

CRITICAL RAW MATERIALS

GLOBAL AND EU, NL

PERSPECTIVES BASED ON HISTORY AND RECENT REPORTS

HENK VAN DEN BERG

MAY 2021

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- Introduction + conclusion
- Three reports
 - Review
 - Points to consider
- Politics, non technical issues – The Hague Centre for Strategic Studies

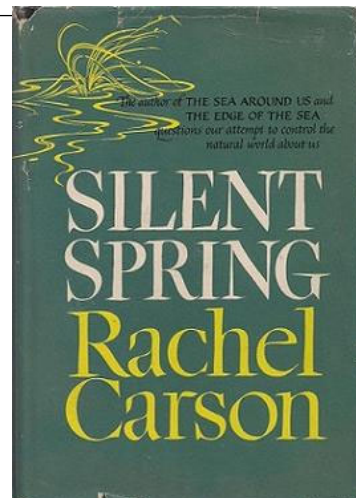
INTRODUCTION - HOW AND WHEN STARTED THE TURN?

EVEN BEFORE THE CLUB OF ROME "THE LIMITS TO GROWTH" 1972

Silent Spring was published on September 27, 1962, documenting the adverse environmental effects caused by the indiscriminate use of pesticides.

It spurred a reversal in the United States' national pesticide policy, led to a nationwide ban on DDT for agricultural uses, and helped to inspire an environmental movement

<https://en.wikipedia.org/w/index.php?curid=48694009>



INTRODUCTION - DEPLETING RESOURCES + + CHALLENGE FOR SUSTAINABLE PROCESSES

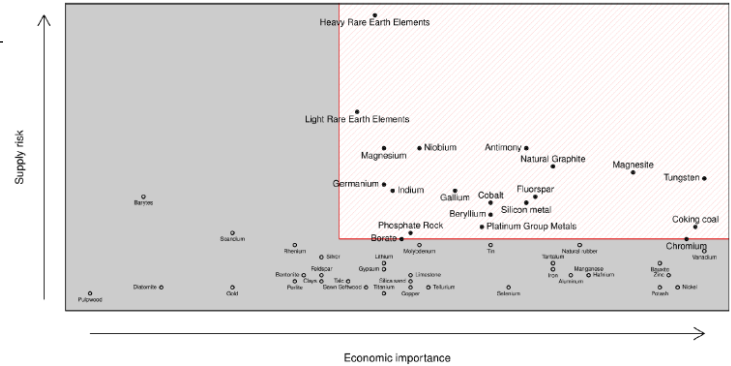
- Ecology issues, started 50-60 years ago
We increased the lengths of our chimneys – SO2 higher in Norway
- Energy crisis – since the seventies
No car driving on Sunday
- Water – highly relevant – 10-20 years ago
- Scarcity of raw materials – an additional challenge
- Recycle economy
- Paris2015 – 80-90% reduction GHG emissions

INTRODUCTION RESOURCES - ACTIVITIES ON SEVERAL LEVELS

Strategy:
EC2010

to

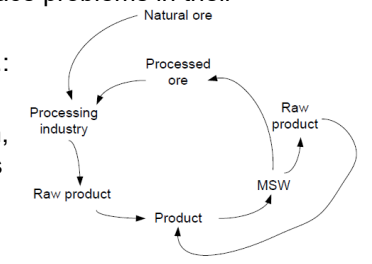
EC2014:



Antimony	Beryllium	Borates	Chromium	Cobalt	Coking coal	Fluorspar
Gallium	Germanium	Indium	Magnesite	Magnesium	Natural Graphite	Niobium
PGMs	Phosphate Rock	REEs (Heavy)	REEs (Light)	Silicon Metal	Tungsten	

INTRODUCTION RESOURCES - ACTIVITIES ON SEVERAL LEVELS

- In Germany and The Netherlands studies to quantify the need for raw materials for industrial partners,
 - Including the evaluation of political issues, price developments etc.
 - Activities of companies which face problems in their materials supply.
- Graedel (Yale) et al. and Lloyd et al.:
 - Cycles of mining, preparation, storage, availability, application, recycle, losses etc. of elements



INTRODUCTION - DEPLETING RESOURCES + + CHALLENGE FOR SUSTAINABLE PROCESSES

- Pollution reduction, energy savings, CO2-Paris2015, Plastic recycle-C cycle, United Nations Smart Development Goals.....

