IAEA
International Atomic Energy Agency

Challenges and Opportunities to Promote Circularity in Mining

Horst Monken Fernandes
Decommissioning and Environmental Remediation Section – NEFW - IAEA

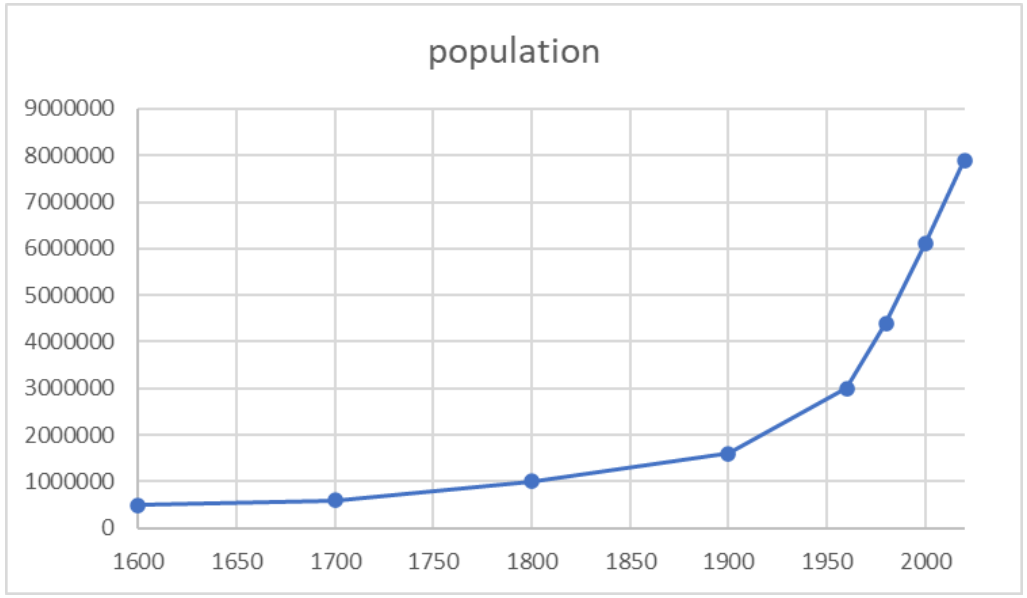
REMPLEX Technical Session 6

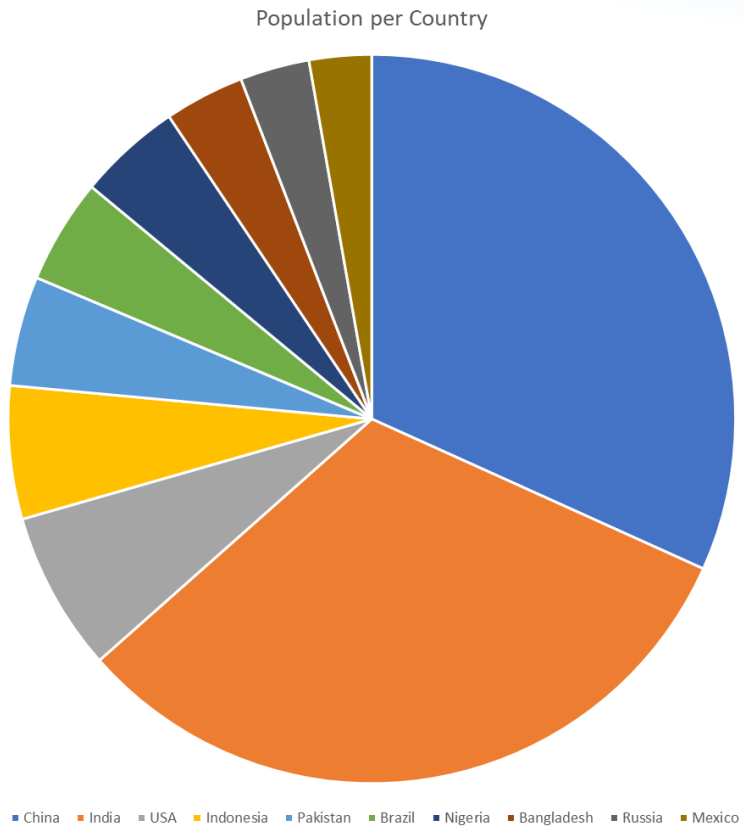
Critical Minerals (including Rare Earth Elements): The Promise, Challenge, and Environmental Risk

Presentation Outline

- Background
- Circularity in Uranium Mining
- Circularity Outside Uranium Mining
- Circularity and Environmental Remediation
- Conclusions
- Environet NORM Project

Population Growth and distribution per Country





UN Sustainable Development Goals

IAEA

7 AFFORDABLE AND CLEAN ENERGY

IMPRESSIVE PROGRESS IN ELECTRIFICATION HAS SLOWED

15 LIFE ON LAND

PROTECT, RESTORE AND PROMOTE SUSTAINABLE USE OF TERRESTRIAL ECOSYSTEMS, SUSTAINABLY MANAGE FORESTS, COMBAT DESERTIFICATION, AND HALT AND REVERSE LAND DEGRADATION AND HALT BIODIVERSITY LOSS

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

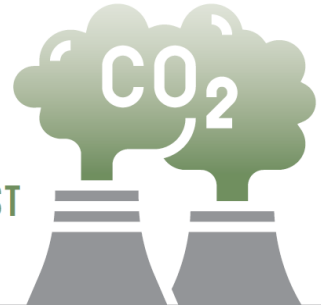
OUR RELIANCE ON NATURAL RESOURCES IS INCREASING

