An introduction to mineral Raw Materials in the Circular Economy

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DocSumECE, 2022

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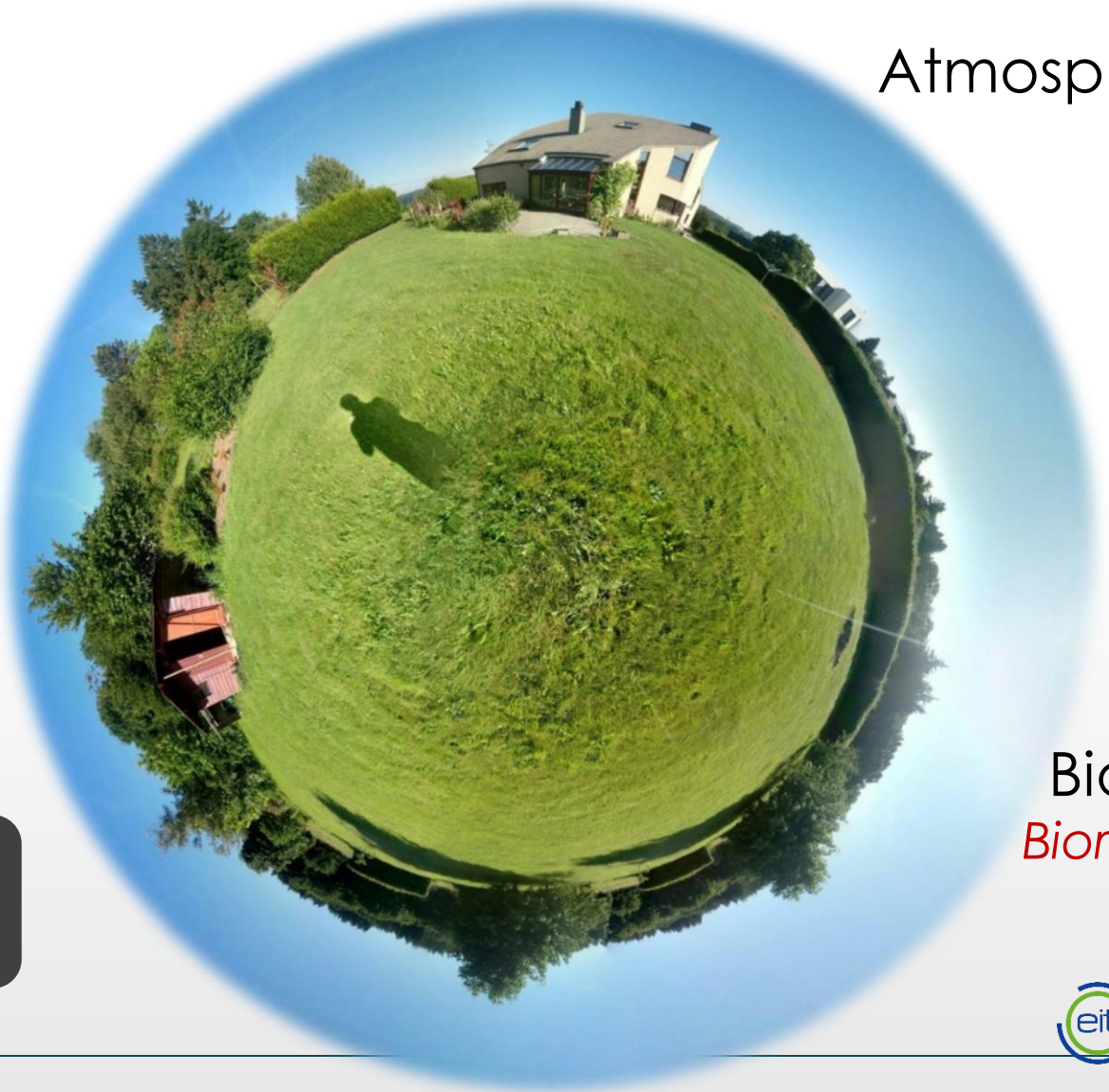
There is no Circular Economy (yet)!

Spherical Economy

- The art of administering an asset (a planet!) by prudent and wise management in order to obtain (for all and for future generations) the best return by using the least resources



Atmosphere

Geosphere
Georesources

If you can't grow it…
you'll have to dig it!

Biosphere
Bioreesources

Spherical Economy

- … and the Anthroposphere
  - 180 t Building Mat /pers
  - 160 t Infrastructure Mat/pers
  - *10 t Steel / pers*
  - *424 kg Aluminium / pers*
  - *220 kg Copper / pers*
  - *etc…*

Sources:
Lanau et al., 2019, Env. Sc. & Tech, 53(15)
Graedel et al., 2010, Metal Stocks in Society, UNEP-IRP

Circular Economy

- Does not exist!
  - Stimulating paradigm to « think in cycles »
    - ✓ Biomimetism
    - ✓ Geomimetism
  - Waste at all stages
    - ✓ Manufacturing
    - ✓ Usage
    - ✓ Collection
    - ✓ Recycling
    - ✓ …

~~Zero Emissions~~

~~Zero Waste~~

~~100 % Recyclable~~

~~Dematerialisation~~

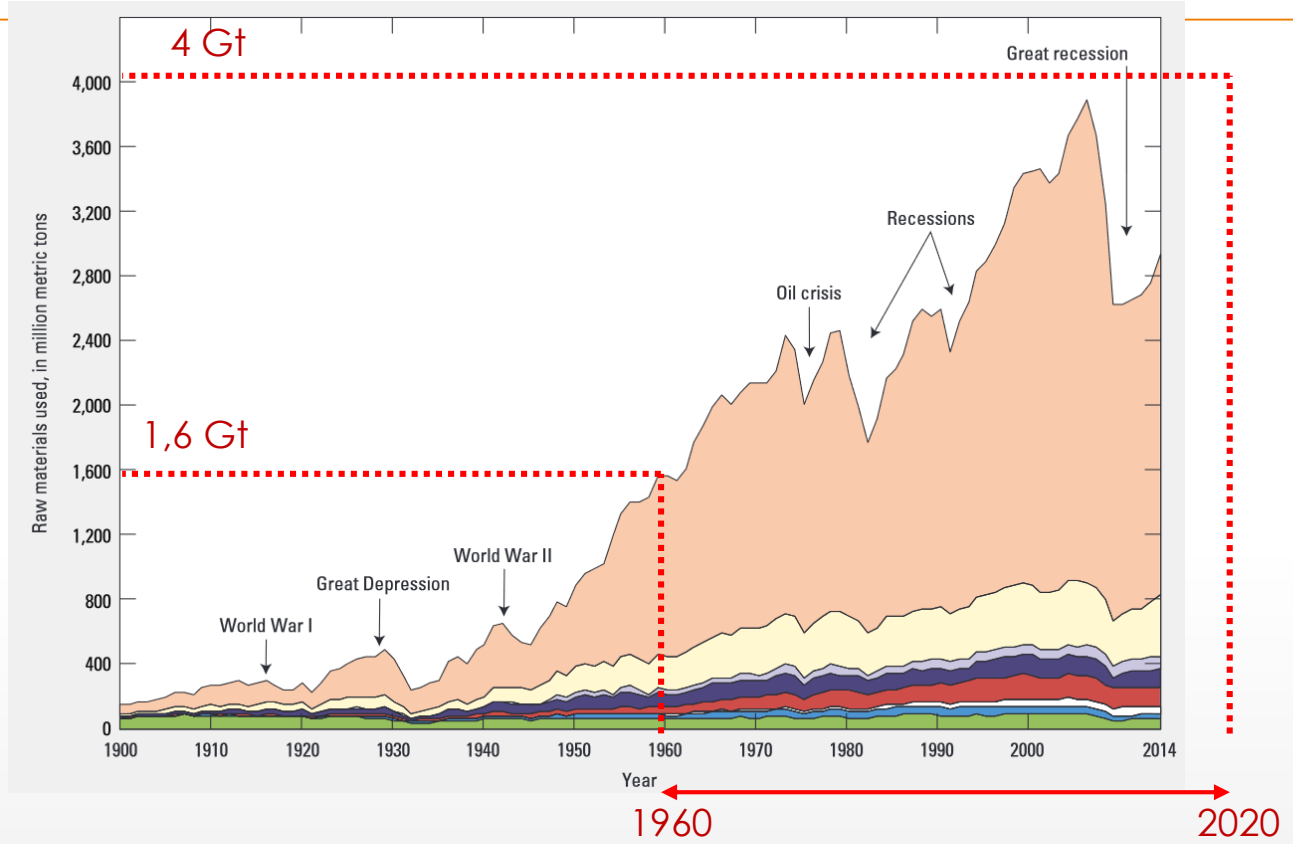
Source:
P. Huovila, Buildings as Materials Banks (BAMB – H2020)

Circular Economy

Source: https://eitrawmaterials.eu/

Extractivistas ?

