South Africa's Mineral Resource Availability as a Potential Driver for Transitioning to a Circular Economy

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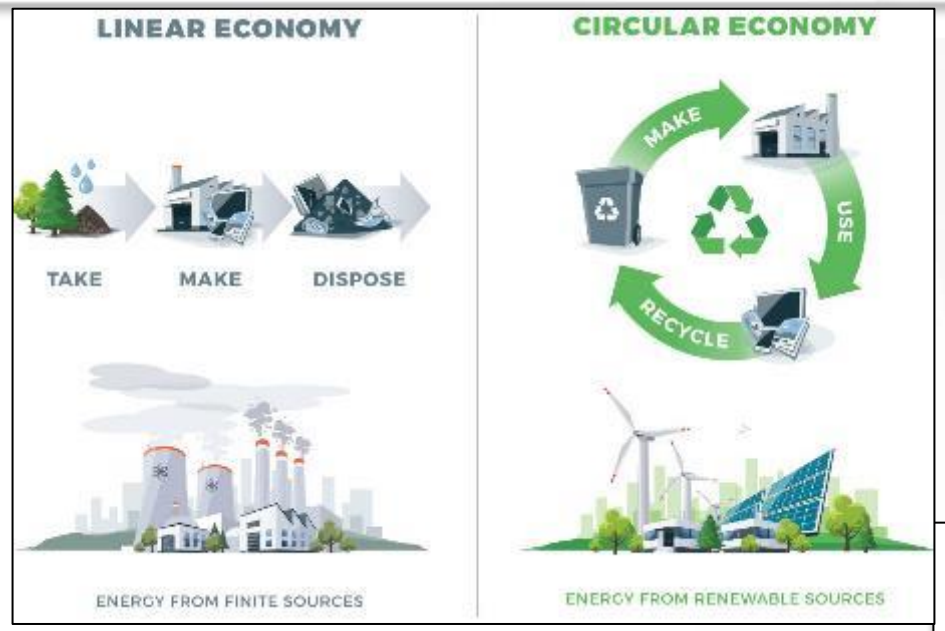
Presentation Outline

1. Definition & principles of a circular economy
2. Significance of a circular economy in the mining sector
3. Background and findings to resource availability study
4. Practical examples from CSIR projects

The Circular Economy Concept

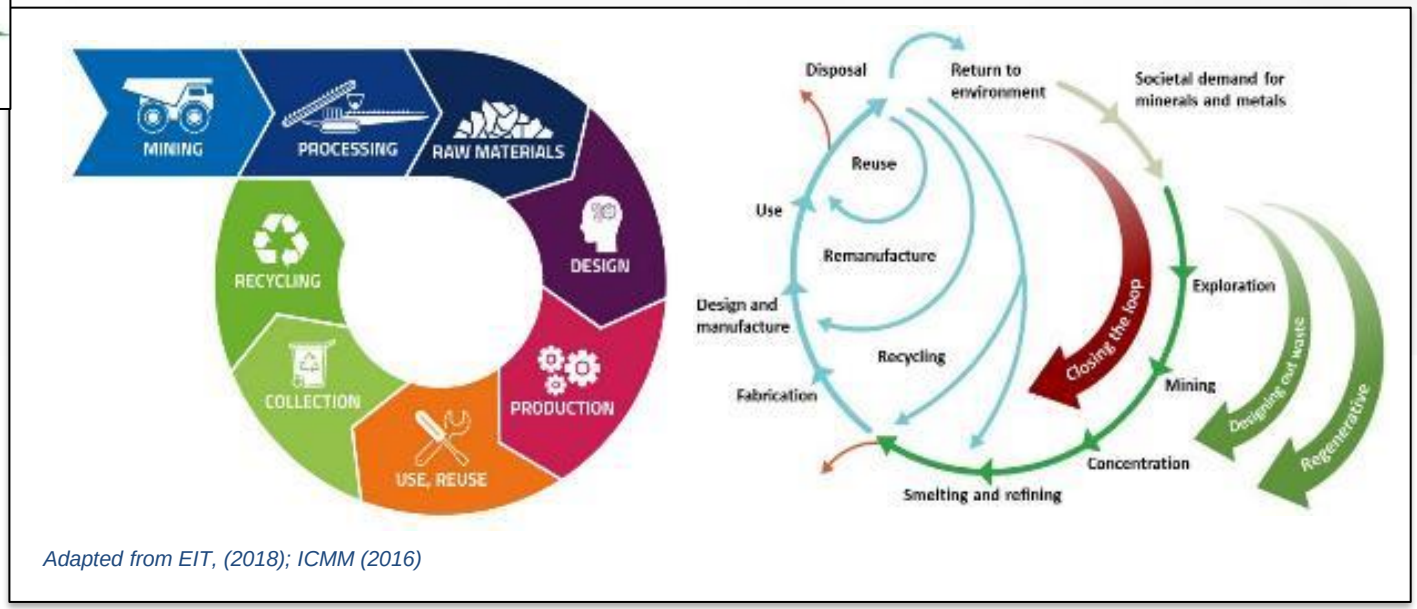


Source: Inter-American Development Bank (2021)