RISING OVER 65% GLOBALLY FROM 2000 TO 2019

13 CLIMATE ACTION

ENERGY-RELATED CO_2 EMISSIONS INCREASED 6% IN 2021

REACHING HIGHEST LEVEL EVER



Source: UN Sustainable Development Goals Report 2022

The context

Recent OECD projections of global material demand through 2060 indicate that primary material use will roughly double, from 89 Gt in 2017 to 167 Gt in 2060 from 2017 levels – including growth in all major categories of materials;

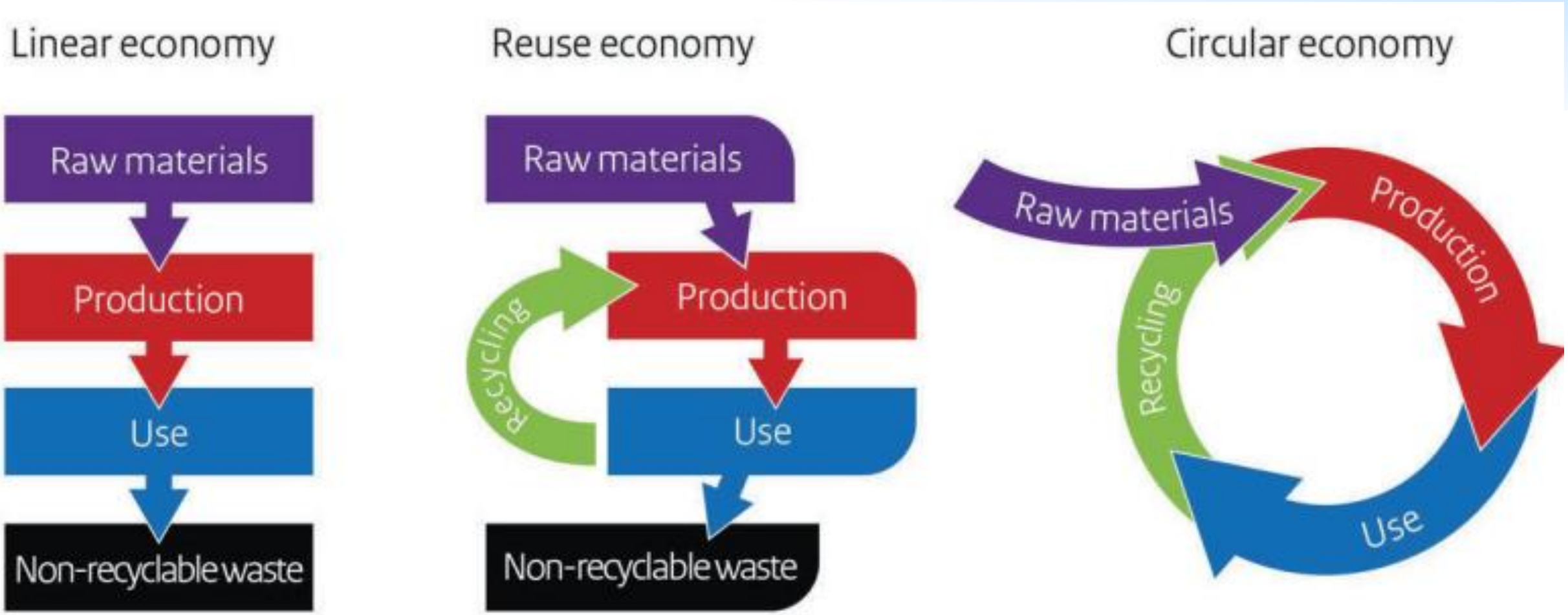
- 63% growth in fossil fuels,
- 73% in biomass,
- 97% in non-metallic minerals, and
- 126% in metals (growth to 2060 from 2017 levels)

Growth in metals demand particularly remains consistent even when broken down to the level of individual ore types, with projections of most metal ore usage levels approximately doubling, or more, to 2060.

Demand for commodities such as iron ore will continue to exceed recent levels through 2050, despite accounting for increasing regulation on material recycling and factoring in an expected slow-down and eventual decrease in China's steel consumption (WEF 2015).

