

NOVA SCHOOL OF SCIENCE & TECHNOLOGY

MATERIALS: CRITICALLITY AND MITIGATION STRATEGIES

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MATERIALS: CRITICALLITY AND MITIGATION STRATEGIES

- The central role of materials
- Critical Raw Materials: the concept
- CRM: Mitigation strategies





THE CENTRAL ROLE OF MATERIALS





Throughout the History of Humanking, Materials have fullfilled a central role in the technological development.

More so today, given that our civilization is heavily dependent on advanced technologies.

- Lightweight materials for Mobility;
- Functional materials for Energy, IT, Communications,...
- Biomaterials for Health, Food,...







However, our reliance on advanced materials for complex technologies places on a tough spot.



11 elements

0 critical



55 elements 21 critical







Furthermore, we consume astronomical quantities of these materials:



Annual worldwide production of various materials essential for the functioning of today's society.

eMaPriCe



THE LINEAR ECONOMICS MODEL:



OUTCOME: Growth.

INCOHERENCE: Unlimited growth can not be achieved on the basis of a physically finite planet.





SOCIETAL CHALLENGES:

Continuous population growth, combined with increased aggregate wealth, results in a very significantly increased consumption of raw material resources.



Progression of world trade, GDP, energy consumption and $\rm CO_2$ emissions compared to population growth between 1975 and 2012.



Evolution of the production of three metals and CFRP composites over the last century.





SOCIETAL CHALLENGES:

Climate change, and the required energy transition, place increased demand on raw material resources.





The Growing Role of Minerals and Metals for a Low Carbon Future



International Bank for Reconstruction and Development / The World Bank, "The Growing Role of Minerals and Metals for a Low Carbon Future", 2017 Scenarios for **increased resource needs until 2050** from the adoption of **Low Carbon** technologies, according to three different scenarios:

- Ambitious: 2DS limitation of global temperature rise to 2 °C;
- Moderate: 4DS limitation of global temperature rise to 4 °C;
- Minimal: 6DS limitation of global temperature rise to 6 °C.

The only truly clean energy is less energy!





THE CIRCULAR ECONOMY OF MATERIALS:

The cycle may be closed at any stage:

- From Disposal to Use: Product Life Extension
- From Disposal to Distribution: Redistribution
- From Disposal to Manufacture: Remanufacture
- From Disposal to Raw Materials: Recycle

Recycling is the less satisfying outcome from both the standpoints of impact reduction (e.g. embodied energy) and value preservation.





CRITICAL RAW MATERIALS: THE CONCEPT











The classification of a processed or raw material as critical (CRM) depends upon each countries' interest for that resource and the nature of its economic tissue.

Ensuring access to critical raw materials is a strategic objective of the European Union, as part of its political and economic agendas.

Europe's main industrial sectors are heavily dependent on access to a range of mostly imported raw materials.





- Political and economic stability
- Level of concentration of supply
- Substitution potential ("*substitutability*")
- Recycling rate
- Environmental risk: risk of implementation by producer countries of scarcity-promoting environmental protection measures



- *C_E* Global economic importance of the resource
- C_R Importance of the resource for each economic sector
- C_s Importance of each economic sector for the EU's economy



ΝνΛ



2020 EU list of CRM (non-energy and non-agricultural)

Antimony	Hafnium	Phosphorus
Baryte	Heavy Rare Earth Metals	Scandium
Beryllium	Light Rare Earth Metals	Silicon Metal
Bismuth	Indium	Tantalum
Borate	Magnesium	Tungsten
Cobalt	Natural graphite	Vanadium
Coking coal	Natural rubber	Bauxite
Fluorspar	Niobium	Lithium
Gallium	Platinum Group Metals	Titanium
Germanium	Phosphate rock	Strontium

EUR-Lex - 52020DC0474 - EN - EUR-Lex (europa.eu)







CRM: MITIGATION STRATEGIES





Enhancing new mining and recycling activities.

Foster efficient use and recycling of critical raw materials.

Negotiate trade agreements, challenge trade distortion measures.

Moreover, the scarcity of intra-European CRM sources, coupled with their economic relevance, calls for new approaches like substitution, with an intent to reduce consumption and to decrease European dependence from imports.

• Substitution then occupies a central role in the European stance, being considered in parallel with recycling and exploitation of own reserves.





Substance for substance.

Process for process.



New technology for substance.











Search for new, more powerful technologies







Process for process.



Search for more efficient processing routes









New business models and consumption habits







Tantalum (Ta)





eMaPriCe





Magnesium (Mg)









Gallium (Ga)











C. Pavel *et al.*, "Critical raw materials in lighting applications: Substitution, opportunities and implication on their demand", *Phys. Status Solidi* **A213**, No. 11, 2937–2946 (2016)/ DOI10.1002/pssa.201600594





THANK YOU