- The circular economy also provides **new opportunities** (and risks) for the mining sector. For example, as we decarbonize the economy it can rapidly increase the demand for metals, e.g., alternative energy technologies, new mobility solutions, etc.
- Creation of **alternate business models**, e.g., mineral leasing as opposed to mineral sales - encourage responsible and sustainable resource use

"A systemic approach to economic development designed to benefit businesses, society, and the environment."

(Ellen MacArthur Foundation, 2016)



Adapted from EIT, (2018); ICMM (2016)

Principles of a Circular Economy

Design out waste, e.g.,

- Redesign mining processes and value chains to be more resource efficient
- Novel mining methods to increase ore extraction & efficiency, water recovery & recycling, biotechnology to recover minerals & metals

Keep materials in use, e.g.,

- Reduce, reuse and recycle various waste streams (including end-of-life equipment), minerals leasing
- Reprocessing of tailings, zero-waste-to-landfill initiatives, urban mining of e-waste

Regenerate natural systems, e.g.,

- Renewable energy, restoring mining landscapes
- Eradication of alien invasives to release water

Significance of Circular Economy in the Minerals Sector

Renewable Energy for Climate Action

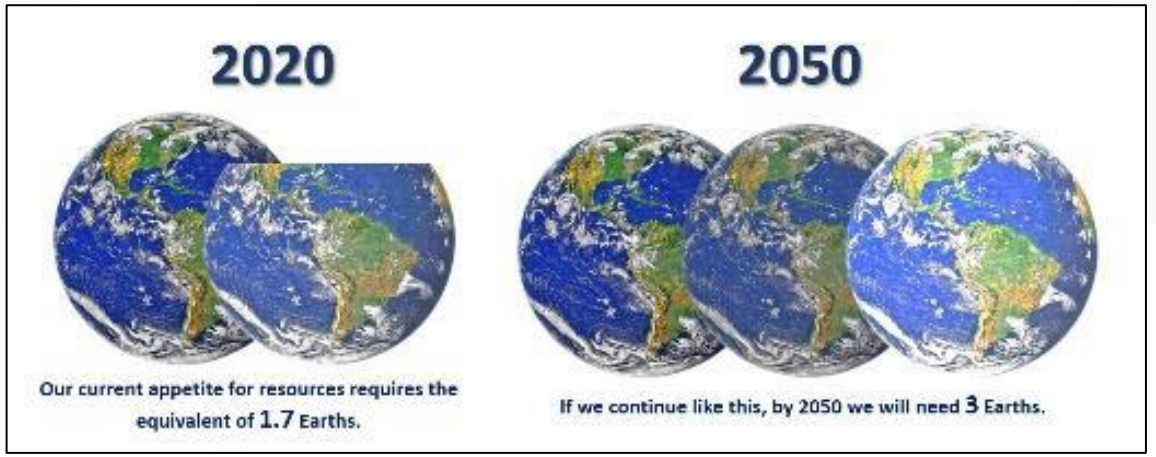
Source: UNDP (2022)

Critical Minerals for Renewable Energy Technologies

Source: Business Standard (2023)

- Global scramble for critical minerals driven by green energy transition
- Technologies needed to support the transition
- Increasing global demand for critical minerals
- But minerals are a finite resource
- Circular economy can potentially bridge the gap in high demand and supply shortage
- Reducing dependence on primary mineral extraction

Sustainable use of Resources for SURVIVAL



Source: Inter-American Development Bank (2021)

