,...) and **actual level of consumption** (patterns of consumption), but is also due to **variations in materiality of different technologies** involving various raw materials, due to **technological evolution**, and due to possible competition from **needs in other domains** that could significantly impact some specific raw materials (for instance, with future telecommunication technologies[21] like 5G technologies, edge computing, photonics and quantum technologies, or in the field of space and defence).

At global level, the IEA Stated Policies Scenario (STEPS) projects **a surge in demand of lithium (13 times), graphite (8 times), cobalt (6 times), nickel (6 times), manganese (3 times), REEs (3 times), molybdenum (2 times), copper (1.7 times) and silicon (1.8 times) multiple times higher in 2040**

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[17] IEA, I. (2021). The role of critical minerals in clean energy transitions. World Energy Outlook Special Report.

[18] UNECE. (2022). Carbon Neutrality in the UNECE Region: Integrated Life-cycle Assessment of Electricity Sources.

[19] See in particular Watari, T., McLellan, B. C., Giurco, D., Dominish, E., Yamasue, E., & Nansai, K. (2019). Total material requirement for the global energy transition to 2050: A focus on transport and electricity. Resources, Conservation and Recycling, 148, 91-103.

[20] The potential limitation from the supply side is not discussed in this paper. However, we mention that such limitation could exist, for instance linked to a future scarcity of resources economically available or to a temporal inadequacy between supply and demand due to the combination of rapid increase of demand and an average lead time of mining projects from discovery to production of 17 years according to the IEA. Besides, the level of supply available for the EU itself can also be constrained by competition with other economies.

[21] Flik, G. (2021). Material Criticality for Future Telecommunication Technologies: Scenario Development and Supply Chain Resilience Strategies.

compared with 2020 levels. It is noteworthy that the STEPS scenario, with GHG emissions rising until 2050, is not in line with a 1.5°c trajectory. **According to the Sustainable Development Scenario (SDS) which complies with the Paris Agreement, the surge in global demand would be even higher**: lithium (42 times), graphite (25 times), cobalt (21 times), nickel (19 times), manganese (8 times), REEs (7 times), molybdenum (2.9 times), copper (2.7 times) and silicon (2.3 times) in 2040 compared with 2020 levels.

At EU level, the Commission published a foresight study[22]. This study provides estimated needs by 2030 and 2050 to sustain the **deployment of strategic sectors and technologies for renewables, e-mobility, and defence & space**, which describes similar trends[23]. As a matter of example, this study anticipates an **additional EU demand of lithium (coming from renewables and e-mobility only) ranging from 6 to 17 times (in 2030) and from 15 to 55 times (in 2050) higher than the current EU consumption for all applications**, depending on the scenario (three scenarios using different assumptions of level of demand and of substitution). In the same vein, due to the intensity of wind energy and traction motors (hence, EVs) in permanent magnets (which require REEs), and of batteries (increasingly manufactured in the EU) in cobalt, the demand of related materials like **dysprosium, neodymium, praseodymium and cobalt is also expected to surge in the coming decades.**

Critical Raw Materials and the agricultural transition

Both Phosphorus (an element such as oxygen or nitrogen) and phosphate rock (a mineral in which you find phosphorus) belong to the EU Critical Raw Materials list. Without phosphorus, life on Earth would not be possible[24]. Phosphorus is an essential nutrient for crops and therefore for food production and it has no substitute. Phosphorus can be derived from various sources, such as phosphate rock, but also manure, sewage sludge, compost, food waste… Globally the production of food is dependent on mined phosphate rock for the production of synthetic fertilisers[25].

Except for Finland, which has minor reserves, the EU is completely dependent on foreign countries for getting phosphate rock. Europe's import reliance of phosphate rock is around 84%[26]. Morocco alone controls 75 percent of the resource[27] and phosphorus is predominantly located in Western Sahara, with heavy geopolitical consequences associated. A third of our imports of phosphate rock comes from Russia. A peak of phosphorus has been predicted to occur in 2033[28]. Although some uncertainties remain about the date, it is certain that we are completely unprepared to deal with

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[22] Bobba, S., Carrara, S., Huisman, J., Mathieux, F., & Pavel, C. (2020). Critical raw materials for strategic technologies and sectors in the EU—a foresight study. European Commission, 100.

[23] Interestingly, the underlying methodology of this foresight study does not take into consideration the actual needs of materials of the European industry, but grounds the estimate of current EU consumption on the economic weight of the EU (22% of global GDP) and the average global supply over 2012-2017.

[24] Christiane Schwarz and Marcel Weingärtner, "Vers une famine planétaire? L'épuisement du phosphore", *DM Film and TV produktion and Arte*, documentary, 2013.

[25] https://rmis.jrc.ec.europa.eu/uploads/CRM_2020_Factsheets_critical_Final.pdf

[26] https://rmis.jrc.ec.europa.eu/uploads/CRM_2020_Factsheets_critical_Final.pdf

[27] Dana Cordell and Stuart White, "Phosphorus", in: Philip Pattberg and Fariborz Zelli, *Encyclopedia of Global Environmental Governance and Politics*, Elgar, 2015, pp.404-413.

[28] Christopher Rhodes, "Peak phosphorus–peak food? The need to close the phosphorus cycle", *Science progress*, vol.96, no.2, 2013, pp.109-152.

the shortages in phosphorus inputs, the drop in production and the hike in food prices that will follow[29].

In Europe, there is an excessive accumulation of phosphorus in agricultural soils, referred to as the legacy of phosphorus. It results from inappropriate fertilisation practices that usually leads to environmental problems[30]. Only 20% of the phosphorus from synthetic fertilisers applied to the crops actually reaches them. The rest ends up in water, creating eutrophication and green algae, as observed in Britany. The phosphate rock from Morocco also contains a high level of cadmium, which ends up in the food we eat, creating health issues.