Raw materials and energy are on the basis of our society
For minerals and metals needed - reuse, recovery and recycle:

- To make more efficient use of raw materials
- To reduce waste and pollution
- To make us less depending on resource countries
- To be able to respond to growing need of minerals and metals

STUDY ON THE EU'S LIST OF CRITICAL RAW MATERIALS

EUROPEAN COMMISSION - FINAL REPORT SEPTEMBER 2020

- ✓ OECD forecasts: global materials **demand** will more than **double** from 79 billion tonnes today to 167 billion tonnes in 2060.
 - ✓ Global **competition** for resources will become fierce in the coming decade. Dependence of critical raw materials may soon replace today's dependence on oil.
 - ✓ **Secure and sustainable supply** of both primary and secondary raw materials, in particular of critical raw materials, for key technologies and strategic sectors as renewable energy, e-mobility, digital, space and defence is one of the **pre-requisites to achieve climate neutrality**.
 - ✓ Critical raw materials: high economic importance for the EU and a high supply risk.
- Action Plan on Critical Raw Materials and for industry-driven raw materials alliances.

Figure 6: Criticality assessment results (individual materials and groups)

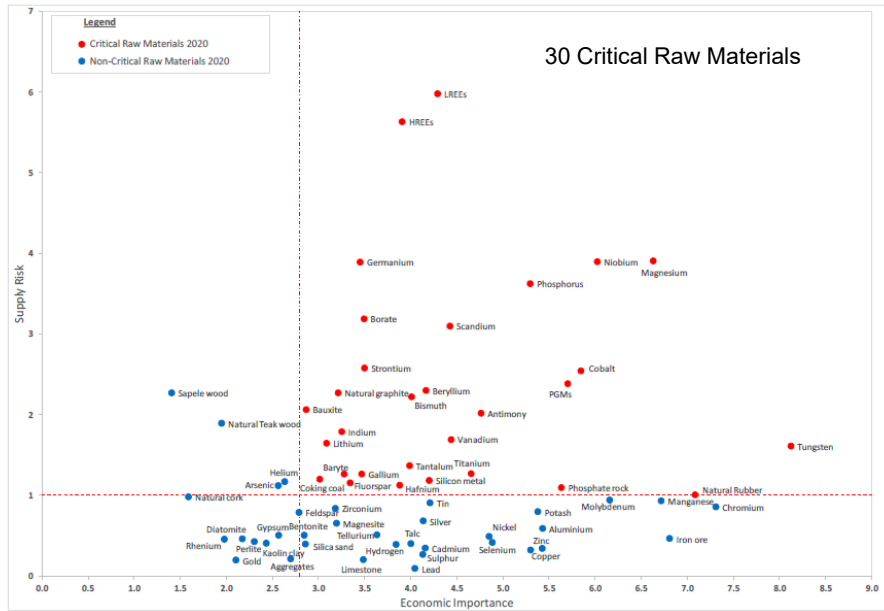
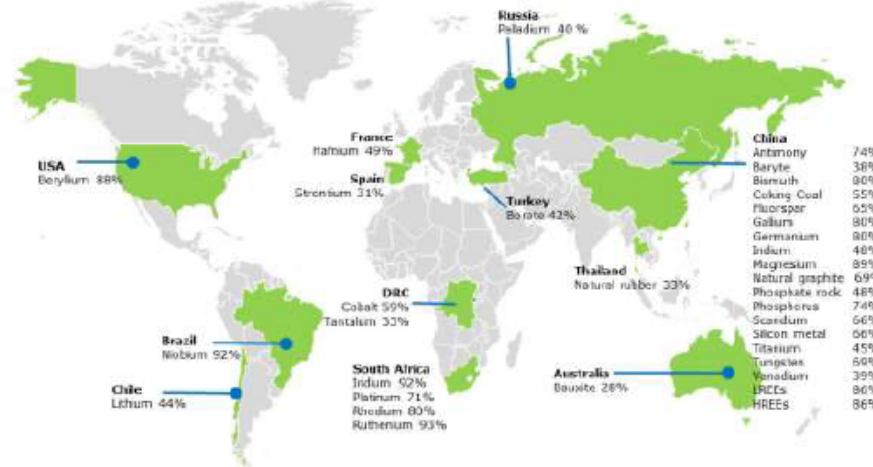


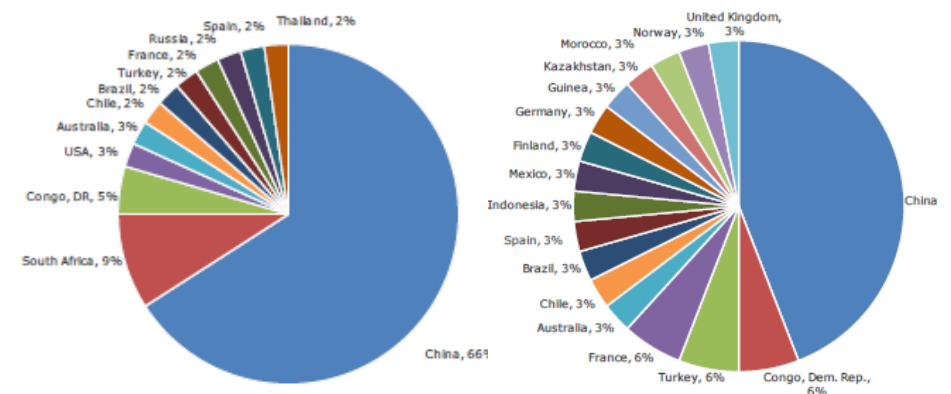
Table A: Major global supplier countries of CRMs – individual materials