- New needs
  - *Li, Graphite,…*
- Growing needs
  - *Lifetime of 20, 40, 60 yrs…*
- Non-recyclability of products
  - *clay<->bricks*



Perfect recycling (!?) could at best contribute to ± 30% of the needs of a growing world

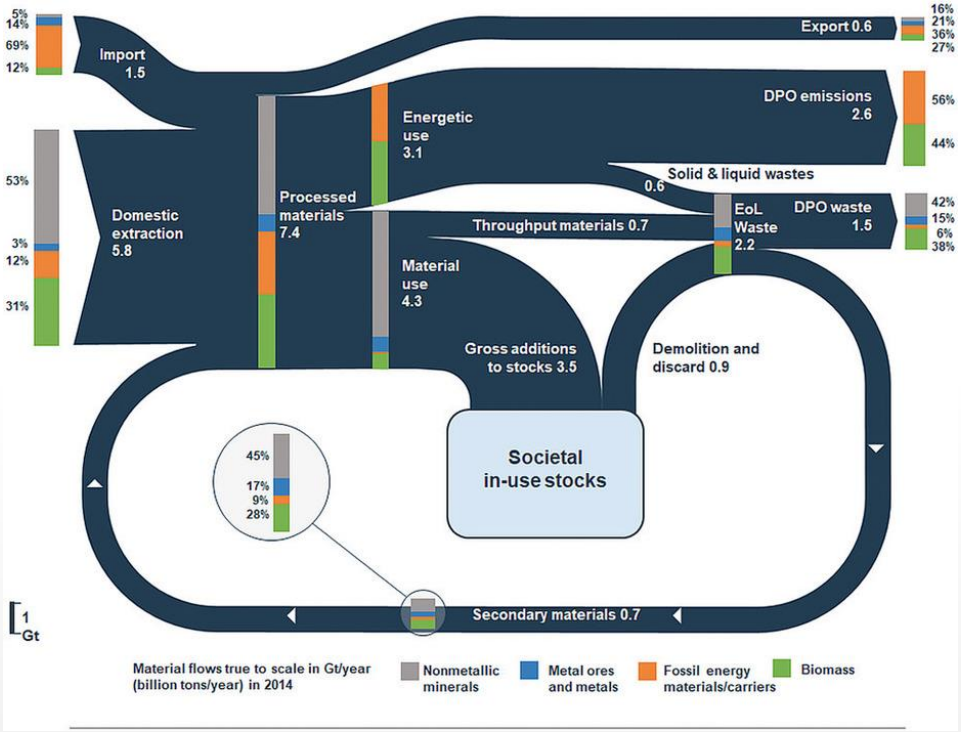
Source: Matos, G., (2017) Use of raw materials in the United States from 1900 through 2014 (USGS) Fact Sheet 2017–3062.

Circular Economy Indicators

- End-of-Life Recycling Input Rate (EOL-RIR)
  - ~= 10% EU28
  - Need for indicators at regional, local level!

- ! Undesirable effect of a recycle rate (EOL-RIR)
  - ↗ if demolition ↗ or lifetime of buildings ↘
  - ↗ if <u>quantity</u> promoted over <u>quality</u>
  - ↗ if financial incentives

- BUT we need:
  - Slow down the loop
  - Promote a performance economy (stock quality, caring)
  - Minimise environmental impact (LCA) (local stone vs. concrete)



Source: *Mayer et al., 2018*

A world of georesources

A world of georesources

- Fossil Energy Resources
  - Petroleum, Gaz, Coal, Lignite,…
  - Uranium
    - *Non-renewable*
- Water Resources
    - *Vital, Purifiable*
- Industrial Minerals
  - Sand, aggregates, gypsum, …
  - Kaolin, talc, diatomea,…
  - Gems
    - *Non-recyclable, Synthetisable*
- Metallic Resources
  - Base Metals
  - Critical Metals ?
  - Precious Metals
    - *Recyclable*

A world of georesources

ORE

- An ore is a rock allowing for the industrial valorisation of its contents in terms of economic profitability

Iron Ore

Typical specifications (2018):

Fe	*58.00% (min)*
Humidity	*8.00 % (max)*
Al_2O_3	*3.50% (max)*
SiO_2	*4.00% (max)*
P	*0.070% (max)*
S	*0.05% (max)*

A world of georesources

DEPOSIT

- A deposit is a <u>geological site</u> which contains a sufficient amount in quantity and quality of rocks (ores) for potential economic exploitation.

OREBODY

HOST ROCK

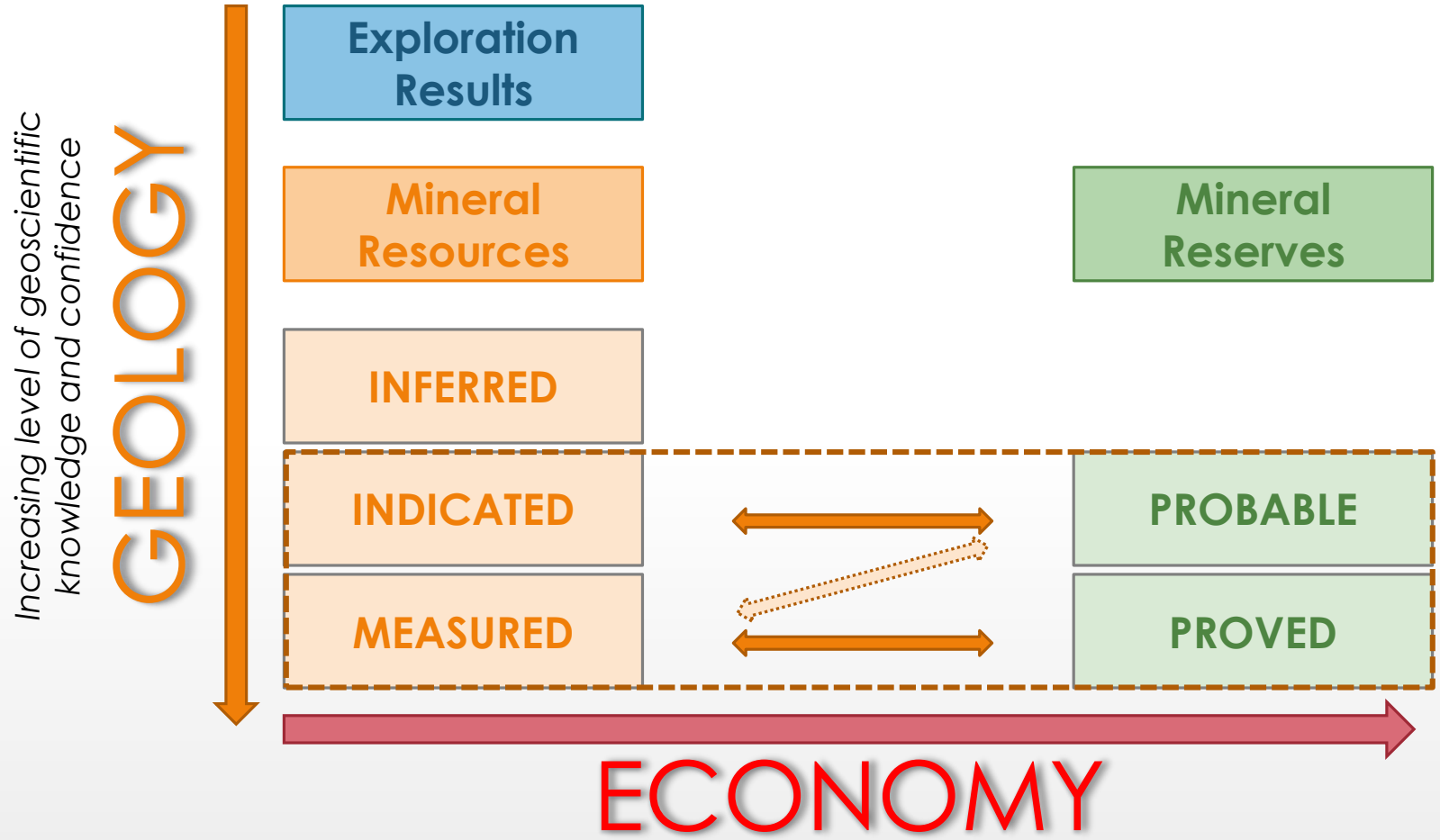
Greenbushes (W Australia)