Strategic autonomy, geopolitics, trade: from a fossil to a metal diplomacy

From a geopolitical point of view, metals follow the same logic as fossil fuels, and notably those traded globally like oil and more and more gas: **being unevenly distributed across the globe and representing a key factor of sovereignty and of strategic autonomy, they are a crucial domain of diplomacy and of international trade arrangements.**

While shifting from a fossil and fissile fuel economy to a renewable-based and climate neutral economy implies fundamental changes in metal intensity, in turn it induces profound changes in the trade patterns on the global scene, due to the **concentration of key minerals into a handful number of countries which concentrate the production of the corresponding metals at an even higher level than in the case of oil and gas** (*Figure* 11), namely cobalt (batteries) in **Democratic Republic of the Congo**, platinum (renewable hydrogen economy) in **South Africa**, REEs and graphite (wind energy and batteries) in **China**, lithium (batteries) in **Australia and Chile**, and to a lesser extent nickel in Indonesia and copper in Chile.

This concentration is even higher for the processing of materials (Figure 12), **with a predominance of China** not only for the processing of REEs, but also of lithium, copper, cobalt, and to a lesser extent of nickel, with China concentrating more than 40% of the volumes processed globally for these metals.

Beyond the geological concentration of deposits and industrial concentration of processing, many raw materials are subject to **trade restrictions of several types** creating **additional risks and uncertainties regarding the ability of the EU to secure its supply of these materials**, and thus potentially undermining its resilience. Among the concerned materials, we notably find **cobalt (84%), REEs (59%), nickel (68%), and platinum (92%), which are part of the key materials for clean energy technologies**[31]. [33]. In addition, trade restrictions (such as export taxes) can be a legitimate tool for governments of developing countries for their future industrial development, as a leverage to fight against poverty and for environmental protection, and are not necessarily against WTO provisions.

[29] Isobel Tomlinson, "A rock and a hard place: Peak phosphorus and the threat to our food security", *Soil Association*, Technical Report, 2010.

[30] Ramiro Recena, Ana M. García-López, José M. Quintero, Annaliina Skyttä, Kari Ylivainio, Jakob Santner, Else Buenemann, Antonio Delgado, Assessing the phosphorus demand in European agricultural soils based on the Olsen method, Journal of Cleaner Production, Volume 379, Part 2, 2022, https://doi.org/10.1016/j.jclepro.2022.134749.

[31] Lithium is also part of concerned materials, although to a much lesser extent since only 6% of global exports are subject to restrictions.

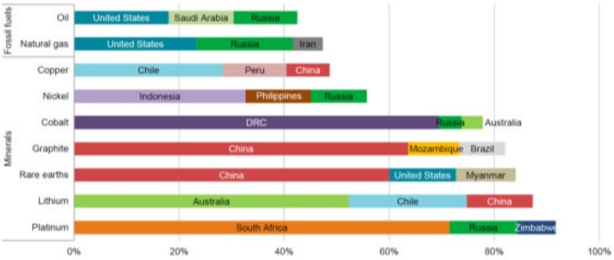

Figure 11 - Share of top three producing countries in total production for selected minerals and fossil fuels [32]

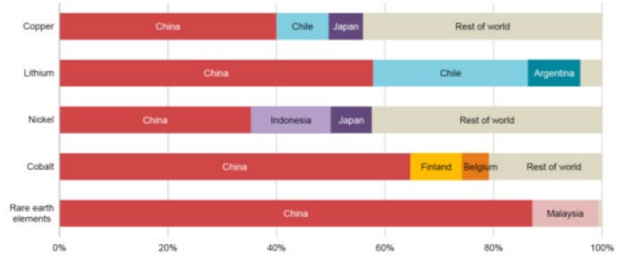

Figure 12 - Share of processing volume by country for selected minerals (2019) [33]

When it comes to the **EU sourcing of critical raw materials to feed into EU industrial processes**, according to the Commission's study on CRM (*Figure* 13), the **level of dependence is also alarming for many of them, notably for materials necessary to clean energy technologies**: 98% of REEs and 46% of natural graphite from **China**, 78% of lithium from **Chile**, 85% of niobium from **Brazil**, 68% of **cobalt** from DRC, PGMs from **Russia and South Africa**, 54% of bauxite for aluminium from **Guinea**, 98% of borates for boron from **Turkey**, and vanadium, and titanium from **China**. We can however pinpoint a share of domestic sourcing for some CRMs, in particular related to the PV industry: 28% of indium, 35% of gallium, 51% of germanium, and 100% of strontium.

Despite the relevance of this analysis, it does not represent the overall raw material dependence to third countries, given **the dependence of the EU to imported components and products and the low level of domestic capacities for manufacturing some key technologies such as PV technologies**, which are not factored in this map. In this regard, one can refer to the foresight study of the Commission, which analyses several strategic technologies and sectors (notably solar PV, wind turbines, li-ion batteries and fuel cells and electrolysers) and looks at the potential bottlenecks along the corresponding value chains, from raw materials, to processed materials, to components, to assemblies. On top of the dependence to third countries, this analysis also emphasises the **absence of the EU, not only on raw materials' segment, but also downstream of the value chains**, the EU representing far below 22% (ie the economic weight of the EU in GDP) of each of the segments, **except on assemblies of wind turbines, and on processed materials and components of hydrogen technologies**.

[32] IEA, I. (2021). The role of critical minerals in clean energy transitions. World Energy Outlook Special Report.

[33] IEA, I. (2021). The role of critical minerals in clean energy transitions. World Energy Outlook Special Report.