https://population.un.org/wpp/Download/Standard/Population/

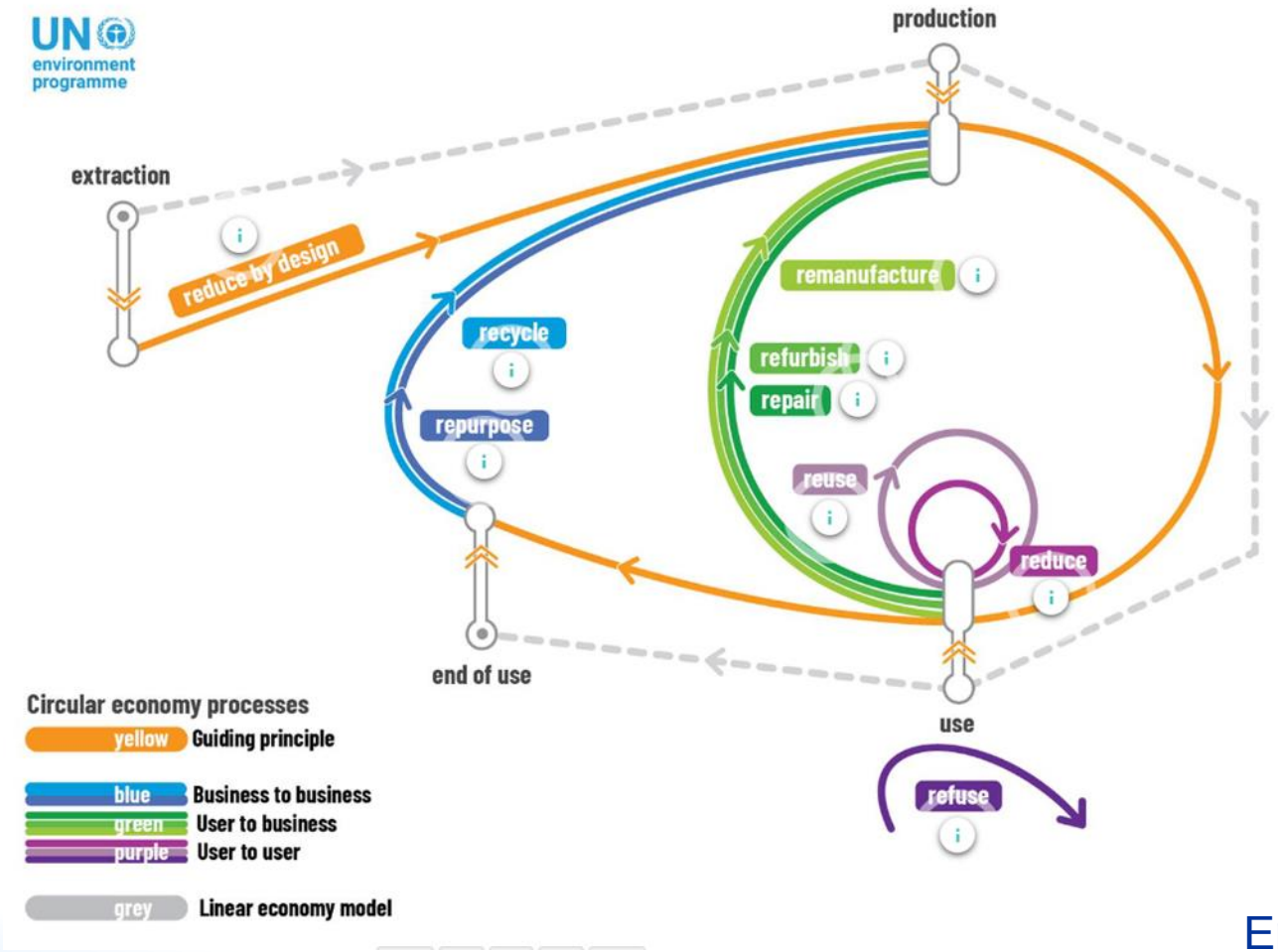
Linear x Circular Economy



Circular Economy: A Key Driver for Sustainable Development

- 100 billion tones of materials enter the global economy every year, resulting in 39 billion tones of greenhouse gas emissions
- **Only 7.2% of the world's resources are reused or recycled**
- Adopting a circular economy maximizes resource value, achieves SDGs, and creates opportunities
- Circular economy could unlock $4.5 trillion by 2030

The Circular Economy



D **Design For the Future:** Adopt a systemic perspective during the design process, to employ the right materials for appropriate lifetime and extended future use.

I **Incorporate Digital Technology:** Track and optimise resource use and strengthen connections between supply-chain actors through digital, online platforms and technologies.

S **Sustain & Preserve What's Already There:** Maintain, repair and upgrade resources in use to maximise their lifetime and give them a second life through take-back strategies, where applicable.

R **Rethink the Business Model:** Consider opportunities to create greater value and align incentives through business models that build on the interaction between products and services.

U **Use Waste as a Resource:** Utilise waste streams as a source of secondary resources and recover waste for reuse and recycling.

P **Prioritise Regenerative Resources:** Ensure renewable, reusable, non-toxic resources are utilised as materials and energy in an efficient way.

T **Team Up to Create Joint Value:** Work together throughout the supply chain, internally within organisations and with the public sector to increase transparency and create shared value.

What is needed to create circular systems?

- Skills circular product, design and production
- New Business Models

Enabling Circular Systems

- Education
- Financing
- **Collaborative Platforms**
- A New Economic Framework

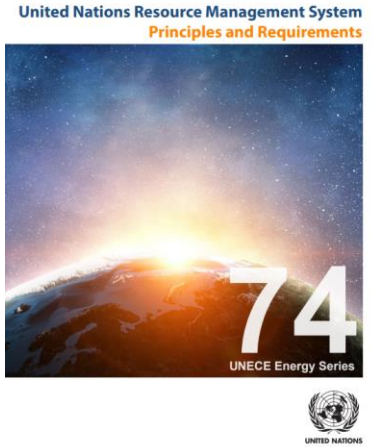
UNFC and UNRMS: A Universal Language and Framework for Resources

UNFC and UNRMS are frameworks for classifying, accounting, reporting, managing on resource projects

They consider viability, feasibility, confidence in estimates, and environmental, social, and economic factors

UNFC and UNRMS promoted in the EU (EU CRM Act) and adopted as the continental system by the African Union

Don’t discount the future: Social discounting - a reflection of a society's relative valuation on today's well-being versus well-being in the future



Important Considerations on Circular Economy

CE is not the same or connected with waste management hierarchy

- In Waste Management Hierarchy the final stage is still disposal
- CE envisages a zero-waste approach
- Interim storage till appropriate use is found → procrastination