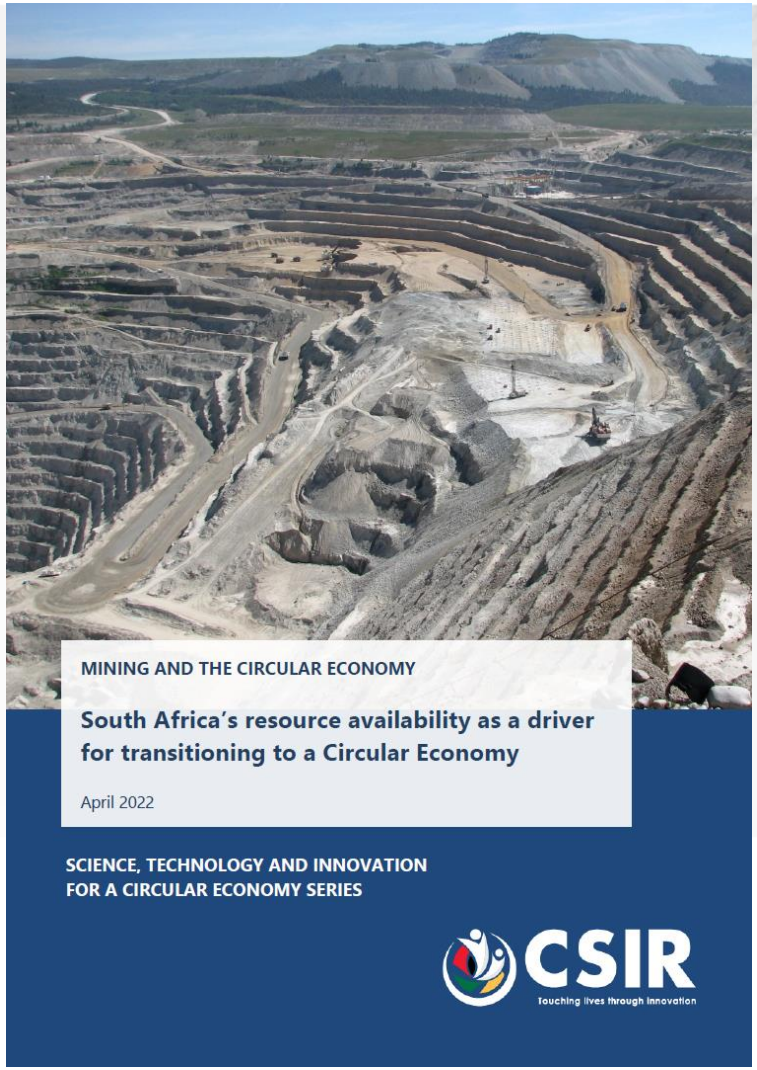
Background to CSIR Project

- CSIR **multi-sectoral study** (2022) led by Prof. Linda Godfrey
- Mining: Understanding the circular economy (CE) in the context of the South African mining sector
- Objective: **To determine if resource scarcity is a driver for SA to transition to a CE** and explore CE opportunities for the mining sector

CSIR Technical Reports:

→	Climate and the Circular Economy: Padayachi, Y. et al. (2023). Climate mitigation as a driver for transitioning to a circular economy in South Africa. CSIR: Pretoria
→	Water and the Circular Economy: Seetal, A. et al. (2023). Enabling South Africa's Water Security through a Circular Economy. CSIR: Pretoria
→	Energy and the Circular Economy: Pandarum, A., et al. (2023). Improving energy security in South Africa through a more circular energy sector. CSIR: Pretoria
→	Mining and the Circular Economy: Khan, S. et al. (2022). South Africa's resource availability as a driver for transitioning to a Circular Economy. CSIR: Pretoria
→	Agriculture and the Circular Economy: Okole, B. et al. (2022). Improved food security in South Africa through a more circular agricultural sector. CSIR: Pretoria
→	Manufacturing and the Circular Economy: Fazluddin, S., et al. (2022). A more competitive South African manufacturing sector through a circular economy. CSIR: Pretoria

Reports available on: www.circulareconomy.co.za/csir



Research Questions

1. How many years of economically viable minerals and metals does SA have?

2. What are SA's critical / strategic minerals?

3. Based on the above, is resource scarcity the / a driver for South Africa to transition to a more circular economy?

4. What are the circular economy opportunities (and challenges) for the mining sector?

Research Question 1

How many years of economically viable minerals and metals does South Africa have?