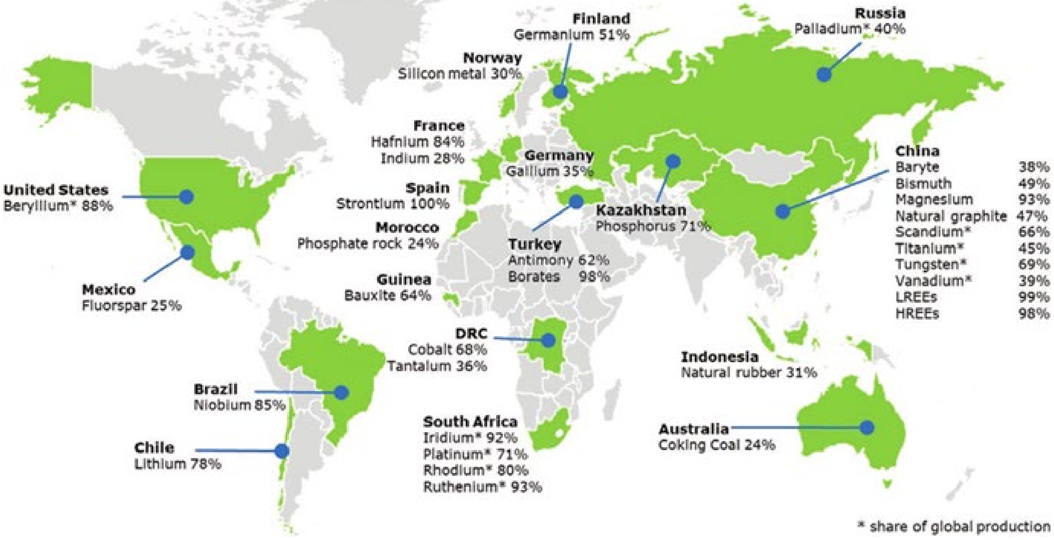

Figure 13 - Countries accounting for the largest share of EU sourcing of critical raw materials [34]

Finally, **from a Human rights' prism**, an analysis of the World Bank states that 44% of all operational mines are located in forests, inducing a significant impact on deforestation, as well as on indigenous people and local communities that depend on forests for their livelihoods. In particular, mining increases the risk of land grabbing, in a context where governments of developing countries often fail to recognise indigenous peoples and communities customary rights to the lands they inhabit. When these rights are not recognised, lands risk to be allocated to outside investors for development. Furthermore, the risk of land grabbing and violations of rights from increased excavation also exist in the EU. For instance, several reports from the UN special rapporteur on the rights of indigenous peoples [35] and from human and environmental rights NGOs, have criticised Sweden for not respecting the indigenous rights of the Sami people to have influence in deciding about mines located in their lands.

3. Possible key Greens/EFA messages

The long-lasting impact of the COVID crisis, the Russian war of aggression on Ukraine jeopardising our economy with an extraordinary inflation, as well as a global context characterised by bold public intervention such as the US inflation reduction act **require ambitious EU responses.**

Now is not the time to **trade off longer-term environmental and biodiversity concerns for short-term industrial and economic interests**, nor to put a halt to the green transition and commitments to advance human and environmental rights and social justice.

Against the risk of a short-term industrial agenda only, **Greens/EFA want to promote a green vision for raw materials use and reuse**, in coherence with our environmental, social, trade, industrial, energy and climate priorities, and with no risk of being cited for hypocrisy. Hence, to mitigate the

[34] European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Blengini, G., El Latunussa, C., Eynard, U. (2020). Study on the EU's list of critical raw materials (2020) : final report, Publications Office.

[35] Tauli-Corpuz, V. (2016). Report of the Special Rapporteur on the rights of indigenous peoples on the human rights situation of the Sami people in the Sápmi region of Norway, Sweden and Finland. United Nations General Assembly, 9.

EU dependency, increase its resilience and strategic autonomy, reduce the supply risk, and foster the reshoring of key industrial sectors in the EU for the achievement of the European climate and environmental goals, such agenda should be based on the following **set of interrelated principles**:

1. Emphasising Sufficiency
2. Prioritising Circularity and the use of and access to secondary materials
3. Validating the primacy of Planet and People
4. Ensuring Excavation last everywhere, and exemplary domestic supply

This set of principles, yet broader than its scope, should be reflected into the upcoming EU legislative framework dedicated to strategic materials (EU CRM Act), in particular with the following elements:

- the **primacy of planet and people over industrial interests** must be reflected in this piece of legislation, which must not consider access to strategic materials as an overriding public interest leading to any sort of exemption or derogation exploiting the loopholes of the existing EU environmental acquis;
- absolute criteria for a human and environmental rights-based approach in mining that ensures **the respect and meaningful participation of indigenous peoples at all levels of decision-making**, complying with ILO 169, and provides for strong mechanisms to **secure their access to remedies**. The principle of free, prior and informed consent (FPIC) to large-scale land acquisitions should systematically be applied, while the right of local forest-dependent communities and of indigenous peoples to customary ownership and control of their lands and natural resources shall be protected;
- science-based and robust specifications must be developed leveraging EU R&I programmes, for **the highest environmental, social and labour standards of mining activities**, to be applied in the EU and in trade relationships;
- the selection of **European strategic projects** must grant **priority to closing the loop of materials** (development of recycling facilities) over other segments of the value chain, should promote **substitution of materials**, favour **exploration and reprocessing of mine waste over new mines**, and apply the **excavation last principle**;
- the Commission must use modelling scenarios that take into consideration **profound changes in the functioning of our societies**, according to the sufficiency principle, away from a "business-as-usual approach" assuming limitless amounts of strategic minerals, and in line with an **absolute reduction of energy and material use.** Modelling scenarios should for example assume changes in the field of transportation, based on a decrease of vehicles on our roads, and in the field of eco-design of products based on the reduction of trade of new units;
- beyond the EU CRM Act *per se*, the Commission should **improve the EU policy framework related to collection and recycling** of equipment containing strategic minerals, as secondary materials should play a decisive role in addressing our strategic dependencies;
- the Commission should consider all tools at its disposal via **internal market regulation** to ensure that the new EU CRM Act does not lead to an increase of imported dirty raw materials in goods placed on the single market. Product regulation and value chain due diligence rules applying to domestic producers and importers are needed to maximise the sustainability benefits of the EU CRM Act, and ensure fair competition.