Material	Stage ⁶	Main global supplier	Share	Material	Stage	Main global supplier	Share
1 Antimony	E	China	74%	23 Magnesium	P	China	89%
2 Baryte	E	China	38%	24 Natural graphite	E	China	69%
3 Bauxite	E	Australia	28%	25 Natural rubber	E	Thailand	33%
4 Beryllium	E	USA	88%	26 Neodymium	E	China	86%
5 Bismuth	P	China	80%	27 Niobium	P	Brazil	92%
6 Borate	E	Turkey	42%	28 Palladium	P	Russia	40%
7 Cerium	E	China	86%	29 Phosphate rock	E	China	48%
8 Cobalt	E	Congo,DR	59%	30 Phosphorus	P	China	74%
9 Coking coal	E	China	55%	31 Platinum	P	S. Africa	71%
10 Dysprosium	E	China	86%	32 Praseodymium	E	China	86%
11 Erbium	E	China	86%	33 Rhodium	P	S. Africa	80%
12 Europium	E	China	86%	34 Ruthenium	P	S. Africa	93%
13 Fluorspar	E	China	65%	35 Samarium	E	China	86%
14 Gadolinium	E	China	86%	36 Scandium	P	China	66%
15 Gallium	P	China	80%	37 Silicon metal	P	China	66%
16 Germanium	P	China	80%	38 Tantalum	E	Congo,DR	33%
17 Hafnium	P	France	49%	39 Terbium	E	China	86%
18 Ho,Tm,Lu,Yb	E	China	86%	40 Titanium	P	China	45%
19 Indium	P	China	48%	41 Tungsten	P	China	69%
20 Iridium	P	S. Africa	92%	42 Vanadium	E	China	39%
21 Lanthanum	E	China	86%	43 Yttrium	E	China	86%
22 Lithium	P	Chile	44%	44 Strontium	E	Spain	31%

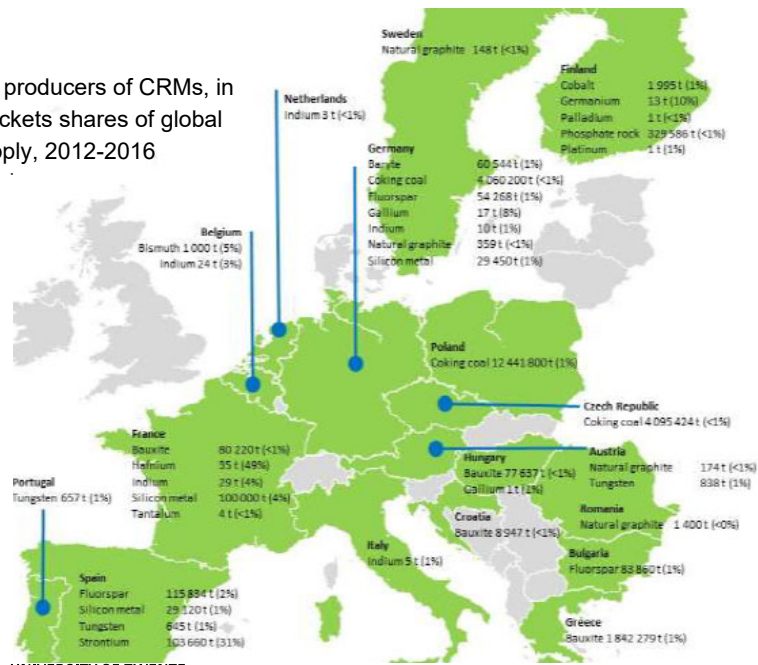
Figure B: Countries accounting for largest share of global supply of CRMs



Main Global and EU supply countries of CRMs (based on number of CRMs supplied, average 2012-2016)