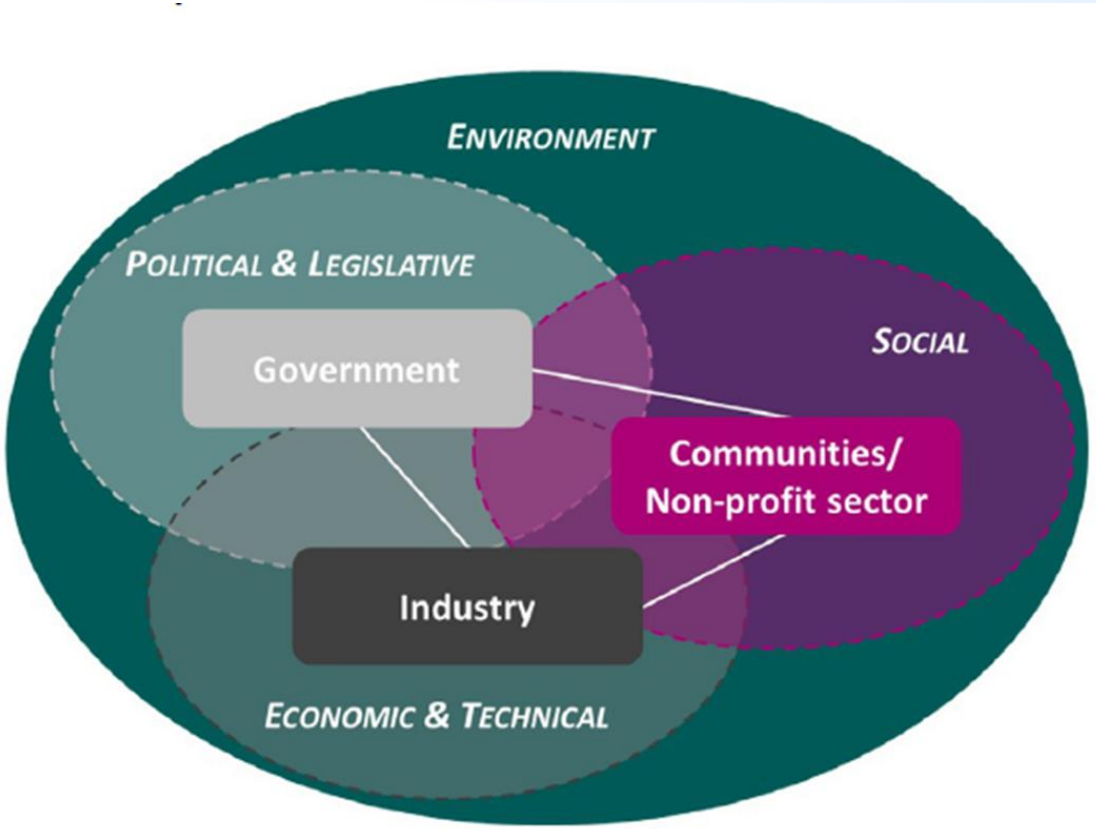
Innovation is needed, to make it feasible the recovery of valuable resources → market dependent

Subsidies are called upon → tax-payer moneys!!!

Legislation developed for a linear economy → adaptation for a circular economy

Stakeholder perception: do I want something containing radioactivity?

Towards a business analytics capability for the circular economy



- Need to develop a deeper understanding of the importance of taking a holistic approach to business analytics when leveraging data and analytics towards a more efficient and effective enabled circular economy, the smart circular economy.

The 3 “Musts” for “Recyclable” to become Recycled

A waste material can only go from being “recyclable” to really being recycled when three conditions are met:

- There is a cost-effective recycling technology/process for it;
- There is a potential market for the recyclate* which the technology/process produces; and
- The price of that recyclate is lower than equivalent virgin material.

The role of government is to make sure that these conditions exist.

Lists of critical raw materials – what about Uranium???

List 2011	List 2014	List 2017
Antimony	Antimony	**Antimony**
Beryllium	Beryllium	**Baryte**
Cobalt	Borates	Beryllium
Fluorspar	Chromium	Bismuth
Gallium	Cobalt	**Borate**
Germanium	Coking coal	**Cobalt**
Graphite	Fluorspar	Coking Coal
Indium	Gallium	**Fluorspar**
Magnesium	Germanium	Gallium
Niobium	Indium	Germanium
Platinum group metals	Magnesite	Hafnium
Rare earths	Magnesium	**Helium**
Tantalum	Natural graphite	Indium
Tungsten	Niobium	**Magnesium**
	Phosphate rock	**Natural graphite**
	Platinum group metals	Natural rubber
	Heavy rare earths	Niobium
	Light rare earths	**Phosphate rock**
	Silicon metal	Phosphorous
	Tantalum	Scandium
		Silicon Metal

The five big bets for the circular economy

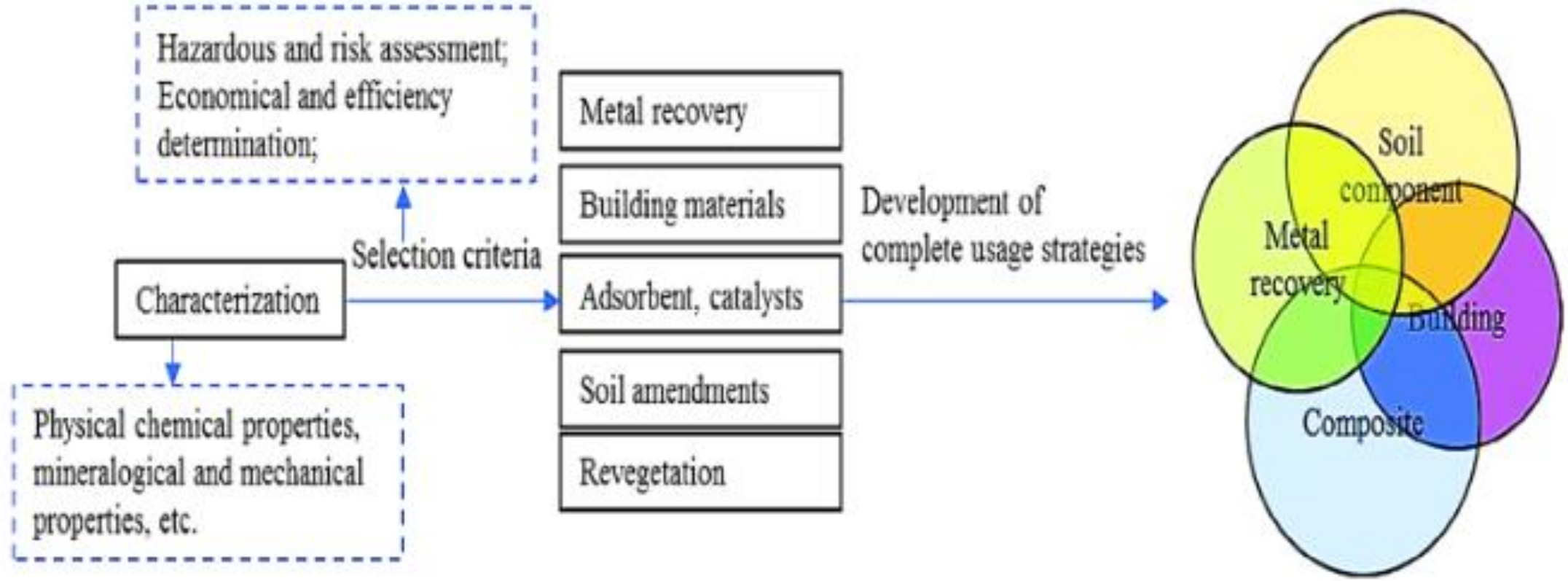
1. Food systems
2. Packaging
3. The built environment
4. Electronics
5. Fashion and textiles