1. Emphasising Sufficiency

Recalling that critical materials like metals are non-renewable resources, the very concept of limit should be introduced into our conceptual framework. The efficiency first principle is a necessary but not a sufficient condition to curb the demand curve. **The notion of collective sufficiency should be promoted, i.e.** reducing the overall consumption of materials, especially of critical raw materials and of metals. In this regard, **binding EU targets of reduction of material consumption in absolute terms must be set up, with a special focus on metals and strategic materials. Such targets must be science-based and keep EU consumption within the planetary boundaries. The same rationale should also apply to phosphorus, in order to close the phosphorus cycle and align it with planetary boundaries.**

In addition, **hierarchy of uses should be democratically established**, in line with social and climate justice, and ensuring resilience of vital societal functions by allocating materials to essential needs. **Priority should be given to achieving our societal ambition of bringing our socio-economic structures within the planetary boundaries** and to guaranteeing the right to effective access to the **basic goods and services deemed essential to a decent quality of life** and a cohesive society, starting with those whose access is most limited and prioritising public services and services of general interest. Non-essential and gadget applications should not compromise it.

Scenarios of future demand, such as those used in the Commission's foresight study, are essentially techno-economic modelling exercises, with no consideration of **possible profound changes in consumption patterns, which is particularly important for a matter like transportation**[36]. For instance, an effort to shift from individual passenger cars to other forms of mobility (public transportation, bikes, multimodality, rail,...) and to reconsider our approach of passenger cars seem decisive. Electrifying vehicles without changing their material footprint would save the automotive industry without addressing the environmental and climate crises.

Hence, for the sake of risk-preparedness and to avoid demand destruction as experienced in the context of the current energy crisis, **the Commission must develop scenarios relying on profound changes in our individual and collective consumption patterns**, leading to a drastic reduction of demand of metals and materials, without compromising our climate and environmental ambitions, nor our social priorities and human rights commitments.

Such sufficiency principle is crucial **at macroscopic level in the design of future scenarios, and also as a guiding principle to be promoted in citizens' lives**, raising awareness about the material implications of our consumption patterns, to progressively shift our individual and collective relationship to metals and other materials. **Measures towards this awareness-raising must be implemented, while protecting most vulnerable citizens from material deprivation.**

In the same vein of introducing the notion of limit and boundary, we must **further develop substitution strategies to mitigate the pressure on a limited number of materials and the risk of exacerbating scarcities**[37]. It can be a material substitution (for instance replacing copper by

[36] as a rule of thumb, the content of critical materials of a battery-powered electric vehicle is equivalent to 100 to 300 e-bikes, while in a business-as-usual scenario, electric car production would be responsible for 50 to 60% of demand for energy transition metals. Scientific literature also shows that a transportation system simply shifting to electromobility without fundamentally changing its design would have a total material requirement higher than the status quo.

[37] Substitution has definitely a merit, but presents also limits, such as the risk of replacing a scarce material by another scarce one (materials presenting similar characteristics being frequently similarly critical), and the implied trade-off in terms of performance.

aluminium in cables and wires, platinum by palladium in renewable hydrogen technologies, or replacing phosphate rock with compost), a technological substitution (for instance in the case of PV panels, wind turbines or battery technologies) or a functional substitution (for instance developing renewable-based hydrogen technologies alongside batteries for energy storage applications).

Sufficiency is also a matter of **food sovereignty and security**. Considering that planetary boundaries for biogeochemical cycles are exceeded by the EU (by a factor of 2 for phosphorus, and a factor of 3.3 for nitrogen[38]), that synthetic fertilisers are responsible for about 2.1% of global GHG emissions[39] and are affected by the skyrocketing prices caused by the war in Ukraine, intensive or industrial farming is not viable.

Given the **EU's dependency on phosphorus**, we should connect the debate on CRM with the need to better support and develop organic farming and apply the Farm to Fork Strategy objectives. Organic farming is the perfect example that one can grow plants without relying on the imports of phosphate rock. We have broken the cycle of phosphorus, by using phosphate rock as a fertiliser. There are plenty of organic alternatives to synthetic fertilisers (like human urine), but the first thing to do is actually to check whether the soils actually need it. We need to move out from an approach in silos and **develop a real governance of phosphorus, in line with circular economy, reconciling the waste, water, and agricultural sectors**. This will allow restoring the phosphorus cycle and ensuring future food security. By getting rid of our dependence on phosphate rock and synthetic fertilisers and applying the Farm to Fork Strategy objectives, we will not only achieve food security, but also improve the quality of water, soil fertility, and protect biodiversity and our health.

In addition, due to the high-level of raw material dependency of the EU on third countries, **sufficiency is also a matter of global justice**. By reducing its level of material use, the EU can mitigate the negative external impacts of its consumption patterns on those third countries, and leave them space for their own industrial development, which would contribute to create a more equitable and sustainable management of the global natural resources.

A first step towards the introduction of sufficiency considerations into our EU policies could be the **establishment of an independent advisory body at the level of the EU**, modelled after the European Scientific Advisory Board on Climate Change established via the Climate Law. This new body would be in charge of monitoring the use of materials across economic activities and of formulating science-based recommendations on the management and allocation of materials, in order to anticipate and cope with potential scarcities and to ensure social and climate justice. This body should notably be responsible for designing **a raw material index**, in order to ensure well-informed democratic choices, by understanding where (strategic) raw materials are used, to what extent their use has been mitigated, addresses societal needs and contributes to higher social and climate justice. Such index could contribute to improve the societal and social acceptability of extractive activities.

