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ETIENNE BERTHET
Technical University of Denmark, Quantitative Sustainability Assessment
etber@dtu.dk

THE SOCIAL AND ENVIRONMENTAL IMPACTS OF THE MINERAL EXTRACTION REQUIRED FOR THE EUROPEAN CLEAN ENERGY TRANSITION

INTRODUCTION

European Climate Law: The key point of the “clean energy technologies"

In 2021, the European Union (E.U.) adopted a **European Climate Law** that wrote the goal of the **European Green Deal** into law. This law aims to reach net-zero greenhouse gas emissions (GHG) by 2050 for Europe's economy and society. The law also defines an intermediate objective of reducing greenhouse gas emissions by at least 55% below 1990 levels by 2030. The European Commission defined a set of policy proposals to reach this intermediate objective under the so-called **"Fit for 55 package".** The package includes a set of changes to existing policies and new measures to reduce GHG emissions in the European Union. The **increase in renewable energy production**, **electrification of end uses**, and a **large deployment of "clean energy technologies"** (identified by the International Energy Agency (IEA) as nuclear energy, electricity networks, electric vehicles, battery storage and hydrogen production and storage) are crucial elements. However, as indicated in the different scenarios developed by the IEA and the International Renewable Energy Agency (IRENA), those elements are **highly dependent on some specific mineral resources** to be built (e.g., cobalt, lithium, nickel, copper, and rare-earth elements among others).

The **criticality** of those minerals regarding their strategic position in the current and projected European demand as already been studied. **However, despite this strategic analysis, the European Union has not yet studied in detail their global social and environmental impacts**. This needs to be done as it is explicitly required in the "Fit for 55 package" definition to be **"socially fair"** and cost-efficient. Moreover, understanding how countries worldwide contribute to generating externalities induced by the European demand is **essential for designing sustainable European policies** to reduce negative environmental externalities or social externalities such as forced labor.

To analyze this issue, it would **not be possible to use the standard approach of production-oriented impacts** (as it has been done for most studies focusing on the European lithium consumption). The global extension of the critical minerals' consumption, combined with the high international degree of their supply chains and the geographical concentration of reserves, **undermines production-based approaches' efficiency** in addressing the socio-environmental impacts of their extraction and production. As such, the design of **sustainable energy policies** must rely on a **consumption-based approach to capture the impacts of their energy system transition throughout the supply chains**. We quantified those global socio-environmental impacts with a consumption-based approach to fill this gap. As such, **we combined different Multi-Regional Input-Output models with detailed data on the mineral production and mineral requirements for the energy transition.**

Then, this study presents a detailed mineral footprint and studies the part of this footprint directed explicitly to the energy transition. Associating current mineral requirements for the energy transition and the projected requirements for 2030 and 2040, the study shows how this footprint is expected to change given the current international value chains.

RESULTS

Increase in renewable energy production

Development of clean energy technologies

Electrification of end-uses

European Green Deal

Requires an increase of the critical raw materials' extraction

Scrutinize by the European Raw Materials Alliance (ERMA) to secure a sustainable supply of raw materials (and, therefore, critical minerals) in Europe and increasing the E.U.'s resilience to these supply chains. However, apart from the strategic position of those critical minerals in the European supply chains, their extractions and processes also present ecological and social threats, which have not yet studied in detail.

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Determining the **2030 and 2040 E.U. raw material demand** for the energy transition following different IEA scenarios

Stated Policies Scenario (STEPS) reflects the policies in place and announced by the governments (including the “Fit for 55” package). It leads to a 2.6°C temperature rise in 2100 compared to pre-industrial levels

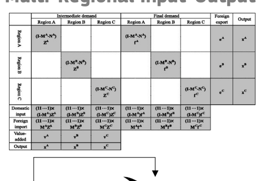
Sustainable Development Scenario (SDS) considers advanced economies will reach net zero emissions by 2050, China will reach it by 2060, and all other countries by 2070. It leads to a temperature rise of 1.6°C in 2100

	2030 STEPS**	2030 SDS**		2030 STEPS**	2030 SDS**
Boron	104%	139%	Neodymium	168%	326%
Cadmium	-8%	30%	Nickel	386%	786%
Chromium	148%	236%	Niobium	348%	766%
Cobalt	361%	861%	Other REEs*	161%	303%
Copper	26%	46%	Platinum	1357%	3511%
Gallium	933%	1573%	Selenium	1%	71%
Germanium	-28%	9%	Silicon	6%	67%
Graphite	564%	1226%	Silver	-3%	49%
Hafnium	82%	94%	Tantalum	284%	423%
Indium	54%	79%	Tellurium	-16%	29%
Iridium	900%	68921%	Tin	32%	101%
Lead	50%	84%	Titanium	79%	149%
Lithium	582%	1270%	Tungsten	82%	94%
Magnesium	211%	619%	Vanadium	161689%	232484%
Manganese	130%	320%	Zinc	33%	90%
Molybdenum	123%	199%	Zirconium	89%	361%