Determining years to depletion of an economically viable mineral

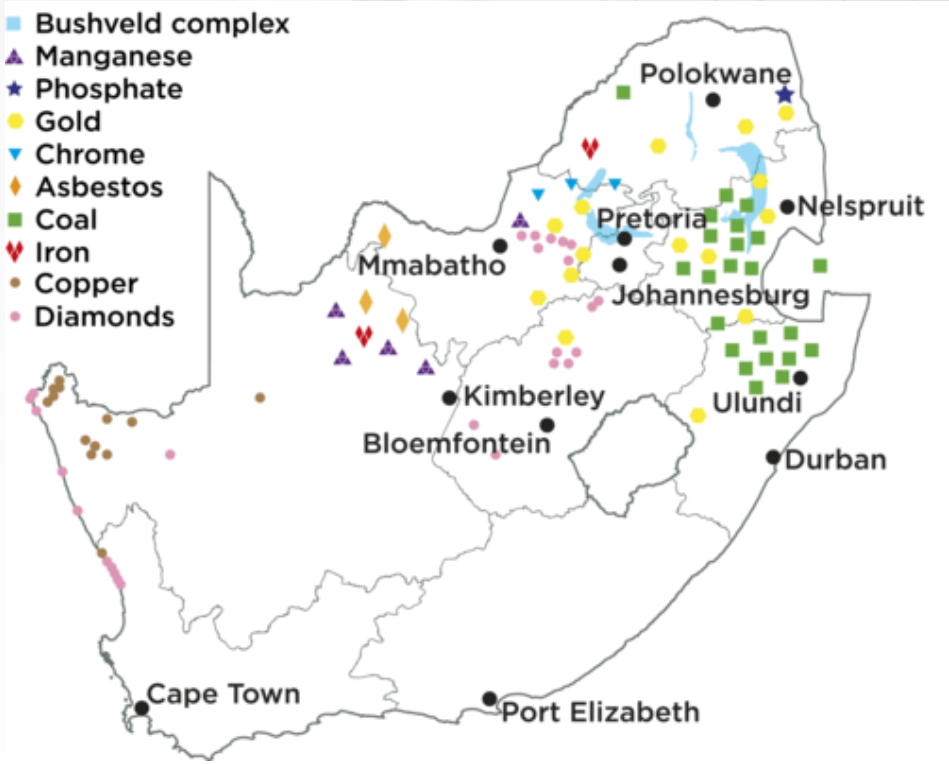
- Economically viable minerals are generally reported in reserves remaining and not necessarily the number of years remaining. Therefore, the remaining number of years had to be calculated.

$$Years\ to\ depletion\ of\ a\ particular\ mineral = \frac{Total\ remaining\ tonnage\ of\ \ reserve\ (Mt)}{Total\ annual\ production\ tonnage\ (Mt)}$$

- e.g., years to depletion (gold 2020) = 0.0032 Mt / 0.000096 Mt = 33 years

Summary of results - years to depletion of economically viable minerals in SA

Range of years to depletion	Mineral commodities
< 50	Gold, Cobalt, Iron ore, Lead, Manganese
50 - 100	Zinc
100 - 500	Coal, Copper, PGM, Vanadium
> 500	Chromium, Fluorspar, Nickel, Phosphate, Titanium, Uranium, Vermiculite, Zirconium, Diamonds



Source: www.siyavula.com

Research Question 2

What are South Africa’s critical / strategic minerals?

Critical Raw Materials and Strategic Minerals in South Africa - Definitions

- **Critical Raw Materials (CRMs):** The European Union defines its critical raw material as raw materials that are **economically** and **strategically important** for the European Economy but may have **high-risk** associated with their **supply** (Ferro & Bonollo, 2019)

- **Strategic Minerals**: are minerals/metals that are essential to the **economy**, **modern technology** and **industry** and have limited supply and are subject to disruption (SGS SA, n.d.)

- In South Africa, the term strategic is generally accepted as critical raw materials and it refers to minerals that are of national importance whose supply is at risk

Source: World Economic Forum (2024)

EU methodology for determining CRMs

- To calculate the criticality of materials:

$$EI = \sum_s (A_s * Q_s) \; * SI_{EI}$$

Where:

EI= Economic Importance
As= The share of an end use of a raw material in a NACE Rev 2 (2-digit level) sector
Qs= The sector's VA at the NACE Rev (2-digit level)
SI_{EI} = The substitution index of a raw material related to economic importance
S =denote sector