[38] EEA-FOEN. (2020). Is Europe Living within the Limits of Our Planet? An Assessment of Europe's Environmental Footprints in Relation to Planetary Boundaries. Joint EEA/FOEN Report. Joint EEA/FOEN Report No 01/2020.

[39] Menegat, S., Ledo, A., & Tirado, R. (2022). Greenhouse gas emissions from global production and use of nitrogen synthetic fertilisers in agriculture. Scientific Reports, 12(1), 14490.

2. Prioritising Circularity & the use of and access to secondary materials

Moving to a circular economy is urgent and represents a significant potential of reduction of materials from primary sources. It starts by reducing demand via efficiency and sufficiency to avoid extraction of materials, as already mentioned in the previous section.

Besides, the expected lifetime of metals in the economy varies between just a few months (for technology metals like Germanium) to more than a century for metals like iron and aluminium, used in construction[40]. **We must prioritise the extension of the expected lifetime of materials through ecodesign and multifunctional and interoperable use, and by reusing (final products or components), repairing, refurbishing, repurposing and only once all these possibilities have been exhausted, by recycling materials.** Extending the right to repair and making it universal by making spare parts easily available to all, prohibiting premature obsolescence and irreparability, extending the legal guarantee of products, banning single use products, or supporting the development of second-hand markets, are examples of measures contributing to the extension of the lifetime.

Given the current (low) levels of recycling of materials, there is a **tremendous untapped potential to alleviate the pressure of primary raw materials on our environment, by keeping mined materials into our economy.** Investing into establishing an entire industrial fabric for recycling must be the lowest-hanging fruit.

There are **dissipative losses of materials**, due to material flows that lead to concentrations such that a recovery is technically or economically unfeasible, even for mass metals like aluminium and iron, for which about a third of the extracted and used materials is lost every year as dissipation. These dissipative losses correspond to the real consumption of metals, which has to be compensated, either with primary or secondary raw materials, by substitution, or by a change of consumption pattern to cope with a lower availability of material. Hence, **we must reduce drastically the dissipative losses to get a chance to improve recycling rates**.

Dissipative losses are driven by factors like **very low concentrations of materials in final products, dissipative applications as such** (like coating, pyrotechnics, some pesticides using copper,...), and by **creating alloys where materials are irreversibly mixed. Ineffective sorting solutions in the recycling industry** are also responsible for part of the dissipative losses[41].

Reducing dissipative losses requires to **design products differently (design for recycling), limiting alloys and low concentration of materials in products** (which usually implies trade-offs in terms of performance), limiting miniaturisation[42] which can make effective sorting solutions uneconomical (or drastically downgrading the functional value of processed materials), favouring low-tech approach, and **banning some dissipative applications**.

Beyond tackling dissipative losses, **we must limit or even ban some material flows leaving the EU as "waste",** especially resource-rich wastes like vehicles, batteries, electronics, solar PV, wind

[40] Helbig, C., Thorenz, A., & Tuma, A. (2020). Quantitative assessment of dissipative losses of 18 metals. Resources, Conservation and Recycling, 153, 104537.

[41] There are also dissipative losses closer to the mining stage, with material flows towards tailings and slags, although depending on the material concentration, tailings and waste disposals should not always be considered as dissipative - see secondary first principle below.

[42] The labour cost of dismantling and collecting valuable materials at the end-of-life of a product is not correlated to the weight of the components: a smaller component (hence, less valuable for recycling industry because lighter) costs the same in terms of labour cost, so its recycling rate will decrease.

turbines, and manure and food waste, and **limit landfill deposits** which further divert materials from the economy. We must also revise the regulatory framework on waste to **impose collection and recycling targets per material and not merely based on the total weight of products**, to ensure a sufficient flow of secondary materials for the recycling industry to emerge.

Closing the loop of strategic materials in the EU, and imposing recycled content in final products could create a **competitive edge and contribute to re-shore manufacturing capacities of key technologies**, leading to a positive reindustrialisation of the EU towards the imperative climate neutral and fair transition. Closing the loop via recycling should be fostered by a **priority granted to secondary raw materials as long as market dynamics are unable to do so**, to facilitate the emergence of an entire industrial ecosystem relying on secondary raw materials. This priority can be seen from two angles: **tilting the playing field to favour secondary materials over primary materials, and improving the recovery of materials from already extracted materials to make secondary raw materials widely available** (reprocessing mining waste).

The balance can be tilted towards secondary materials in various ways. For instance, a **tax could be imposed on virgin materials** (a virgin tax), **subsidies** or tradeable credits could be provided **for the use of secondary materials**, a reduced tax rate could be granted to secondary materials, or several of these options could be combined. Besides, we could dedicate a share of the market to secondary materials, to boost its demand regardless of its relative cost, for instance by **introducing targets of minimum recycled contents into final products, such as via the eco-design regulation**. Concerning the latter, we must ensure that enough secondary raw materials are in the system before imposing a minimum recycled content target, otherwise it might be counter-productive. The development of mandatory green criteria into public procurement procedures, including targets of goods with a certain percentage of recycled content, should also be explored.

When it comes to improving the recovery of materials, the digital product passport under the ecodesign regulation should significantly enhance the traceability of material and should include the percentage of each critical raw material in the constituting products. Given the significant number of old mines in Europe, **we must also invest in mapping material content of most resource-rich waste streams like tailings**[43] to further identify the most valuable ones that might be reprocessed without causing excessive impacts on the environment. For instance, **a database reporting the volumes and types of extractive waste deposits, providing the mineral exploited and waste types should be established.** Together with "near zero waste mining"[44], this is a rising field of research, which deserves to be further supported. Besides, **companions** of host metals in waste from active and inactive mines **should systematically be recovered.** An example of such reprocessing is found in Sweden with the state-owned company LKAB planning to recover REE and phosphorus from iron mines[45].