EU producers of CRMs, in brackets shares of global supply, 2012-2016



Countries accounting for largest share of EU sourcing of CRMs

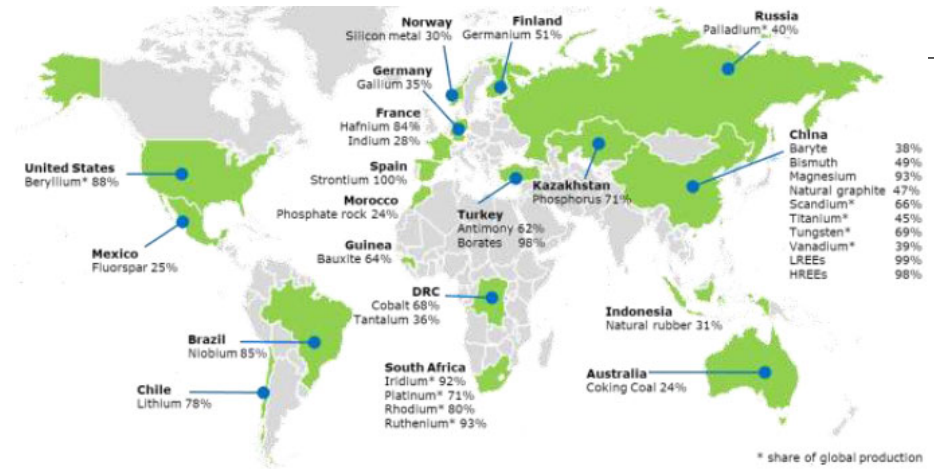


Table C: Major EU sourcing countries of CRMs – individual materials

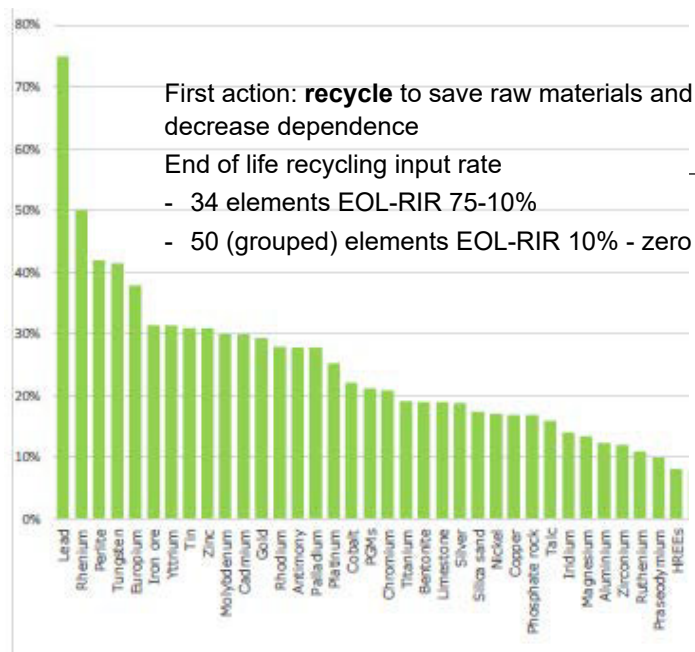
Material	Stage	Main EU supplier	Share	Material	Stage	Main EU supplier	Share
1 Antimony	E	Turkey	62%	23 Magnesium	P	China	93%
2 Baryte	E	China	38%	24 Natural graphite	E	China	47%
3 Bauxite	E	Guinea	64%	25 Natural Rubber	E	Indonesia	31%
4 Beryllium	E	n/a	n/a	26 Neodymium	P	China	99%
5 Bismuth	P	China	49%	27 Niobium	P	Brazil	85%
6 Borate	E	Turkey	98%	28 Palladium	P	n/a	n/a
7 Cerium	P	China	99%	29 Phosphate rock	E	Morocco	24%
8 Cobalt	E	Congo,DR	68%	30 Phosphorus	P	Kazakhstan	71%
9 Coking coal	E	Australia	24%	31 Platinum	P	n/a	n/a
10 Dysprosium	P	China	98%	32 Praseodymium	P	China	99%
11 Erbium	P	China	98%	33 Rhodium	P	n/a	n/a
12 Europium	P	China	98%	34 Ruthenium	P	n/a	n/a
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14 Gadolinium	P	China	98%	36 Scandium	P	n/a	n/a
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17 Hafnium	P	France	84%	39 Terbium	P	China	98%
18 Ho,Tm,Lu,Yb	P	China	98%	40 Titanium	P	n/a	n/a
19 Indium	P	France	28%	41 Tungsten	P	China	26%
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21 Lanthanum	P	China	99%	43 Yttrium	P	China	98%
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Legend
Stage E = Extraction stage P = Processing stage

The importance of critical raw materials for the EU:

The importance of metals and minerals to **sustain** businesses and the economy is particularly true for the EU, where about 30 million jobs are directly reliant on access to raw materials.

- ✓ **Industrial value chains** - non-energy raw materials are linked to all industries across all supply chain stages.
- ✓ **Strategic technologies** - technological progress and quality of life rely on access to a growing number of raw materials. For example, a smartphone might contain up to 50 different kinds of metals, all of which contribute to its small size, light weight and functionality.
- ✓ **Climate, energy and environment** – raw materials are closely linked to clean technologies essential to reach carbon neutrality targets by 2050. They are irreplaceable in solar panels, wind turbines, electric vehicles, and energy efficient lighting.