Orebody (pegmatite) containing economic amounts of Lithium (1% Li) and Tantalum (Ta) as by-product

A world of georesources

RESOURCES & RESERVES

Committee for Mineral Reserves International Reporting Standards (CRIRSCO, 2006)



Consideration of mining, metallurgical, economic, market, legal, environmental, social, governemental … factors

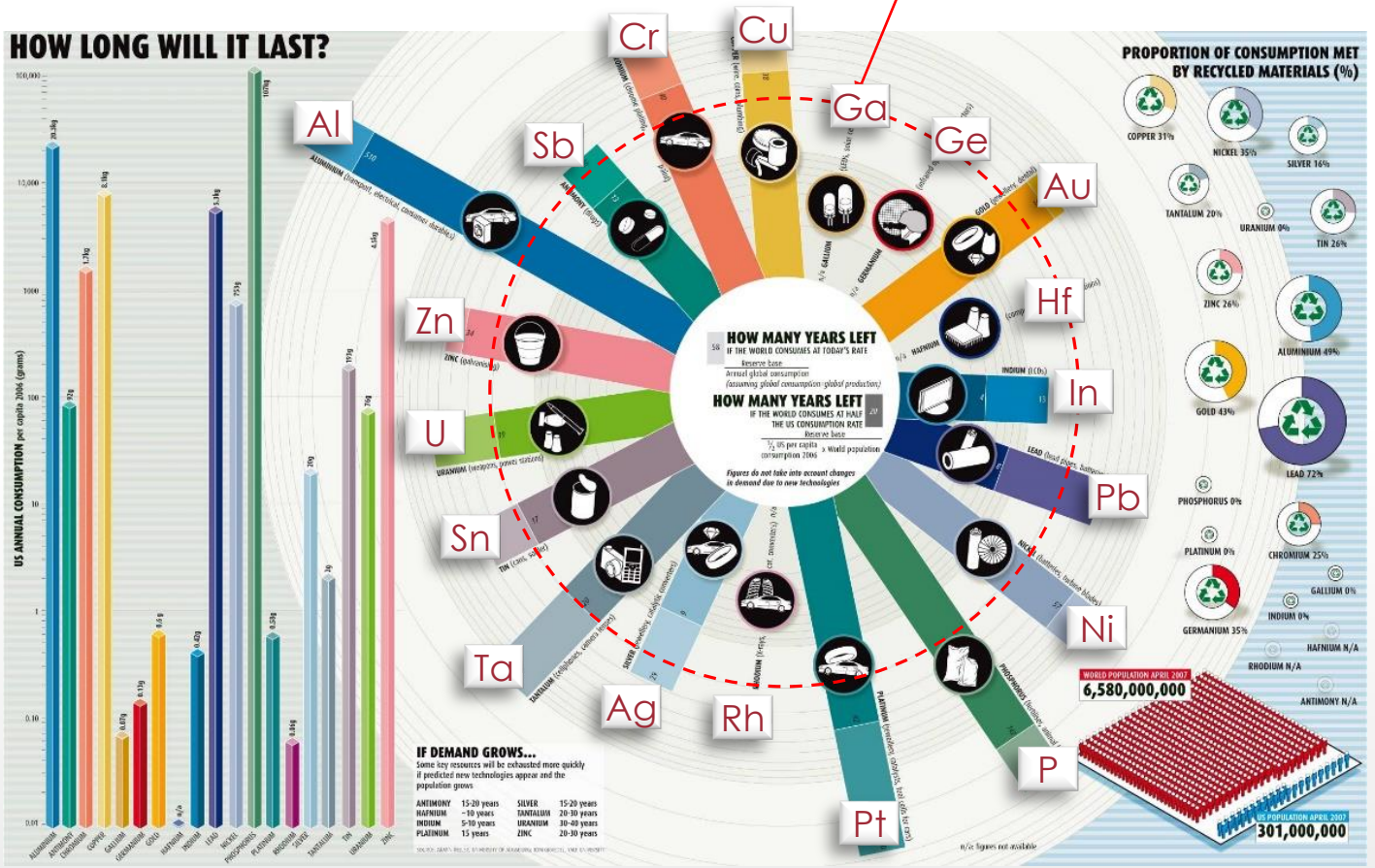
A world of georesources

RESERVES

- How long will it last?

Commodity	Reserves 1999	Annual Production 2000	Lifetime +5% Scenario
Zinc	190 Mt	7,75 Mt	16 yrs
Aluminium	25 Gt	123 Mt	48 yrs
Indium	?? t	200 t	?? Yrs
Nickel	46 Mt	1,1 Mt	22 yrs
Tin	8 Mt	207 kt	21 yrs

*After « **Breaking New Ground** »*
Report of the Mining, Minerals & Sustainable Development Project
Int. Institute for Environment and Development (IIED), 2002



A. Reller & T. Graedel, 2007

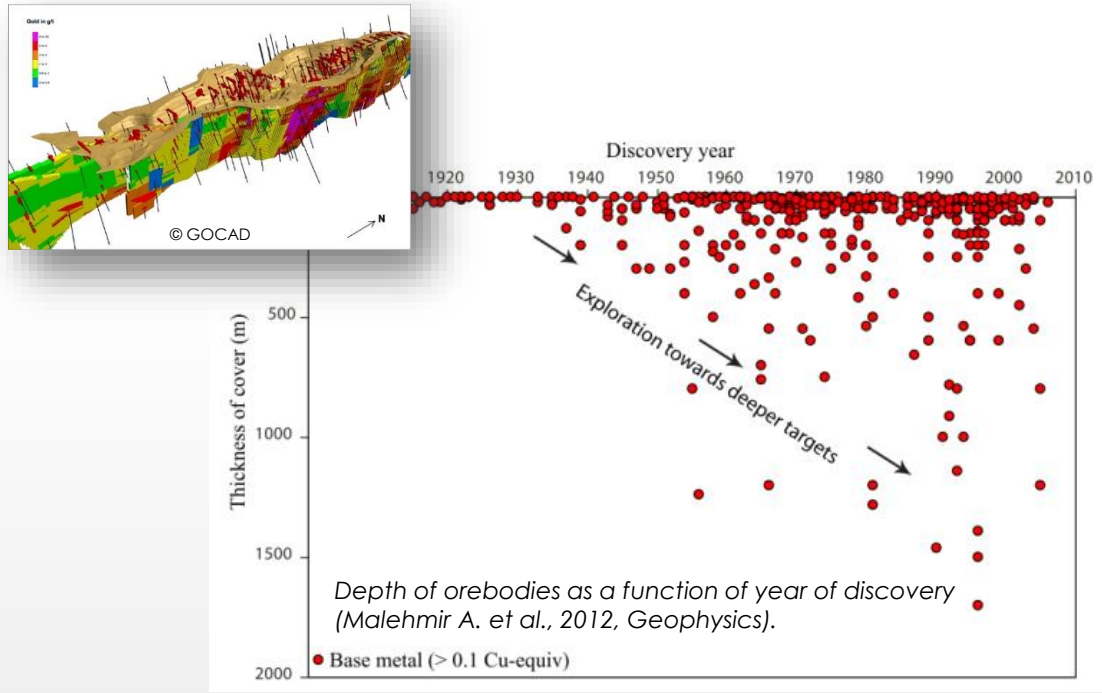
A world of georesources

RESERVES

- The notion of Ore & Reserve are dynamic
  - They change over the course of time with regard to the value of metals, cost of energy, development of new extraction technologies, deeper exploration, etc

Commodity	RESERVES 1996	RESERVES 2016
Ag	280 kt	570 kt
Cr	3,7 Gt	> 480 Mt
Co	4 Mt	7,1 Mt
Mn	680 Mt	620 Mt
Ni	47 Mt	79 Mt
Pb	68 Mt	89 Mt
W	2,1 Mt	3,3 Mt
Zn	140 Mt	200 Mt

World reserves for selected commodities
USGS **1996** vs USGS **2016**



Depth of orebodies as a function of year of discovery (Malehmir A. et al., 2012, Geophysics).