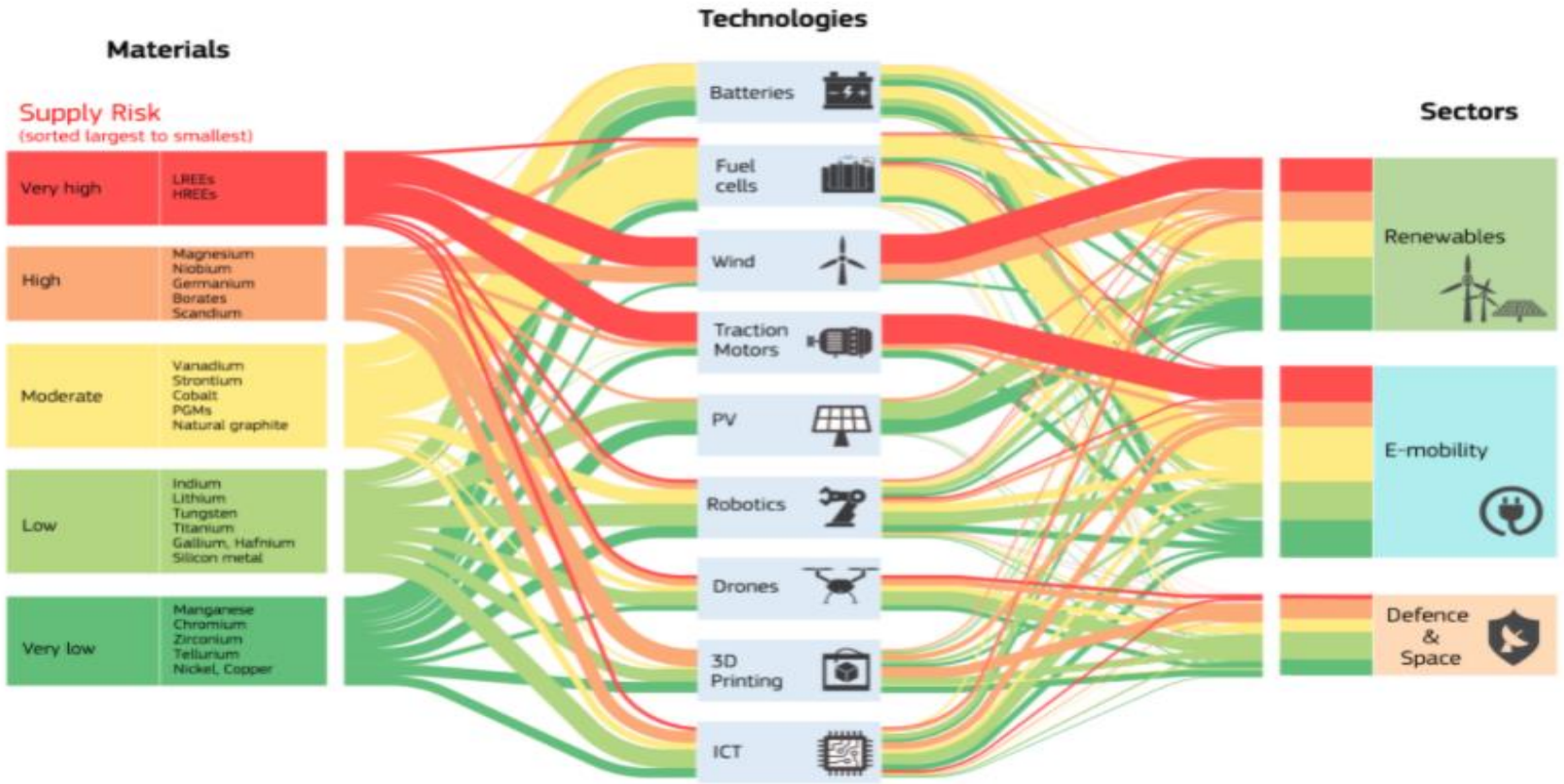
- To calculate Supply Risk:

$$SR = HHI_{WGI} \bullet (1 - EoL_{RIR}) \bullet SI$$

Where:

HHI =is the Herfindahl Hirschman Index
WGI= is the scaled World Governance Index
IR =stands for Import Reliance
EOLRIR =is the End-of-Life Recycling Input Rate
SISR = Substitution Index (in supply risk)