STUDY ON THE EU'S LIST OF CRITICAL RAW MATERIALS

EUROPEAN COMMISSION - FINAL REPORT SEPTEMBER 2020

Evaluating the report we see:

- ✓ The revised EU methodology focuses on risk related to the first steps in the raw material's life cycle, such as extraction/harvesting, or related to a bottleneck further down the value chain, e.g. influencing potentially the refining steps.
- ✓ **These studies generally do not consider the steps in which the refined material is used in a multitude of applications** (except in the links in the economic importance).
- ✓ Report 158 pages, more than 100 pages appendices – explanations + data

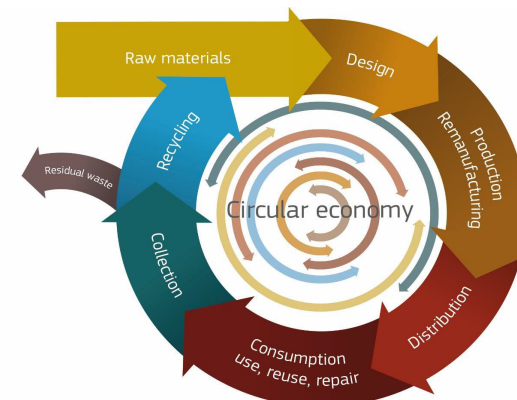
REPORT ON CRITICAL RAW MATERIALS AND THE CIRCULAR ECONOMY

EUROPEAN COMMISSION - STAFF WORKING DOCUMENT JANUARY 2018

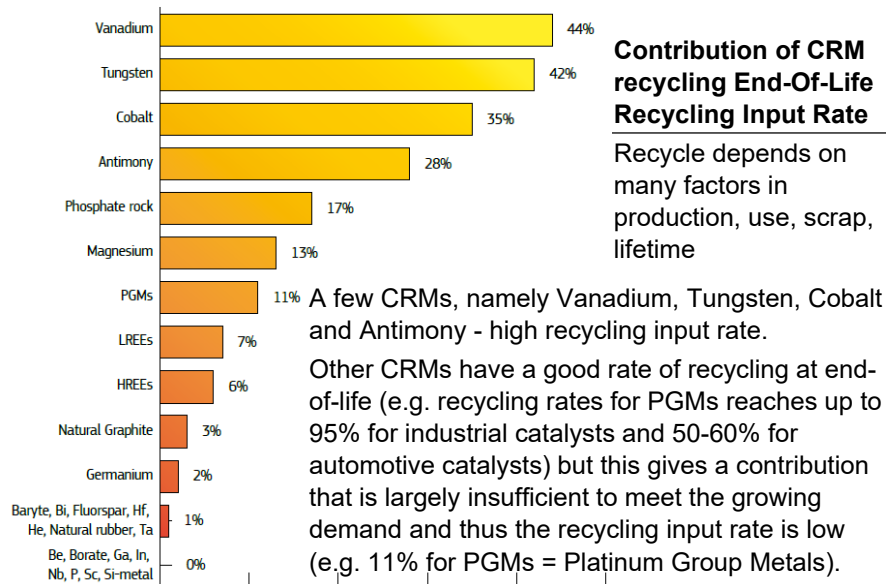
- ✓ The European industry is dominated by the **manufacturing** industry (i.e. the manufacture of end products and applications) and also the refining industry (metallurgy, etc.), compared to the extractive industry (mine and carriers).
- ✓ Pronounced **imbalance** exists between the upstream steps (extraction / harvesting) and the downstream steps (manufacturing and use).
- ✓ Considering the very **limited supply of CRMs from secondary sources**, the need for access to primary sources, including ores, concentrates, processed or refined materials is huge and crucial.

REPORT ON CRITICAL RAW MATERIALS AND THE CIRCULAR ECONOMY

EUROPEAN COMMISSION - STAFF WORKING DOCUMENT JANUARY 2018



Professor Thomas E. Graedel – Yale University and several researchers – collected global data. Static + dynamics



Contribution of CRM recycling End-Of-Life Recycling Input Rate

Recycle depends on many factors in production, use, scrap, lifetime

A few CRMs, namely Vanadium, Tungsten, Cobalt and Antimony - high recycling input rate.

Other CRMs have a good rate of recycling at end-of-life (e.g. recycling rates for PGMs reaches up to 95% for industrial catalysts and 50-60% for automotive catalysts) but this gives a contribution that is largely insufficient to meet the growing demand and thus the recycling input rate is low (e.g. 11% for PGMs = Platinum Group Metals).

Energy use (and associated CO2 emissions and other emissions to air) and **water use** are typically much lower for secondary CRMs than for primary CRMs.

Metal	Energy use (MJ per kg of metal extracted)		Water use (m ³ per tonne of metal extracted)	
	Scrap	Ores	Scrap	Ores
Magnesium	10	165-230	2	2-15
Cobalt	20-140	140-2100	30-100	40-2000
PGM	1400-3400	18,860-254,860	3000-6000	100,000-1200,000
Rare Earths	1000-5000	5500-7200	250-1250	1275-1800

General Policy Measures – 1. Waste Framework Directive

7th Environment Action Programme:

- ✓ To reduce the amount of waste generated;
- ✓ To maximise recycling and re-use;
- ✓ To limit incineration to non-recyclable materials;
- ✓ To phase out landfilling to non-recyclable and non-recoverable waste;
- ✓ To ensure full implementation of the waste policy targets in all Member States.