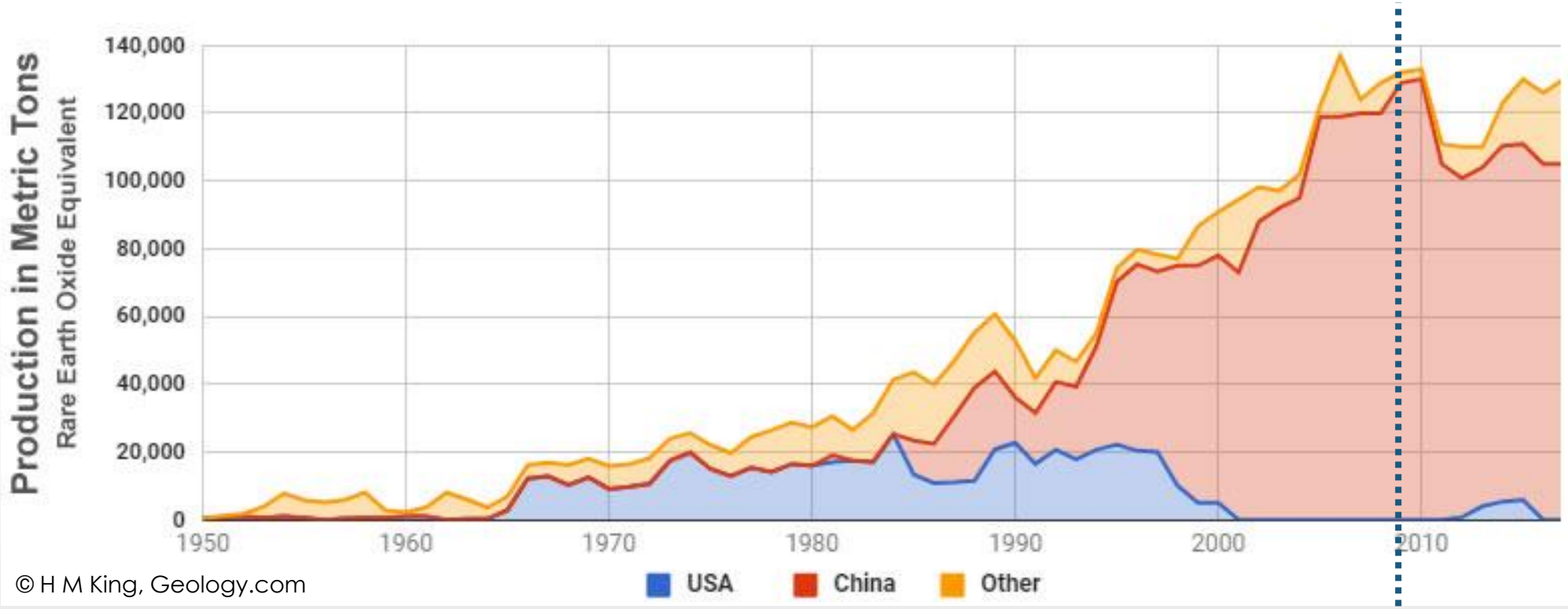
Most currently mined orebodies were identified from the surface or at very shallow depth (300m)

Critical Raw Materials for the EU

… in 2020

Critical Raw Materials for the EU *The REE crisis*

- China export ban *Aug 2009*
  - *China's Ministry of Industry has called for a total ban on foreign shipments of Tb, Dy, Y, Tm et Lu and a combined export quota of 35 kt/yr for Nd, Eu, Ce and La.*