Linking CRMs to technologies



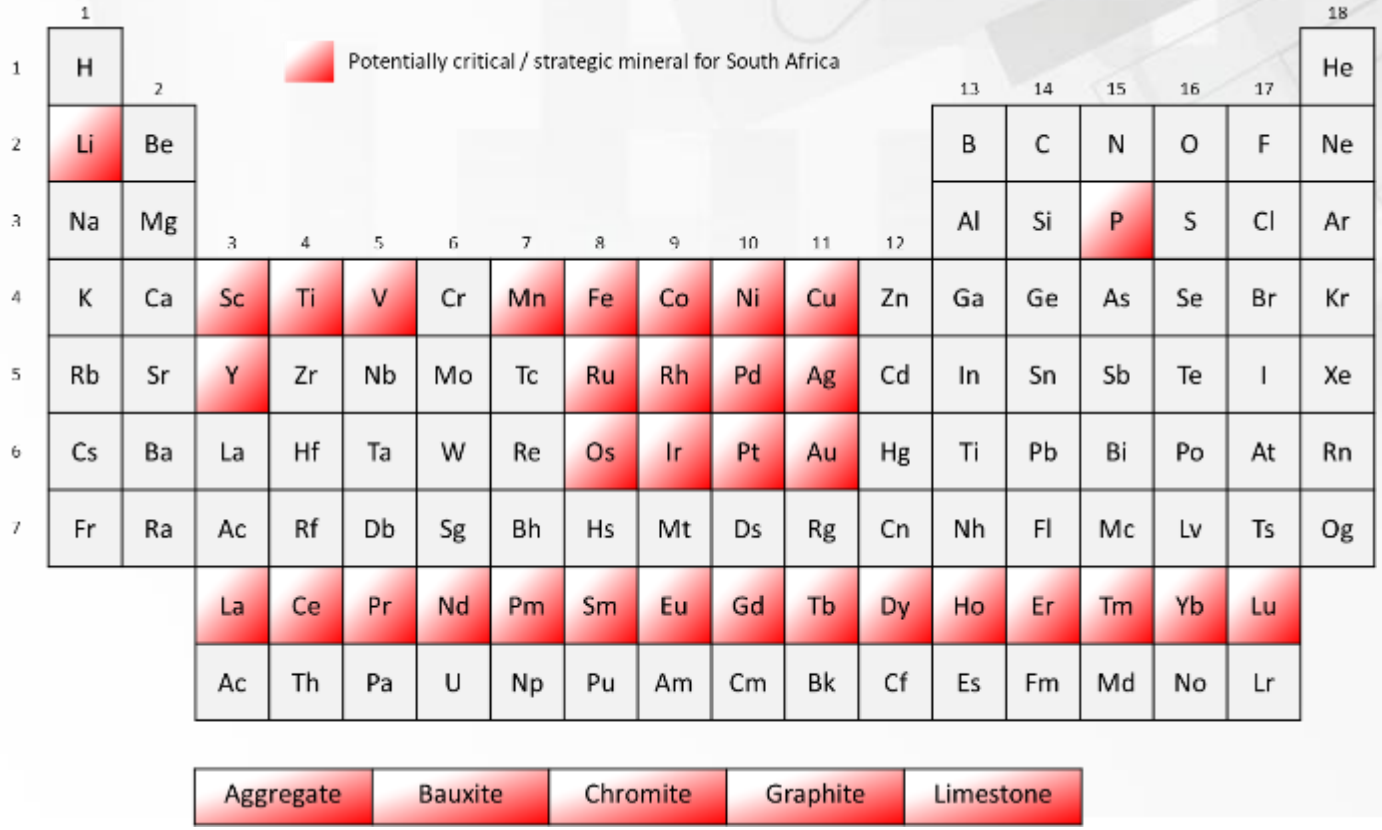
Source: *Critical Raw Materials for Strategic Technologies and Sectors in the EU - A Foresight Study*

Critical minerals in SA linked to technologies

Emerging technology	Corresponding mineral required to develop the technology
Hydrogen fuel cells	Platinum, REE, PGM, cobalt, vanadium, manganese
3D printing	Titanium, magnesium, REE, lithium
Solar photovoltaic cells	REE, copper, aluminium, indium, gallium, selenium, silver, tellurium
Robotics	Cobalt, chrome, lithium, vanadium, PGM
E-mobility (electric vehicles)	Manganese, nickel, copper, PGM vanadium, cobalt, natural graphite, lithium
Drones and UAVs	Manganese, chromium, nickel, copper, tellurium
Cloud and Remote Computing	Copper, REE, indium, tungsten
Energy Storage	Copper, cobalt, nickel, lithium, REEs

Indicative list of SA's CRMs (2022)

1. Aggregate
2. Bauxite
3. Chromite
4. **Cobalt**
5. Copper
6. **Gold**
7. Graphite
8. **Iron**
9. Limestone
10. Lithium
11. **Manganese**
12. Nickel
13. Phosphorous
14. Platinum-group metals (PGM)
15. Rare earth elements (REE)
16. Silver
17. Titanium
18. Vanadium