- NORM (mining) related industries????

Enablers

- Harmonized and supportive policies
- Business development support
- Data availability- inventory
- Technology – innovation
- Access to financial services and infrastructure

Valorisation analysis scheme



Shaker M.A. Qaidi et al. (2022)

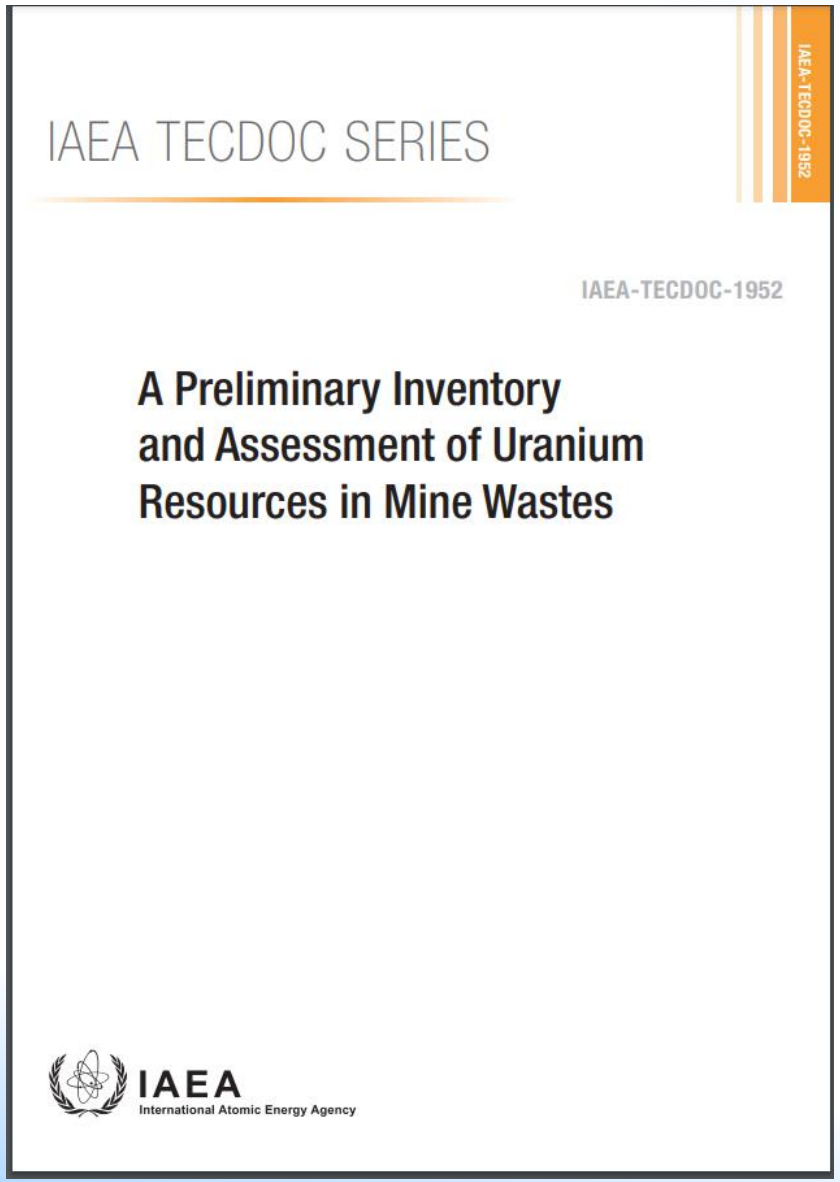
Mining Residues: A Circular Solution for Resource Recovery

- A low-hanging fruit
- Address **"humankind's earliest and most persistent form of environmental contamination."**
- Tailings impoundment facilities require high capital and operational costs
- Uranium by-product from gold tailings
- Most iron ore tailings could be made into industry-grade sand
- Potential with phosphogypsum and red mud
- Making a challenge to opportunity