[43] In theory, landfill mining could also exist, although its potential seems negligible because of unfavourable economics notably due to much lower concentration.

[44] See for instance Spooren, J., Binnemans, K., Björkmalm, J., Breemersch, K., Dams, Y., Folens, K., ... & Kinnunen, P. (2020). Near-zero-waste processing of low-grade, complex primary ores and secondary raw materials in Europe: technology development trends. Resources, Conservation and Recycling, 160, 104919.

[45] https://www.lkabminerals.com/en/exploration-confirms-potential/

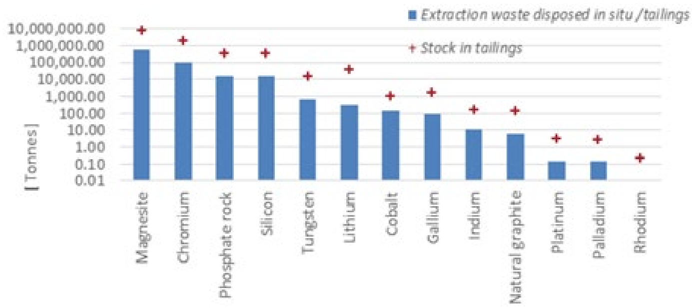

Figure 14 - Amounts of some materials (EU-28) in tailings and extraction waste disposed in situ, and stock in tailings (log scale)[46]

3. Validating the primacy of Planet and People

Sufficiency, circularity and secondary first principles will not suffice to match the needs from strategic sectors and technologies in the near future, notably because recycling is limited in first order by volumes already extracted and processed for the first time and some metals have been recently introduced in our economy. **But nature, communities and biodiversity cannot be the collateral damage of a race to climate neutrality**.

Despite the rising need of some metals and materials to address some of our most pressing societal challenges, **we cannot accept the creation of new exemptions and derogations in the legislative framework and international conventions**, in particular concerning human and indigenous rights and environmental protection, nor the use of existing derogations to justify mining in protected areas. Hence, **protecting nature and local and indigenous communities, and mitigating biodiversity loss must be prioritised over industrial interests**. We should not only claim but also enforce that. Thanks to satellite imagery for instance, land surface deformation can be monitored, and illegal and illicit mining activities can be tracked. Fed by this metal hunger, pressure on our environment keeps rising, including through mining of deep seabed, which is believed to have the highest biodiversity on Earth and provides critical environmental services, including long-term carbon sequestration. This type of mining is **highly likely to cause inevitable and permanent biodiversity loss[47], therefore the precautionary principle must apply to this emerging sector**. The EU should oppose such dreadful activity and defend a ban on Deep Sea Mining Activities. Therefore, to maintain this precautionary approach, the EU and its Member States must promote a moratorium on such activity, notably at the International Seabed Authority, until the effects of deep-sea mining on the marine environment, biodiversity and human activities at sea have been studied and researched sufficiently and deep seabed mining can be managed to ensure no marine biodiversity loss nor degradation of marine ecosystems.

We will undoubtedly keep importing materials (raw, processed or embodied) from third countries, despite the level of efforts to be deployed to reduce the need and to close the material loop. Considering the currently alarming level of dependence to a limited number of countries, **we must quickly diversify our supply, and fundamentally rethink our approach of trade, to shift from a free**

[46] Mathieux, F., Ardente, F., Bobba, S., Nuss, P., Blengini, G. A., Dias, P. A., ... & Solar, S. (2017). Critical raw materials and the circular economy. Publications Office of the European Union: Bruxelles, Belgium.

47 see for instance Miller, K. A., Brigden, K., Santillo, D., Currie, D., Johnston, P., & Thompson, K. F. (2021). Challenging the need for deep seabed mining from the perspective of metal demand, biodiversity, ecosystems services, and benefit sharing. Frontiers in Marine Science, 8, 706161.

trade prism to a fair and sustainable trade one, contributing to regeneration of ecosystems instead of further destroying them. This means building trade relationships in line with European social and environmental values, aiming for local benefits that last beyond the lifetime of the mine and that contribute to prosperous development beyond extraction. Such trade relationships should actively incentivise sustainable production and consumption of goods and provision of services over the perpetuation of outdated economic models based on economic growth and causing environmental degradation and contributing to the climate crisis. This could be achieved in various ways: pre-ratification conditions regarding social, environmental and human rights and concrete benchmarks and timelines, tariff reductions conditional on sustainable production models and conservation of vital natural resources, primacy of multilateral environmental agreements over trade/investment agreement in case of inconsistency, and sanctionable trade and sustainable development chapters applied to the whole agreement...

For the sake of global justice and coherence in development policy, the EU must also work alongside its partners in low-income countries. Notably, the EU hunger for materials should not lead to neo-colonial extractivist relationships. Instead, the EU must aim at negotiating with its partners to develop sustainable trade and cooperation agreements, that uphold the right of each party to regulate (including the ability to limit the exports of raw materials when justified by sustainable development objectives), create **added-value for both parties and ensure a high level of sustainable development, climate and human rights protection**.