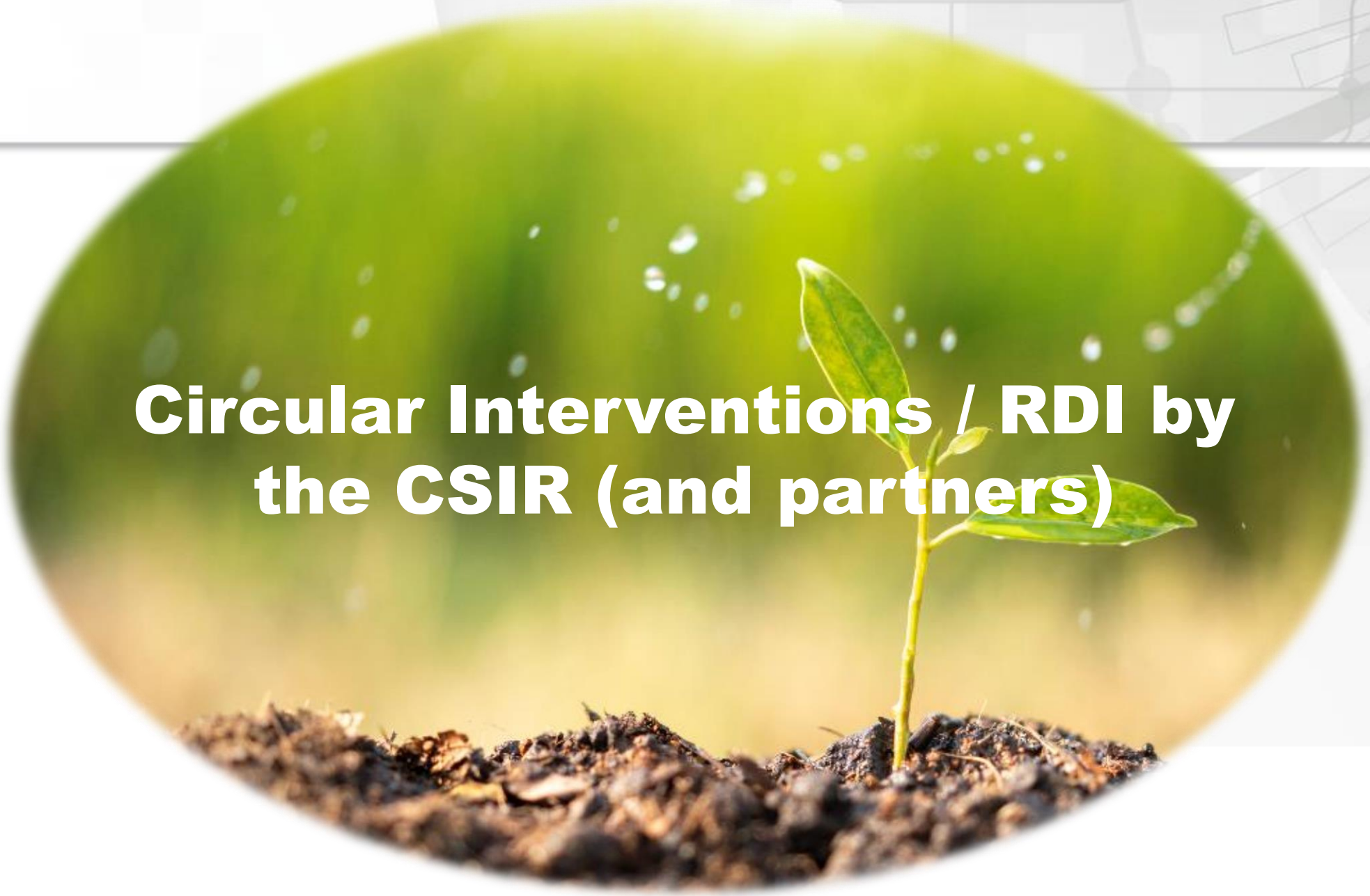
DMRE currently in process of developing SA's critical mineral strategy (including SA's critical minerals list)

Research Question 3

Is resource scarcity a driver for South Africa to transition to a more circular economy?

Findings - Resource scarcity a driver for SA to transition to a more circular economy?

- Minerals are **finite resources**, thus at constant **shortage risk**
- To prolong complete mineral depletion, natural resources must be mined and utilised in a more **sustainable manner**
- Certain minerals have **less that 50 years** of economically viable mining remaining
- Some of these (<50 years) can be classified as **critical** based on **supply shortage** and their significance in **development of emerging technologies**
- This suggests that **resource scarcity** may be a **driver for SA** to transition to a more **circular economy**
- Intake of certain **technologies** will **increase the demand** for certain minerals and thus **strain the supply**



Circular Interventions / RDI by the CSIR (and partners)

Example 1 – Paper/packaging Waste

Paper & packaging waste typically disposed to landfill or dumpsites, placing pressure on municipal resources

- Development of **Sorting Facilities** or **Materials Recovery Facility (MRF)** (in partnership with community and municipality)
  - Alleviate environmental impacts caused by dumping;
  - Reduce volume of waste reaching landfills;
  - Local job creation.