Future raw material demand specifically related to the European energy transition **increases significantly for both scenarios and will exceed the total current E.U. footprint**

** Rare Earth Elements, ** The percentages are in comparison with the 2020 E.U. raw material demand specifically related to production of renewable energy and clean energy technologies.*

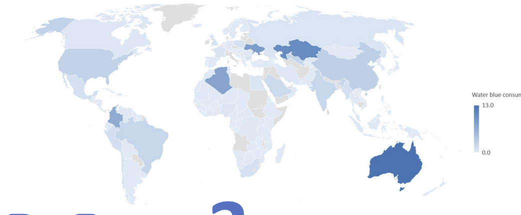
Multi-Regional Input-Output



We quantify the global socio-environmental impacts of European critical minerals supply required for different energy transition scenarios with a consumption-based approach. Multi-Regional Input-Output (MRIO) models capture the global economy with input-output tables, linking supply chains with the final demand no matter their degree of internationalization. We combine these models with detailed data on minerals extraction from World Mining Data and United Stated Geological Survey.

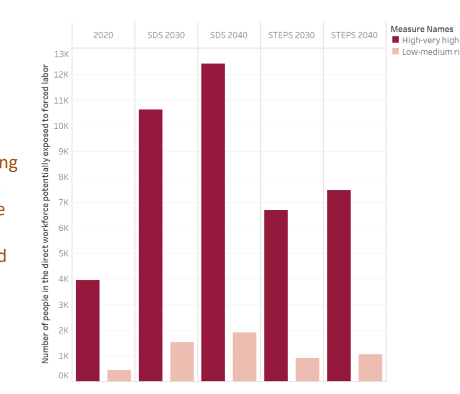
Water consumption

Country distribution of total water blue consumption by mining sectors for the energy transition in the EU in 2040 under the SDS scenario. (Calculations are made with Eora)



+73Mm^3 (in 2040 SDS scenario)

Direct workforce in mining industry supplying the energy transition in the EU exposed to a significant risk of forced labor



- **x3** 2040 vs. 2020 (legal mining only)
- **x11** 2040 vs. 2020 (including artisanal and small-scale mining)

CONCLUSIONS

- Our study identified **various hotspots** in terms of minerals or countries regarding the supply risk for the energy transition in the E.U. or the associated **socio-environmental impacts**. Minerals such as **cobalt, graphite, lithium, nickel and rare earth elements** require detailed studies on the current E.U. supply chains and the supply possibilities to cope with the increasing demand led by the energy transition.
- More generally, these minerals and other critical minerals in terms of supply risk or socio-environmental risks require consumption-based studies capturing three different risks: **the supply risk, the environmental risk, and the social risk**.
- **The design of the E.U. policies for the energy transition must deal with these three risks to ensure a successful Green Deal.**

Production side: Control over the supply chain of critical minerals is a strategic asset in developing low-carbon technology value chains and developing advantages over competitors.

- **The E.U. must diversify its supply chains of critical minerals for the energy transition.**
- The EU **needs to act and favor new, responsible mining projects on their land, and link their development aid to the implementation of environmental and social standards in the mining sector**, while supporting traceability initiatives.
- The development of ore extraction activities is dependent on the geographical location of exploitable ores and leaves little possibility of diversification for most minerals. **However, the possibility of diversifying the places of ore processing and developing these activities inside the E.U. must be investigated with the socio-environmental impacts as a key criterion**. Developing mining activities in the E.U. will ease the monitoring and the reduction of these impacts.

Consumption side: Given vulnerabilities in critical minerals, four areas must be pursued on the demand side:

1. **re-use,**
2. **recycling,**
3. **reduction,**
4. **and reindustrialization**

- **The supply and socio-environmental risks associated with critical minerals will be lowered with a decrease in consumption**. To still be aligned with the Green Deal goals, one lever is to increase the metal intensity. Another is to vary the sub-technologies to diversify the minerals required.
- **The development of recycling and circular economy will also participate to create value chains in the E.U.**
- Finally, **these risks will be mitigated with frugality, by decreasing energy consumption and the consumption of these minerals for other end-uses**.

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[1] DTU: Technical University of Denmark, Quantitative Sustainability Assessment, Kgs. Lyngby, Denmark
[2] NTNU: Norwegian University of Science and Technology, Industrial Ecology Digital Laboratory, Trondheim, Norway
[3] DIW Berlin - German Institute for Economic Research
[4] DTU: Technical University of Denmark, Department of Technology, Management and Economics, Kgs. Lyngby, Denmark

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