The EU must also **show leadership by supporting its partners**, in particular in low-income countries, in developing processing capacities and finding the necessary technical and financial assistance, notably investments (including via the EU Global Gateway), to ensure that their raw materials supply chains become as exemplary as possible with regard to environment, workers and human rights, including via the use of export credits. Similarly, EU investment agreements with resource-rich partner countries must fully respect their right to regulate policies for sustainable development, climate action and human rights, without making such regulations subject to challenges under ISDS or investment courts. We cannot shut our eyes to the impacts of our material needs on third countries. A first timorous step has been done with the Conflict Minerals Regulation. The EU Battery regulation contains promising environmental and human rights due diligence obligations which apply to all domestic and foreign producers placing batteries on the European market. Finally, the upcoming legislation on due diligence (the Corporate Sustainability Due Diligence Directive) should truly lead to the EU responsibly sourcing materials. In this context, we must fight for the highest environmental, social and labour standards to be used for mining activities, in the EU and beyond. For the time being, although the Initiative for Responsible Mining Assurance (IRMA) seems to be the most promising, **there is no single science-based and widely recognised standard establishing the highest social and environmental mining practices, but various existing initiatives and schemes** (see *Figure* 15). For this reason, **we must develop robust standards, based on best available techniques and solid science, for the EU to behave as a trend-setter** (see next section). Such standards for sustainable mining should not only be compliant with our environmental and climate objectives, but also be regularly updated to reflect the technical state-of-the-art, and should notably cover the restoration phase of land.

In addition, for the EU to behave as a trend-setter, domestic supply must be carried out in partnership with local and indigenous communities, and industrial actors should be responsible for fair compensation and for the long-term effects from mining even after excavation has stopped.

The **Raw Materials Club** recently announced by the Commission could become a valid alliance to not only diversify sourcing, but also as a key driver to develop multilateral solutions towards a global regulatory alignment on highest environmental, social and human rights standards, in line with the United Nations Resolution on the right to a clean, healthy and sustainable environment .

Name	Climate	Sustain-ability	Responsible sourcing	Rights of workers	Fairness and inclusivity	Governance	Security of supply
World Bank Climate Smart Mining Initiative	● (orange)	● (orange)				● (orange)	● (orange)
European Battery Alliance							● (yellow)
European Raw Materials Alliance							● (yellow)
Extractive Industries Transparency Initiative						● (orange)	
Global Battery Alliance	● (purple)	● (purple)	● (purple)				
Energy Resource Governance Initiative		● (orange)	● (orange)	● (orange)		● (orange)	
Fair Cobalt Alliance				● (yellow)	● (yellow)		
International Council on Mining & Metals	● (purple)	● (purple)	● (purple)	● (purple)	● (purple)	● (purple)	
Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development		● (orange)	● (orange)	● (orange)	● (orange)	● (orange)	
Initiative for Responsible Mining Assurance	● (purple)	● (purple)	● (purple)	● (purple)	● (purple)	● (purple)	
Towards Sustainable Mining	● (purple)	● (purple)	● (purple)	● (purple)	● (purple)		
OECD Responsible Business Conduct			● (orange)	● (orange)	● (orange)	● (orange)	
Responsible Minerals Initiative			● (purple)	● (purple)			
Responsible Minerals Foundation	● (teal)	● (teal)	● (teal)	● (teal)	● (teal)	● (teal)	
Women's Rights and Mining			● (teal)		● (teal)		

Note: Primary activity type: ● (orange) = Technical assistance. ● (purple) = Industry standardisation. ● (yellow) = Investment/funding. ● (teal) = Research and analysis.

Figure 15 - Some international initiatives on sustainable and responsible extraction by activity area [48]

4. Ensuring Excavation last everywhere, and exemplary domestic supply

The apparent weakness of the EU in terms of raw materials must become the foundation to **build its competitive edge and reinforce its industrial leadership for the climate neutral and just transition**. In this perspective, **developing domestic supply grounded on previous principles (sufficiency, circularity and secondary materials, and people and planet first) should be the priority while considering excavation as a last resort option.**

Access to domestic sources of primary raw materials in Europe is portrayed not only as a component to address the rising demand for the transition, but also as a means to reduce our dependency and increase our strategic autonomy, a means to provide jobs and to contribute to reindustrialisation, and as a way to reduce the overall impact of mining, thanks to more environmentally friendly techniques in Europe compared to the global average[49].

Despite **all efforts that must be deployed to improve it and mitigate its impacts, mining of raw materials cannot be harmless**. That is why we must prioritise sufficiency (demand reduction), circularity, the development and use of secondary raw materials, and protection of nature and communities in EU industrial policies through developing fair compensation and consultation procedures as well as pay great attention to long-term effects on local and indigenous communities as well as human right and environmental defenders. Besides, regardless of the environmental and social considerations, developing a new mining project to extract primary raw material is lengthy and capital intensive, and thus cannot contribute to the resilience of the EU in

[48] IEA, I. (2021). The role of critical minerals in clean energy transitions. World Energy Outlook Special Report.

[49] See figures below which compare European values and global average in terms of CO2 footprint (Figure 27), of waste (Figure 28), of material moved (Figure 29), and of employment (Figure 30). Extracted from Gregoir, L., & Van Acker, K. (2022). Metals for clean energy: pathways to solving Europe's raw materials challenge. Eurometaux, KU Leuven.

the near future. For this reason, to reduce our dependency and increase our strategic autonomy, we **must prioritise the development of processing capacities for strategic materials over new mining projects**.

However, **in a spirit of global and climate justice and to lead by example in a global context, we cannot oppose, by principle, any new mining project in the EU**, which has potential to extract some strategic materials, such as **REEs** (Sweden, Finland, Germany, Spain), **Cobalt** (more than 100 deposits in the EU, mainly in Finland and Sweden, but also in Poland, France, Germany and in Greece), **Niobium** (mainly in Finland, and small deposits in Spain and Portugal), **Lithium** (Portugal, France, Czechia, Germany), and **Graphite** (Fennoscandia, Austria and Germany)[50]. Our mineral and metals needs **should not further exacerbate the existing inequalities climate and environmental injustice with the Global South**, and diminish their ability to use their own resources for their own prosperity. For the sake of global justice, the EU could not focus on the processing and refining segments of the value chain for itself, leaving the environmental and social impacts of mining and excavation to third countries.