Critical Raw Materials for the EU

Collecting data

Share of global production

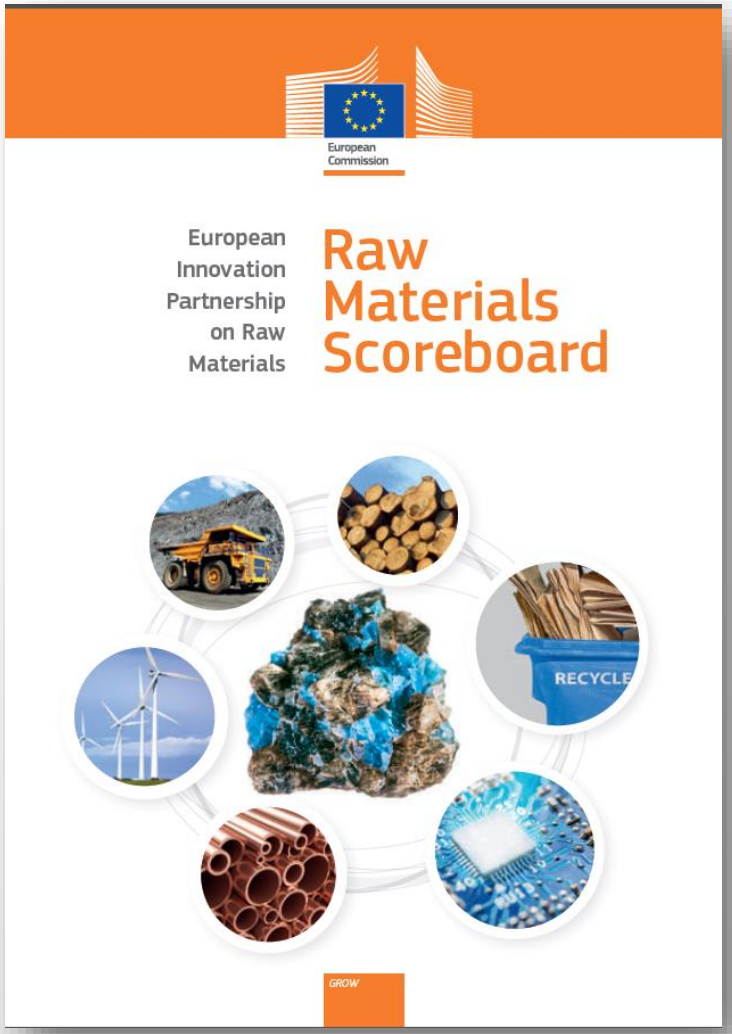
Share of Imports

Value added and jobs

Knowledge & skills

Mining activity

Mineral Exploration



Social License to Operate

Waste managment

Environmental Impact

Circular Economy

Recycling

Critical Raw Materials for the EU

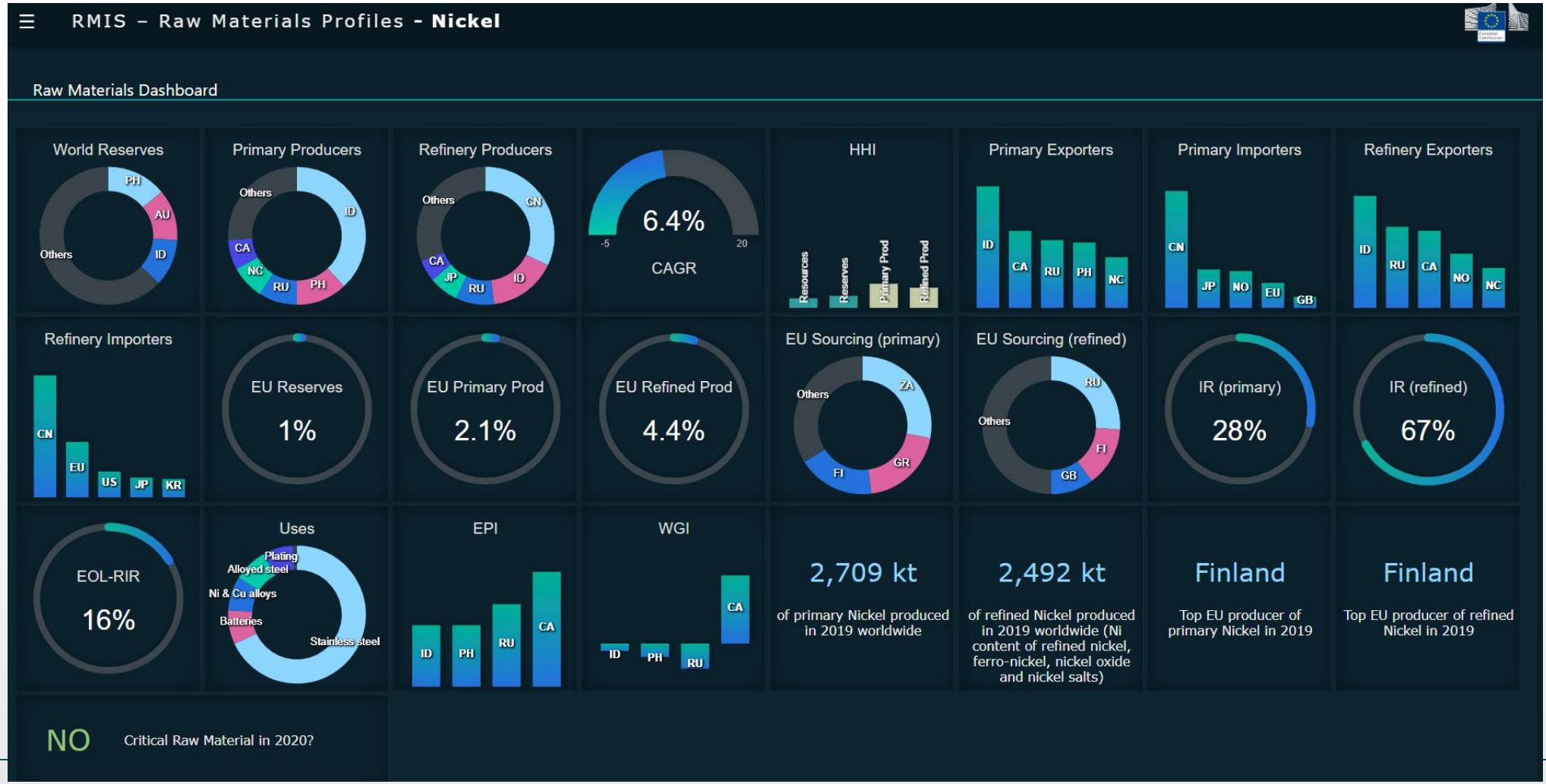
Raw Materials Information System

https://rmis.jrc.ec.europa.eu/

Critical Raw Materials for the EU

Raw Materials Information System

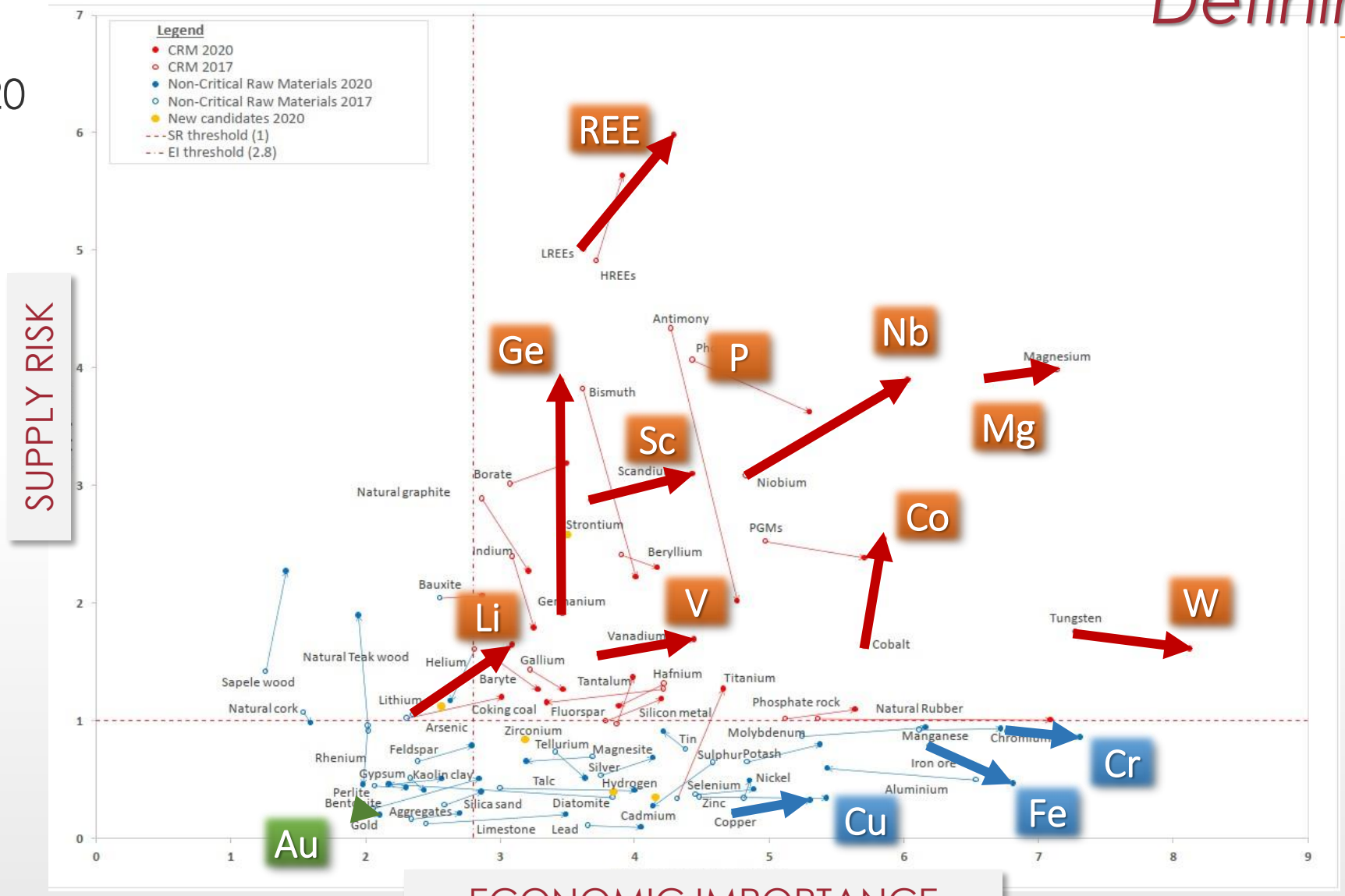
- NICKEL Dashboard 2022



Critical Raw Materials for the EU

Defining a list

- 2017->2020



Critical Raw Materials for the EU

A dynamic problem

- Multi-factor assessment of risks all over the value chain
  - Dynamics of demand and supply
  - Concentration of production at various stages of the value chain
  - Dynamics of technology development
  - Known resources / reserves
  - Social license to operate of the primary sector
  - Potential for recycling
  - Social factors, governance, …
  - Potential for substitution
  - Prices
  - Restrictions to international trade, regulations
  - Access to funding for mining projects
- Importance of scale
  - Continent, Country, Industry,…
- Importance of time
  - New innovations,

Critical Raw Materials for the EU *Taking action*

Critical Raw Materials for the EU

European Innovation Partnership

Raw Materials Initiative

H2020 – SPIRE - …

KIC Raw Materials

- Promoting innovation across the whole materials value chain
  - Technologic
    - Deeper GEOLOGICAL exploration and resource assessment
    - MINING in challenging environment
    - Resource efficiency in mineral and metallurgical PROCESSES
    - SUBSTITUTION of critical and toxic metals in products
    - DESIGN of products and services
    - RECYCLING and material chain optimisation
  - Non-technologic
    - Land use planning, mineral policy, education,…

Green Deal

Yet another energy transition ?