IAEA

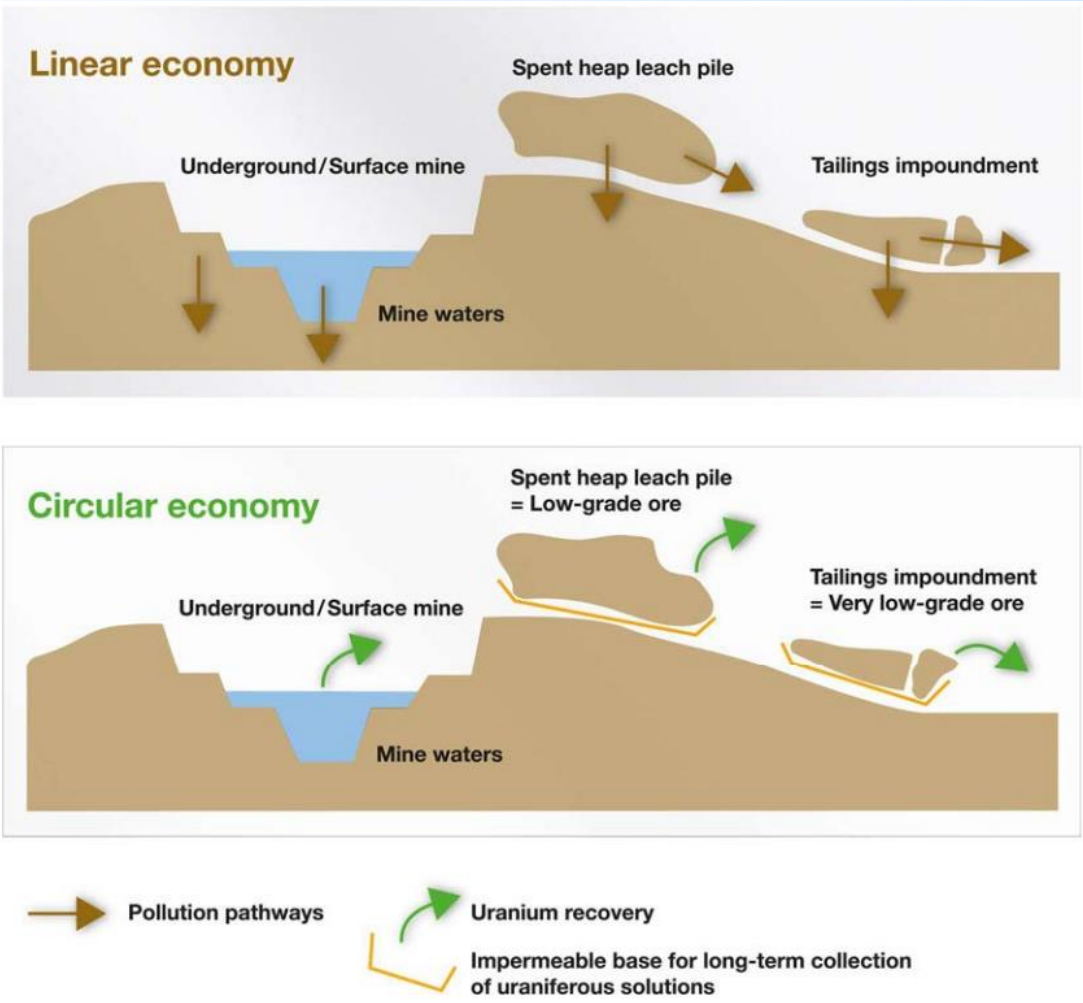
UNECE

Unconventional uranium resources



- Bauxite residue
- Tin slags
- Coal bottom and fly ash
- Phosphoric acid waste stream
- Process liquids of copper ores
- REE

THE ROLE OF THE URANIUM MINING INDUSTRY IN A CIRCULAR ECONOMY



Some conclusions from the TECDOC

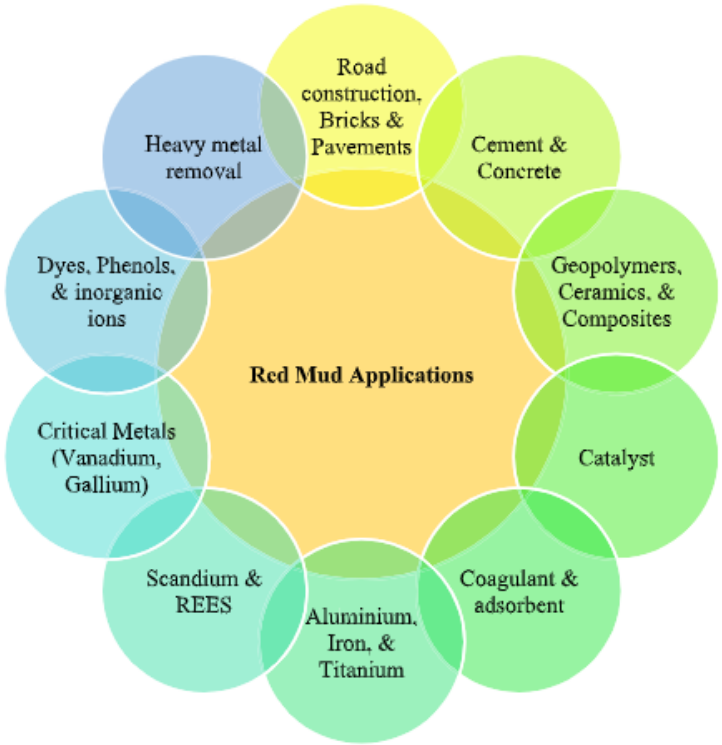
Metallurgical accounting indicates that the global mass of uranium mill tailings contains at least between 0.87 to 1.74 Mt U_3O_8

Mine waters of active and historical uranium mines may contain uranium concentrations that are of possible economic interest and could be extractable using established technologies (Pocos de Caldas is an example)