Therefore, should new extraction of minerals be unavoidable despite all the previous principles and provisions,, **we must impose the highest environmental and social standards to the mining industry in the EU, based on robust, science-based and widely recognised standards (to be developed at EU level).**

This should encompass the development of independent, thorough environmental impact assessments, the **involvement of stakeholders** (especially local and indigenous communities and social dialogue) from inception of the project following the principles of information and public participation[51], and fully enforced environmental laws **securing access to justice.** There must be **no ground for any exemption from the EU acquis, in particular environmental legislation** (water, biodiversity, soil, air,...) and human rights, and the EU framework should be improved to ensure that mining does not take place in the **most precious areas,** with no ground for being considered as an imperative reason of overriding public interests. For the sake of social and environmental justice in the EU, we must also avoid exacerbating existing inequalities vis-à-vis our right to a clean, healthy and sustainable environment, by ensuring that new activities related to mining and processing of materials do not add industrial risks or pollution on already affected communities and most vulnerable citizens.

Instead, **mining techniques should continuously be improved** to reduce waste and pollution of air, soil and water, to avoid use of toxic and hazardous substances, and **a ban of the most harmful and polluting solutions should be applied**, as constraints have always been a driver of innovation. Improvement of mining techniques should also deliver on better working conditions of miners in terms of health and safety. For instance, without contemplating this as a silver bullet widely opening the door to domestic extraction in the EU, less invasive techniques like **mineral extraction from geothermal brines** which also provide side benefits could probably be part of such European future mining approach, even if further scientific work and evidence must be provided. The **restoration phase** should be fully covered by such standards. The principle of **"polluter pays"** should be applied, for instance via mandatory financial guarantees for environmental and social risks

[50] Lewicka, E., Guzik, K., & Galos, K. (2021). On the possibilities of critical raw materials production from the EU's primary sources. Resources, 10(5), 50.

[51] There is a particular need to improve consultation and exchange of views with the Sami communities in Sweden and Finland whose cultures face an existential risk from new excavations.

arising from during and after the end of exploitation. In this regard, the **liability of mining companies** should be diligently enforced. Finally, this should also imply a **fair compensation for the appropriation of common resources** to affected communities, for instance via the promotion of models based on local ownership.

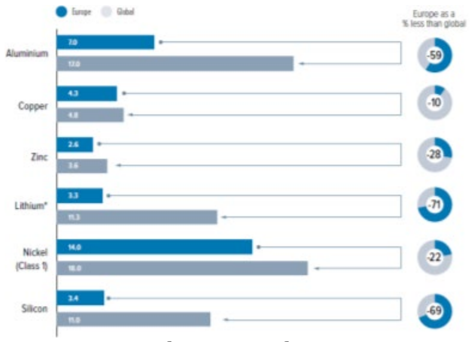

Figure 16 - CO_2 footprint for primary metal production

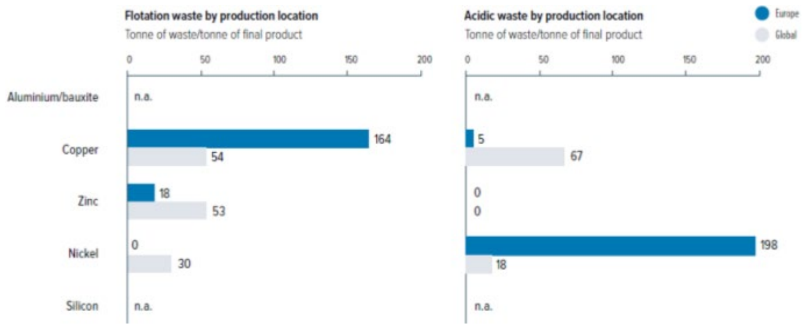

Figure 17 - Processing waste by commodity

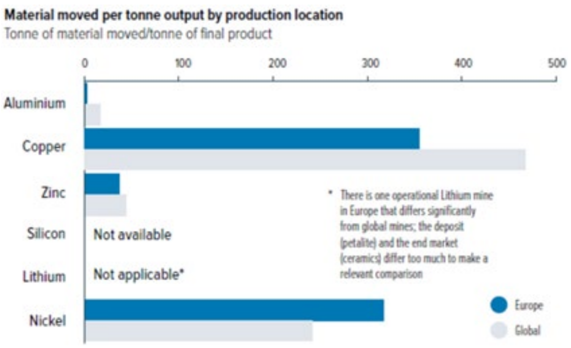

Figure 18 - *Spatial impact in terms of material moved*

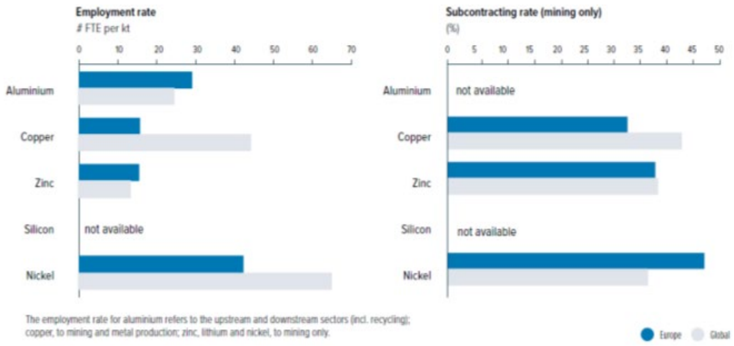

Figure 19 - Employment rates

To conclude, by prioritising sufficiency and circularity, claiming primacy of planet and people, incorporating these principles in EU trade and investment agreements as well as in internal market product regulation, and adequately working with third countries, we could prevent the climate neutral and fair transition from derailing, while improving our resilience, protecting our sovereignty and providing a salutary competitive edge to our industry in this imperative transition thanks to more ambitious environmental, social, ethical and technical standards.