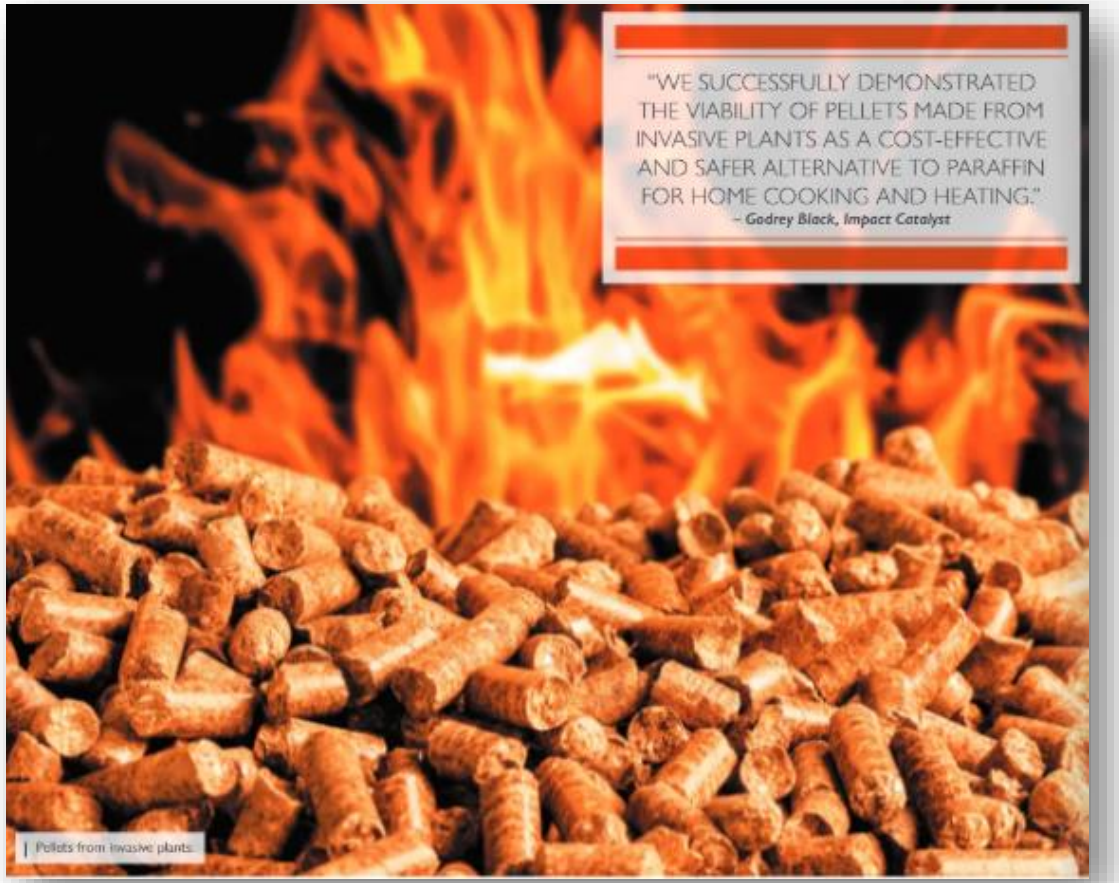
Intervention **appropriate** for waste volumes, e.g., smaller volume sorting cooperative in Sao Paulo

Example 2 – Coal Waste for Asphalt Mixes

- Investigate the potential to **repurpose coal waste** for continuously graded **asphalt** wearing course mix in the **construction industry**
- Globally, coal waste has been repurposed to produce graded asphalt wearing course mix, which is used in the construction industry
- However, there is currently a gap in existing knowledge on the engineering performance of coal waste in South African asphalt mixes

Source: Modarres and Rahmanzadeh (2014)

Example 3 – Conversion of Invasive Plants to Energy Pellets



Pellets from invasive plants.

- Impact Catalyst initiative
- Removal of alien invasive plants from around mines
- Conversion to **energy pellets**
- **Cost-effective** and **safer** alternative to paraffin
- **Demonstrated** in mine community in Limpopo
- Addresses **environmental degradation issues** and **socio-economic needs** of communities


Equipment used to produce pellets from invasive plants.

Full CSIR Science Scope article available: www.csir.co.za/science-scope-vol21-no-1

Example 4 - Sustainable AMD Treatment

- **Waste Beneficiation** and **Circular Economy**
- United Nation **Sustainable Development Goals** (**SDG's**) 6, 9 and 12

Sustainable AMD Treatment

Water Reuse

Resource Recovery

Sulfuric Acid

Valuable Minerals

Rare Earth Elements

Example 5 – Beneficiation of Wood Waste

- Research by the CSIR Biorefinery Industry Development Facility (BIDF) on the valorisation of **saw dust**, **wood chips** to obtain a variety of high-value marketable chemicals
- New value chains for high value products –
  - **Xylose** for conversion to **Xylitol** (artificial sweetener)
  - Pine oil
  - Nanocrystalline cellulose fibres

Traditional, low value

Innovative, high value

Thank you

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