General Policy Measure – Funding

2. Circular Economy Finance Support Platform

3. Horizon 2000

4. Best practices – e.g. The Netherlands – “A Circular Economy in the Netherlands by 2050” (2016) - limited scope

KEY ACTORS AND PROJECTS IN THE EU

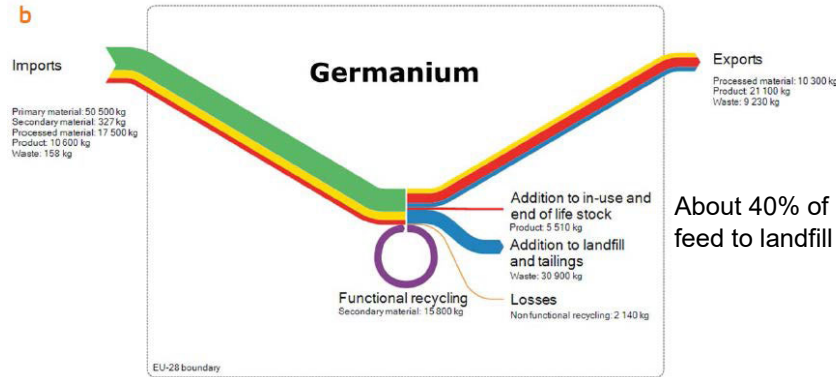
- ✓ The European Innovation Partnership on Raw Materials
- ✓ The Ad hoc Working Group on Critical Raw Materials
- ✓ The European Institute of Innovation and Technology: Raw Materials Knowledge and Innovation Community (EIT Raw Materials)
- ✓ SCRREEN: the European Expert Network on Critical Raw Materials
- ✓ ERECON: The European Rare Earths Competency Network (2013-2015)
- ✓ ++

Impression:

- **Several actions stimulated by the European Commission**
- **Effective in changing the society towards recycle, reduction?**

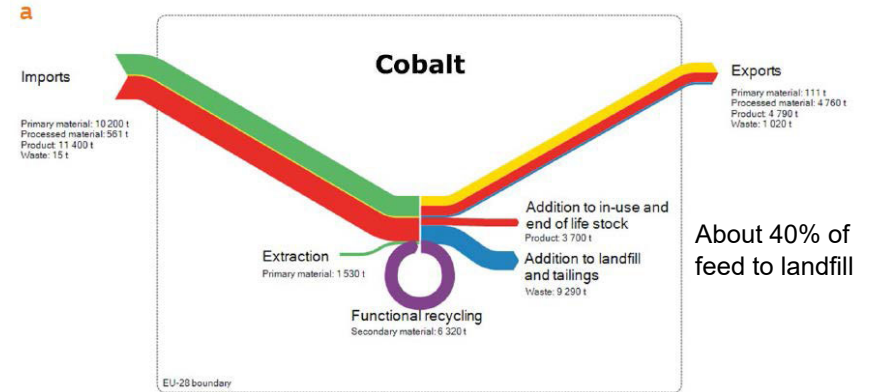
Main source of primary CRMs (mining) + other potential sources (mining waste and landfills), + sectors where most CRMs are used

- Landfill as a CRMs source? Stock data + annual additions
- **Electrical and Electronic Equipment**



Main source of primary CRMs (mining) + other potential sources (mining waste and landfills), + sectors where most CRMs are used

- **Batteries**



Main source of primary CRMs (mining) + other potential sources (mining waste and landfills), - **Automotive sector**

- Under current circumstances of low **lithium** and rare earth prices, high costs for technology largely untested at an industrial scale and the absence of substantial waste streams, the EU recycling infra-structure targeting EV batteries and electric motors is still weak.
- The management of used **tyres** is relatively well organised in Europe. In 2015, 92% of used tyres (vs. 51% in 1996) were either reused as second-hand tyres, reconditioned through retreading, recycled or sent to energy recovery. But downgrading of the rubber
- Vehicle manufacturers have established the International Dismantling Information System (IDIS) compiling information for treatment operators of end-of-life vehicles to promote the environmental and economic dismantling and treatment and to help meet the targets set in the ELV Directive. Now ~85% of 95%

Main source of primary CRMs (mining) + other potential sources (mining waste and landfills) +

- Renewable energy
- Defence industry
- Chemicals and fertilizers – e.g. 86% of phosphate rock for fertilizer
- Automobile industry

Report quantifies substantial losses of CRMs in waste streams
Impressed by data collected