Renewable Times

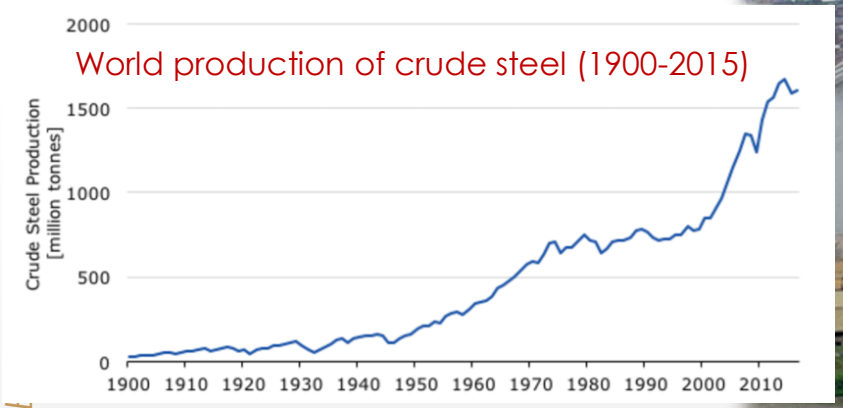
- XVIIIth
  - Only renewable energies
  - 3-4 manpower / perso. day

Blast furnace in the region of Spa(1612) Jan Brueghel

Unsustainable pressure on the BIOSPHERE

Fossil Fuel Times

- XXth
  - Non-renewable energies (> 80%)
  - 400 manpower/person.day



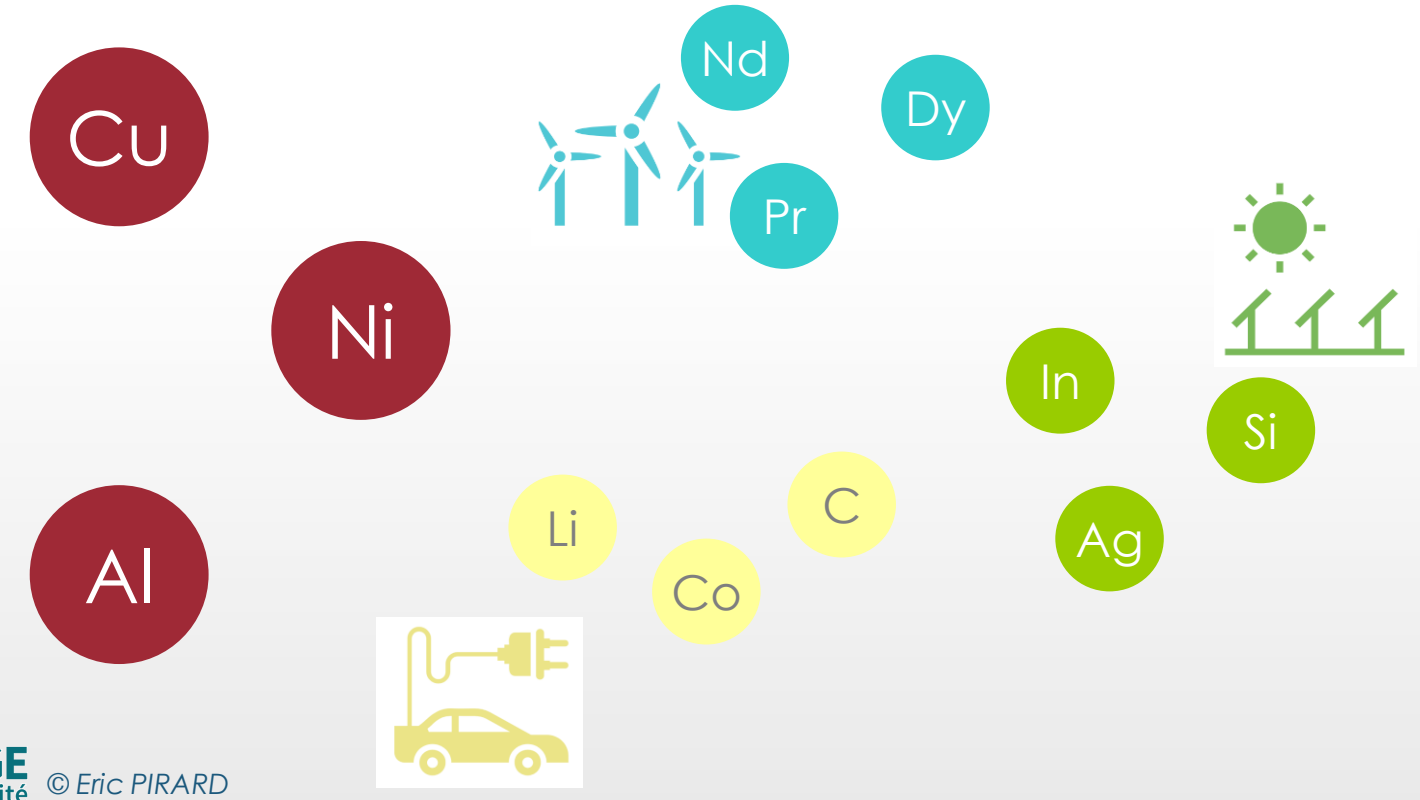
1,9 tons CO_2 / ton steel
5% of world's GHG emissions

HFB Blast Furnace Liège

Unsustainable pressure on the ATMOSPHERE

“Green” Energy Times

- XXIst
  - Deployment of “**metal-intensive**” renewable energies
  - Steadily growing energy needs



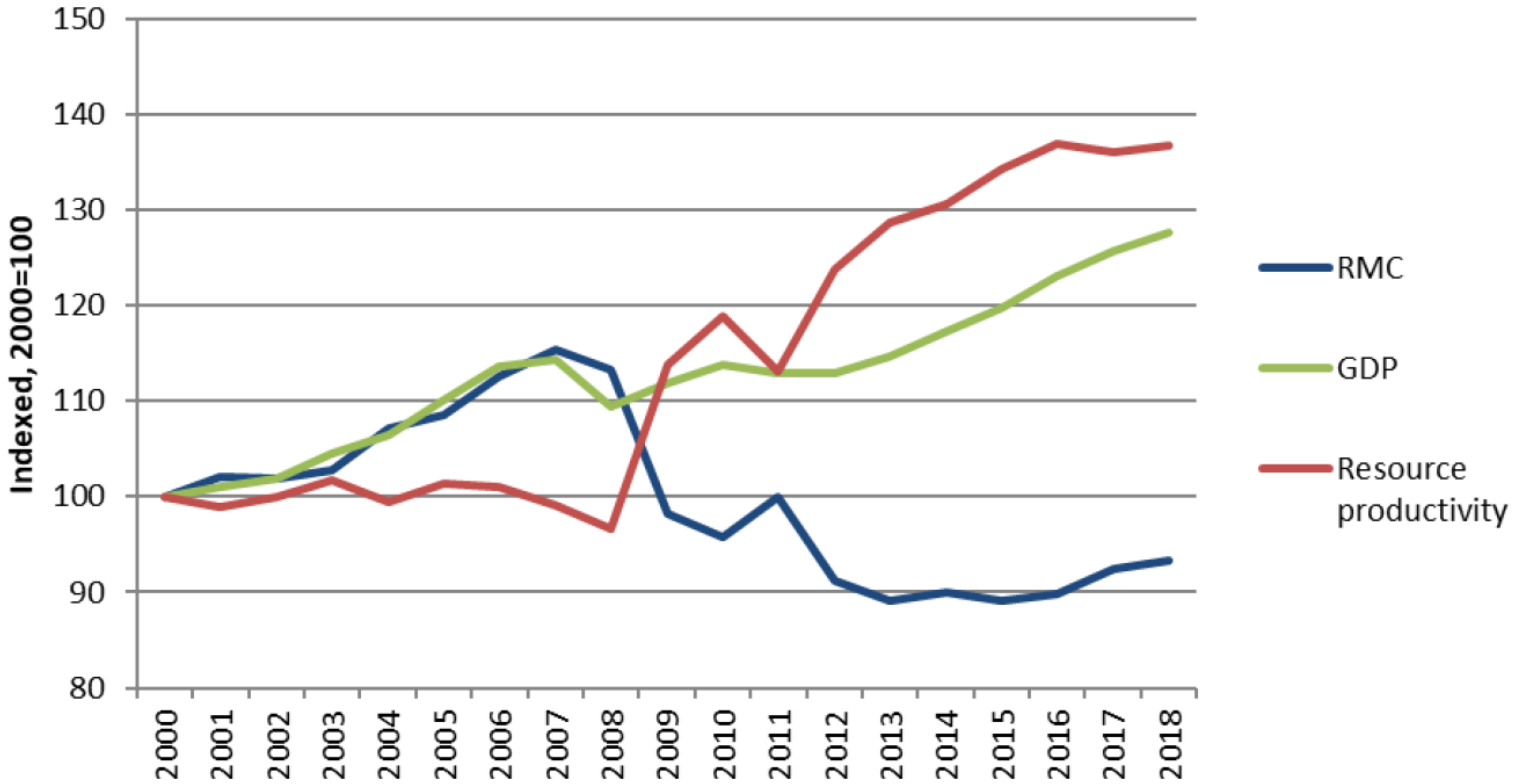
Unsustainable pressure on the GEOSPHERE ?