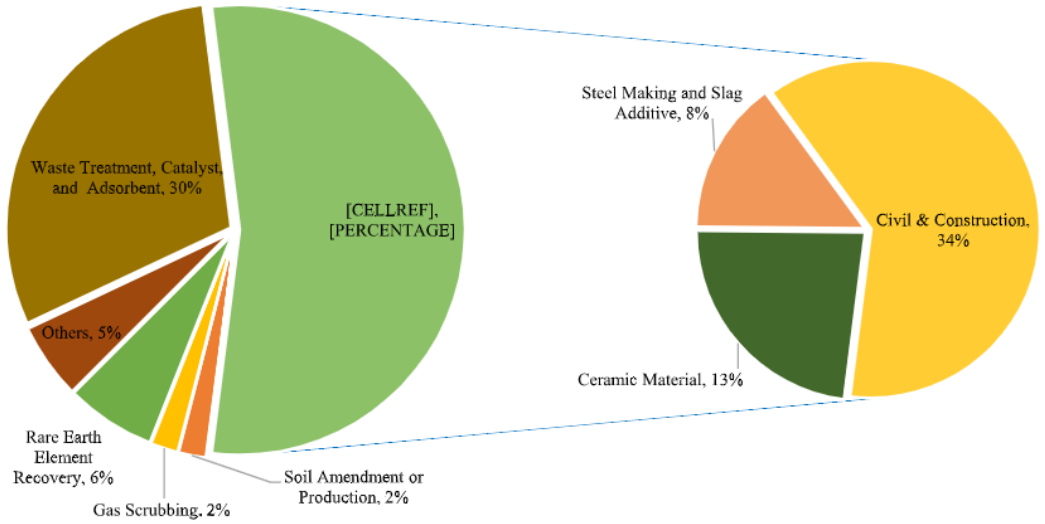
Recovery of uranium from mine wastes may ultimately initiate the valorisation of uranium resources, support total resource use of uranium ores and help the transformation towards a circular economy in uranium mining.

Practical Examples Outside Uranium Recovery

Red Mud (Bauxite) Applications

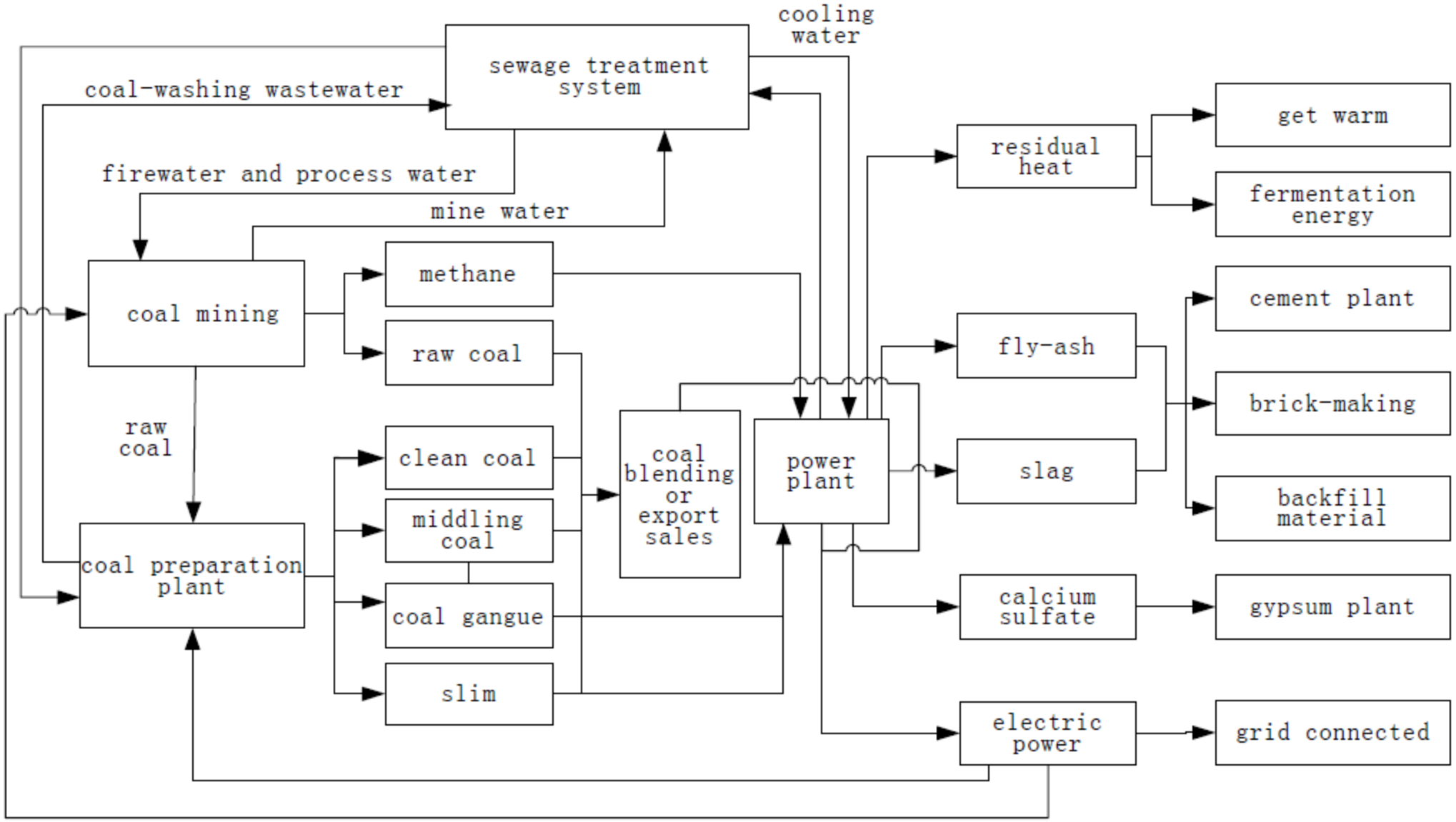


RM utilization rate in various applications for the period from 1964 to 201



Shaker M.A. Qaidi et al. (2022)

Circular economy model of coal mine



Re-thinking Mine Remediation: from Harm Reduction to Value Generation (Legacy to Asset)