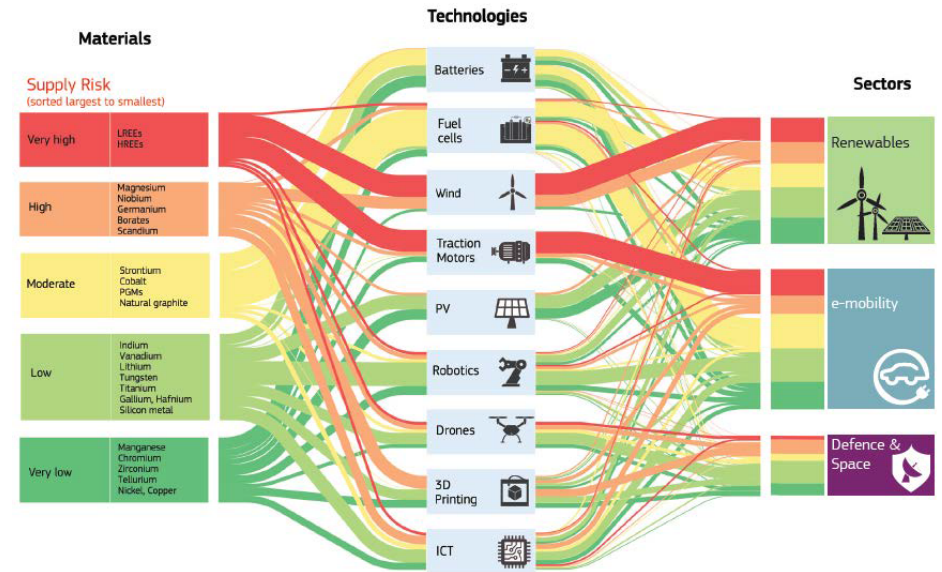
The end of:

Report on Critical Raw Materials and the Circular Economy
January 2018

Critical Raw Materials for Strategic Technologies and Sectors in the EU A Foresight Study September 2020

Challenges supply chains of the nine technologies below used in the three strategic sectors renewable energy, e-mobility, defence and aerospace.

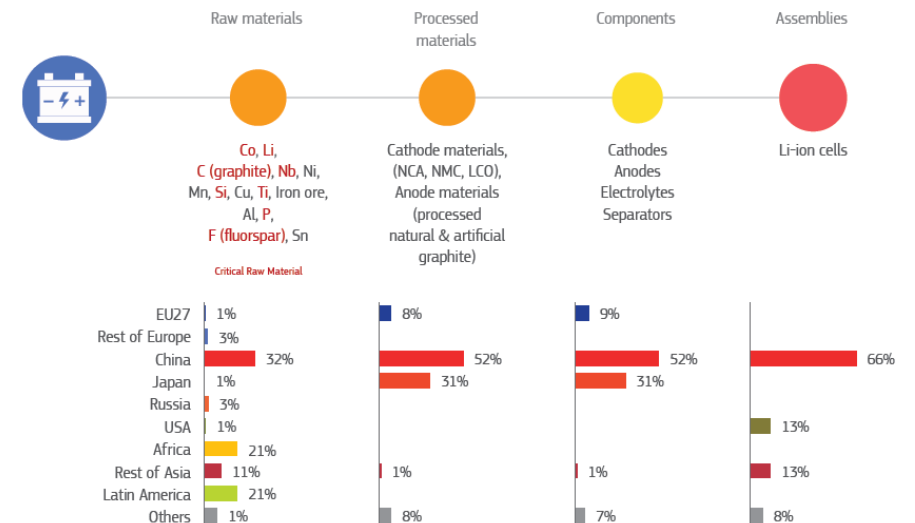
- Li-ion battery technology
- Fuel cells (FCs) - energy conversion technology, hydrogen, as fuel, decarbonisation
- Wind energy - cost-effective renewable energy technology
- Electric traction motors
- Photovoltaic (PV) technology
- Robotics is an emerging technology
- Drones (Unmanned aerial vehicles or UAV)
- 3D Printing (3DP, Additive manufacturing or AM)
- Digital technologies sustain the enormous digital sector



Li-ion cells supply risks for the EU are in the raw materials stages and the Li-ion cells production

- China, together with Africa and Latin America, provides 74% of all battery raw materials.
- By itself China supplies 66% of finished Li-batteries. Currently, the EU provides less than 1% of Li-batteries.
- The **fuel cell** industry relies heavily on platinum-based catalysts, with platinum making up about half of the cost of a fuel cell stack. South Africa is by far the largest producer of platinum in the world, followed by Russia and Zimbabwe. Despite the high supply risk associated with all raw materials in fuel cells, the highest supply vulnerability regards the assembly step, where the USA plus Canada (48%) and Japan plus South Korea (51%) dominate production. Currently, the EU provides less than 1% of fuel cells.

Figure 8. Li-ion batteries: an overview of supply risks, bottlenecks and key players along the supply chain. (See the Glossary for the acronyms used)



Robotics

- 44 raw materials are relevant to robotics, of which the EU produces only 2%. **China is the major supplier of raw materials for robotics with 52%**, followed by South Africa (15%) and Russia (9%).
- Similar potential bottlenecks could also occur in the supply of robotics components.
- On the other side, the **EU** is a major player of processed materials and **assemblies of robotics** with respectively 21% and **41%** of global supply.