Green Growth

The illusion of dematerialisation

Green Growth

- Decrease of **apparent** metal consumption



http://www.materialflows.net/decoupling-material-use-and-economic-performance/

RMC
Raw Materials Consumption

vs.

IMP-RME
Raw Material Equivalents of Imports

Green Growth

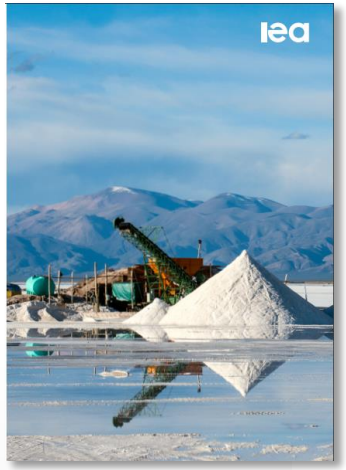
- A clear trends towards **technobesity**

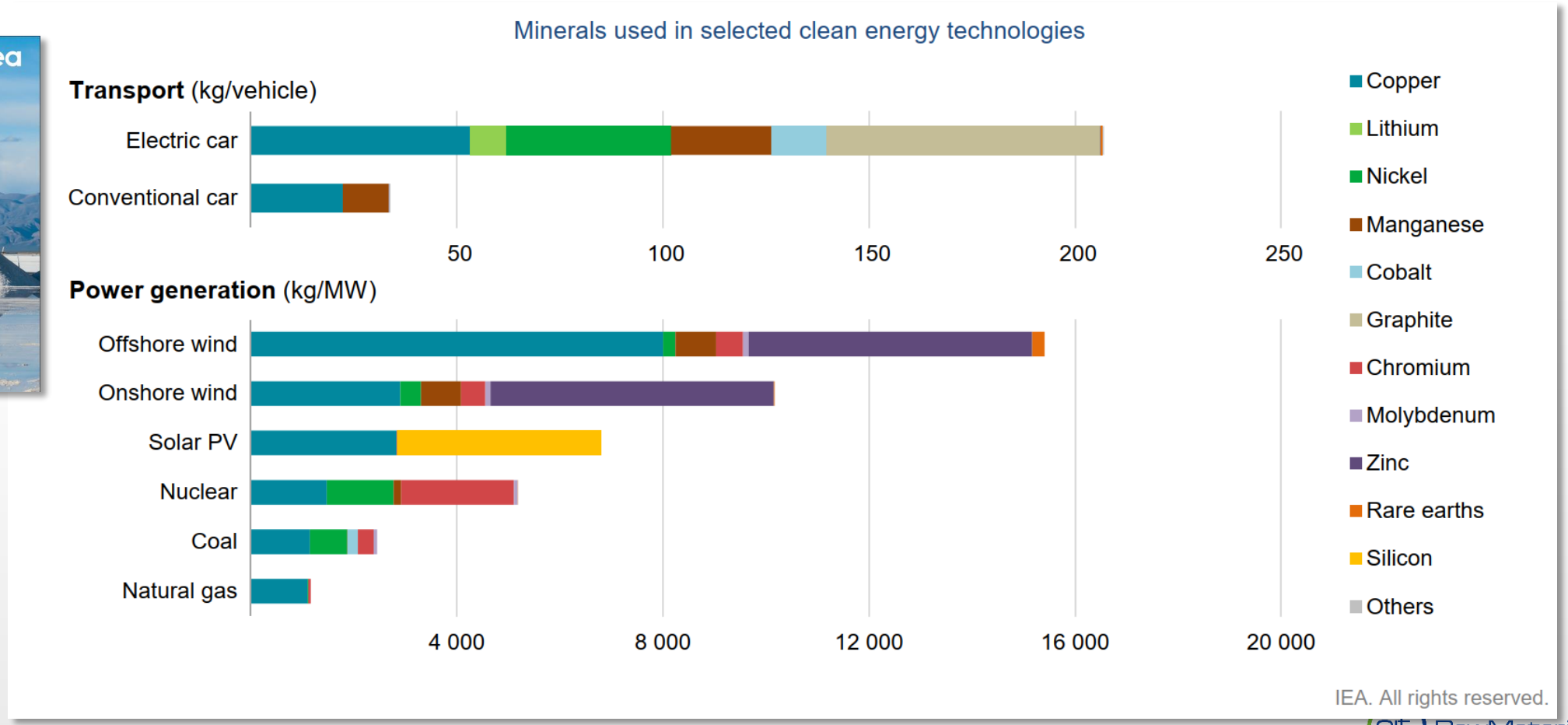
Mini means 600kg in 1960

Mini SE means 1440 kg in 2021

Green Growth

- The role of critical minerals in clean energy transitions
  - IEA (2021)