- Remediation for Recreational and Commercial Purposes (While closed mine sites should be reclaimed so that plants and wildlife do not require ongoing management, certain business opportunities could thrive, for example tourism):
  - Seasonal sports, e.g., hiking, biking, golf, zip lining, skiing, tobogganing;
  - Fishing and hunting grounds, camping resorts/retreats; and,
  - Nature observatory parks, specialty gardens, etc.
- Regenerating Land to Healthy Agro-Ecosystems
- Regenerating and Reclaiming to Natural Ecological Systems
  - Reclaimed to self-sustaining ecosystems
- **Reprocessing existing, older wastes can eliminate costly remediation** by geochemically and geotechnically stabilizing residuals. **This will reduce liabilities and associated final closure costs** and may create marketable "green" products

Reconversion strategy around the 3 pillars of sustainable development

Economic

Industrial facilities: **~7%**

Agricultural activities: **~50%**

Photovoltaic power plants: **~6%**

Environmental

Ecological lands (hives, ecosystems protection, etc.): **~10%**

Forest lands: **~25%**

Social

Leisure activities (fishing, hunting, etc.), training areas for firefighters, one-off agreements: **~20%**

Several different reconversions are possible for each site

Source

orano

Solar Farm in a Mine Pit Lake

Conclusions

The concept of Sustainability, is present in the international stage for decades and has been steadily being incorporated in IAEA's Standards and other publications;

The concept of Circularity, however, has not been captured yet in already available standards and publications;

More than concepts, practical approaches, as much as possible based on real cases, are needed and must be shared

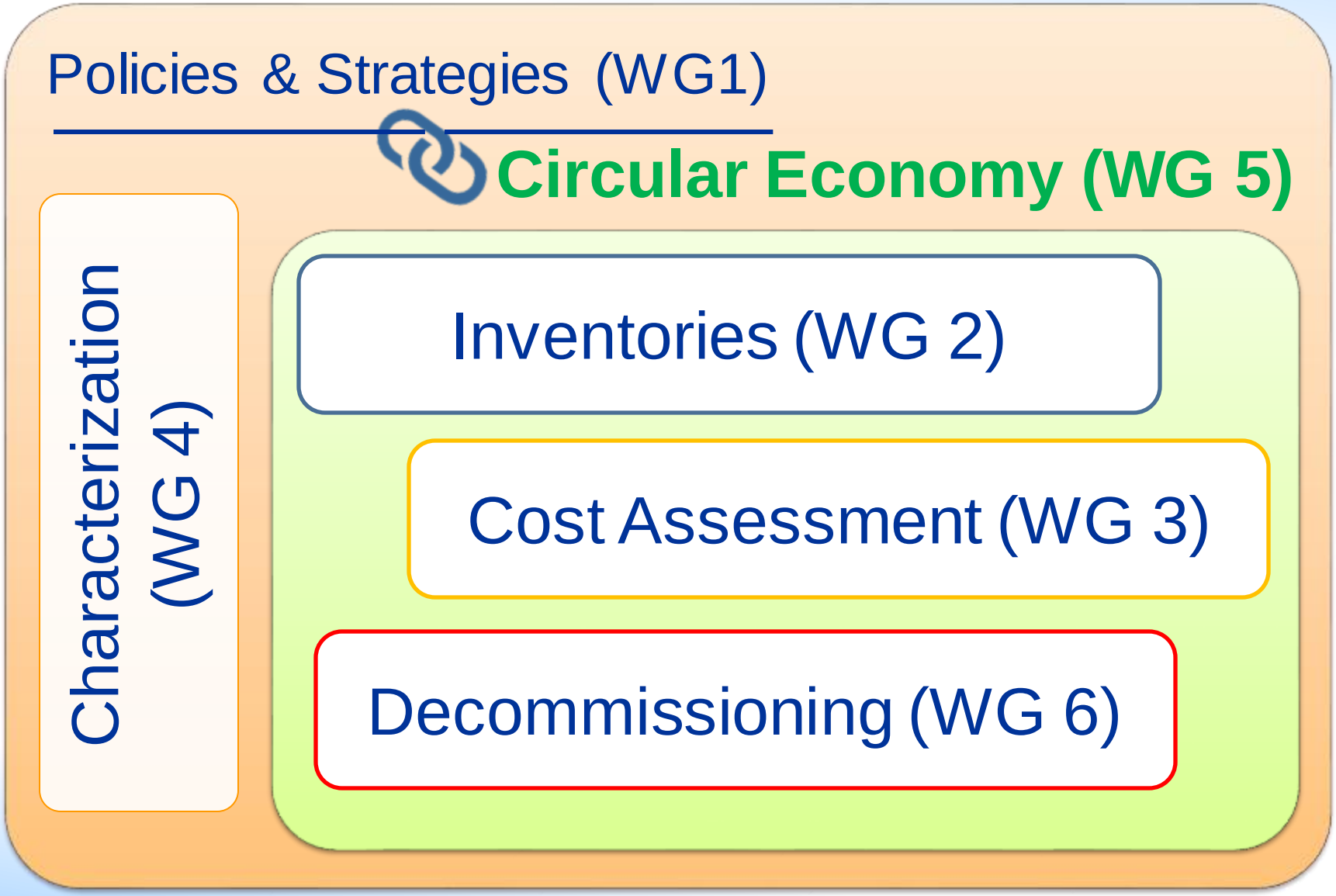
Changes in paradigms are needed. **Wastes should be seen as residues that can be put in beneficial use**. In that regard **innovation will be needed along with funding schemes, stakeholder education, etc**.

Regulations established for linear economy will need to be adapted to a circular economy,

Circularity is not only to be consider to embrace materials but also sites;

The IAEA is committed to support and work with it's Member States in this transition

Environet NORM Project – The Holistic Approach



Click to edit Master title style

JOIN ENVIRONTE – Network on Environmental Remediation and NORM Managment

https://nucleus.iaea.org/sites/connect/ENVIRONETpublic/Pages/default.aspx

IAEA 60 Years
Atoms for Peace and Development

Thank you!