Critical Raw Materials for Strategic Technologies and Sectors in the EU A Foresight Study September 2020 – important report:

- Deals with subjects which are relevant for our society and the process industry
 - Contents and recommendations are based on extensive data
- Report distinguishes and analyses four important factors:
- Raw materials - Processed materials
 - Components - Assembles

Report provides:

- Amounts materials needed + growth profile
- Resources by country
- Analysis of dependency for EU
- Data based on needs for the EU

Comments: less on recycling – recycling delayed after growth needs

EC reports show:

- EC reports are first of all focussed in the position of Europe, less focus on global scarcity.
- The dependent position of the EU is clearly quantified
- Immense amounts data have been collected for mining, refining, processing, use, recycle, losses and waste
- Almost all metals and minerals (non C raw materials) are relatively cheap and sufficient available
- Recycled raw material is often more expensive than virgin
- Recycling, reuse is a must – depletion of resources, pollution
- Raw materials are the corner stones of our society, are vital important for conventional and new industries

The Hague Centre for Strategic Studies

Scarcity: source of conflicts 2011

Examples: Africa according to UNEP 2009

- Angola (1975-2002): oil, diamant
- DRC (1996-2008): copper, coltan, diamant, cobalt, wood, tin.
- Congo (1997 -): oil.
- Ivory Coast (2002-2007): diamant, cacao, cotton.
- Liberia (1989-2003): wood, diamant, iron, palm oil, cacao, coffe, rubber, gold.
- Senegal: wood, cashew nuts.
- Sierra Leone (1991 –2000), diamant, cacao, coffe.
- Sudan (1983-2005): oil

Fact Sheet UN Environment Programme 2011

- Since 1990, at least eighteen violent conflicts have been fuelled by the exploitation of natural resources.
- 40% of all intrastate conflicts since 1960 have a link to natural resources.
- Less than a quarter of peace negotiations aiming to resolve conflicts with links to natural resources have addressed resource management mechanisms.



Securing critical materials for critical sectors

Policy options for the Netherlands and the European Union

HCSS report 148 pages, December 2020

The demand for critical raw materials, on which the Dutch economy is highly dependent, will spike - introducing undesirable dependencies due to China commanding a controlling share of the global supply. What can the Netherlands do to secure its supply of critical materials & technologies?

Previous slides presented at Energy & Resources symposium April 2011



Securing critical materials for critical sectors

Policy options for the Netherlands and the European Union

HCSS report 148 pages, December 2020

Critical sectors

NL & the EU are dependent on imported materials, components and technology for meeting their energy, transport and digital ambitions.



Permanent magnets in wind turbines require rare earth elements, mined predominantly in China



Manufacturing of c-Si photovoltaic panels is concentrated in a small number of countries and is led by China



Electric vehicles require batteries, for which China, Japan and Korea are global production leaders



Developing digital technologies, such as semiconductors, requires an ever-increasing range of materials



Securing critical materials for critical sectors

Policy options for the Netherlands and the European Union

HCSS report 148 pages, December 2020

Strategies to secure critical raw materials (CRM)

Ensuring a resilient CRM-supply chain requires states and companies to make strategic policy choices that enable supply chains to adapt and recover from disruptions.



China's Quasi-Monopoly

China employs a range of strategies to develop each step of domestic supply chains and secure access to strategic resources abroad, with the aim of meeting national ambitions.



Securing critical materials for critical sectors

Policy options for the Netherlands and the European Union

HCSS report 148 pages, December 2020

Recommendations for the Netherlands & EU



Develop a long-term national strategy that reflects the needs of industrial actors



Support small/medium enterprises to collaborate on industrial objectives



Conduct R&D for innovative waste collection, processing and re-using



Invest in resource-abundant countries in order to diversify supply



Encourage capacity-building in technical expertise for policymakers



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Securing critical materials for critical sectors

Policy options for the Netherlands and the European Union

HCSS report 148 pages, December 2020

Interventions to be supported on the EU level



Expand European Raw Materials Alliance



Support application of R&D in waste processing & recycling



Analyse EU stocks and waste flows to map potential of secondary CRM



Invest in mining expertise within the Union



Set standards for sustainable & responsible finance and mining practices



Develop strategic international partnerships



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DEPLETING RESOURCES + + CHALLENGE FOR SUSTAINABLE PROCESSES

Pollution reduction, energy savings, CO2-Paris2015, Plastic recycle-C cycle, United Nations Smart Development Goals.....

Raw materials and energy are on the basis of our society

For minerals and metals needed - reuse, recovery and recycle:

- To make more efficient use of raw materials
- To reduce waste and pollution
- To make us less depending on resource countries
- To be able to respond to growing need of minerals and metals