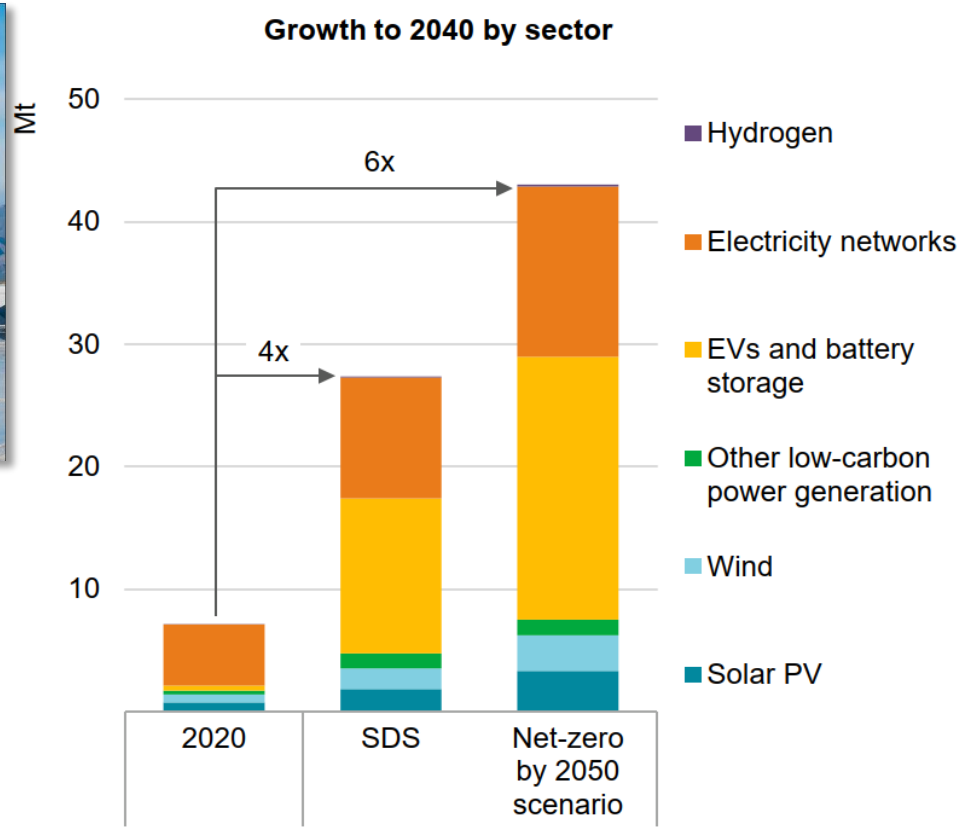


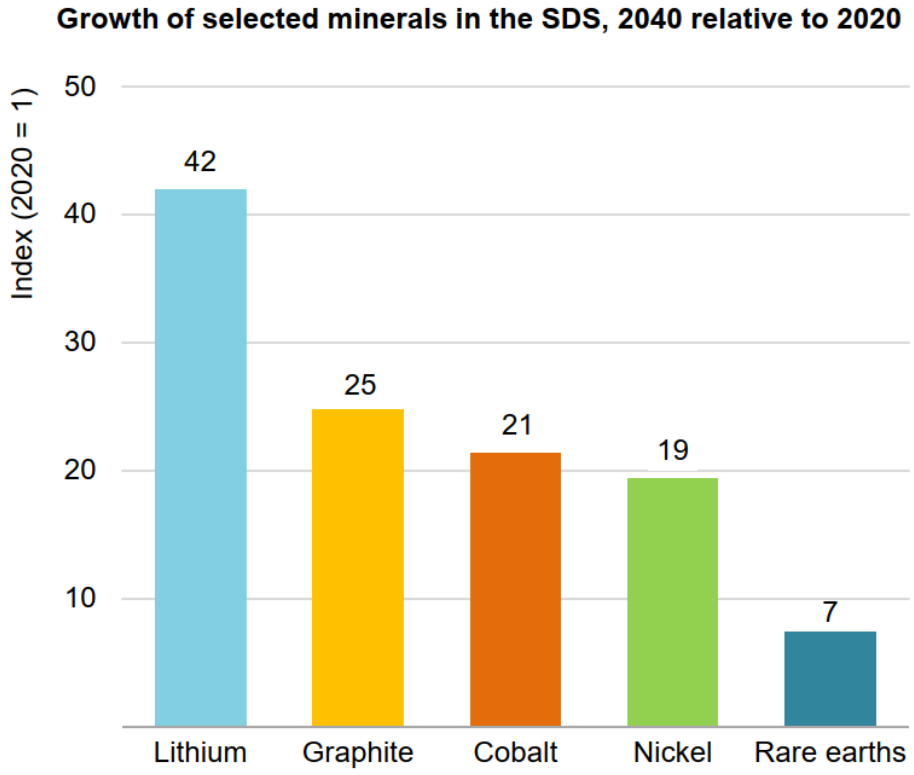


Fuelling energy transitions

- The role of critical minerals in clean energy transitions
  - IEA (2021)

Mineral demand for clean energy technologies by scenario





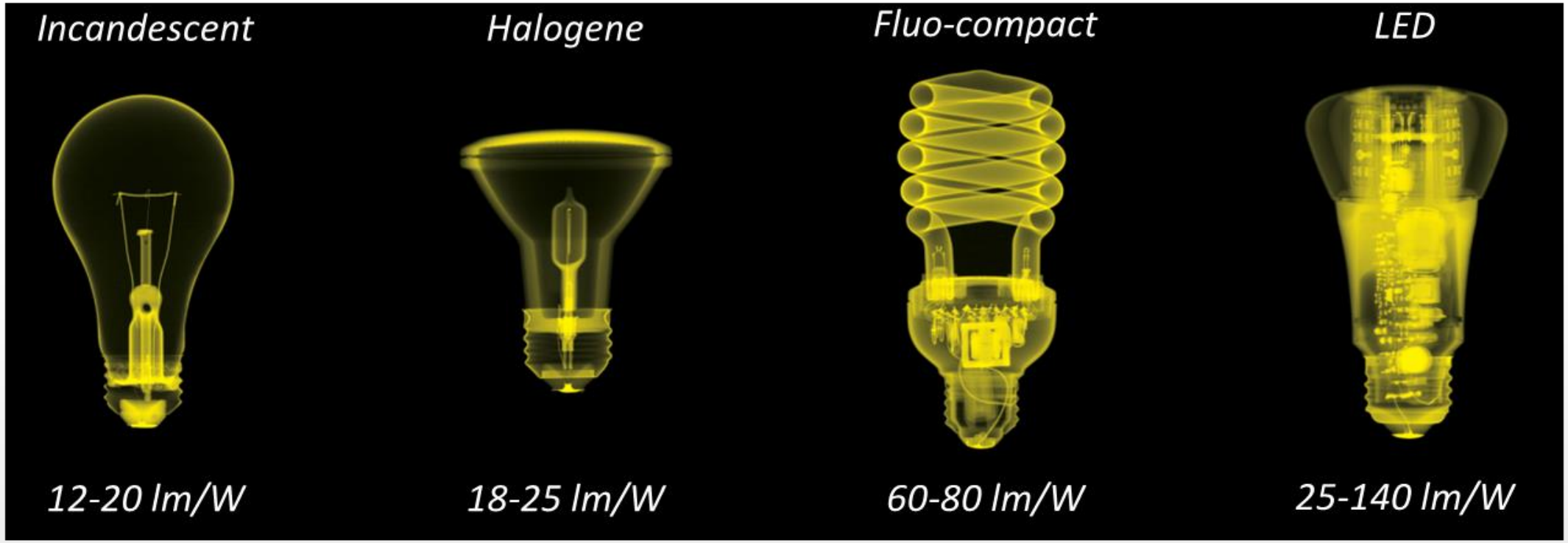
Green Revolution

Towards a more circular economy

Green Revolution

Therefore, instead of worrying about reaching "peak" production or "exhausting" a resource, we should instead be more concerned about what we do with the resource after it has been extracted.

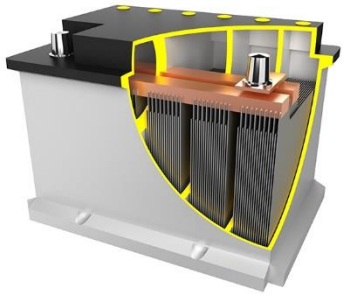
Meinert et al., 2016, Mineral Resources: Reserves, Peak Production and the Future



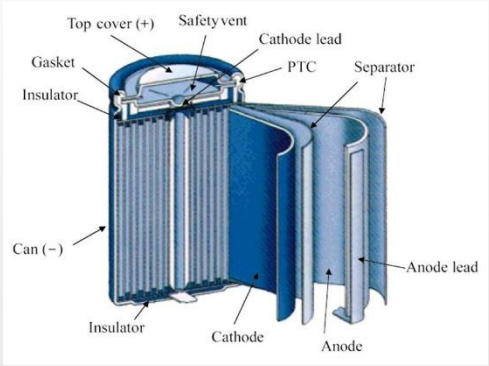
Not just the lifecycle analysis of the use phase…

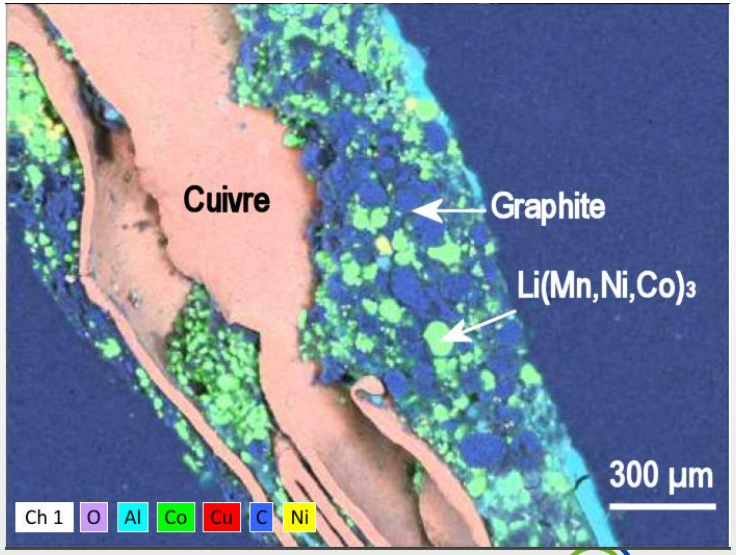
Green Revolution

- Durability and Recyclability of products is going the wrong way
  - Lead-Acid Battery
    - Optimal collection and recycling



  - Li-ion Battery
    - Sorting Problems
    - Limited recovery of Co, Ni,…
    - Non-recovery of graphite, Li, …





Black mass adhering to anode

Green Revolution

- Diffusion and Downcycling
  - Microalloying elements in steel are lost
    - Ex. 0,1% Nb

  - Recovered metals do not satisfy tech specs
    - Ex. contaminated silicon from PV panels

  - Manufacturing processes are not adapted to recycled feeds

A Circular Economy Finally ?

- **Recycling** can only cover **a fraction** of our (increasing) needs
- Many metals are not recoverable (**dispersive uses**)
- Products need to be **redesigned** and made to last
- Manufacturers to accept **new specifications**
- **Incentives** needed to oblige a minimal fraction of recyclates in new products

THE END...

Anthropy or Entropy ?