Industrial Circular Economy

DESULF webinar “Can industrial dust be useful?”
15.11.2021@15-17:30

Marjaana Karhu, VTT

91% of our natural resources go to waste after use *
→ huge waste of raw materials and energy
→ pollution of the environment
→ constant need for further exploitation

Demand for materials is growing, e.g. the production certain raw materials (graphite, Li, Co) need to increase over 450% by 2050 to meet demand from energy storage technologies **
→ eventual dwindling of finite raw material reserves

*The Circularity Gap Report 2021, https://www.circularity-gap.world/2021
**Hund et.al, Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition. World Bank Publications. 2020.

Linear mode of operation “take-make-waste” is taking our planet to the breaking point

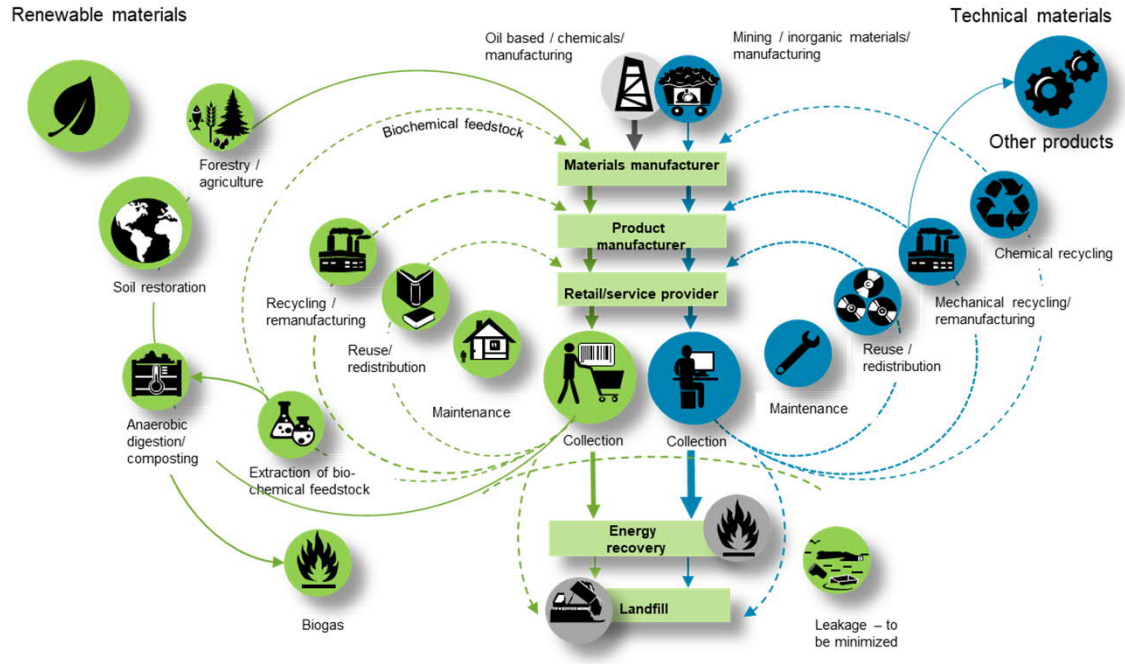
‘Humanity’s demand for ecological resources and services exceeds what Earth can regenerate.’

https://www.overshootday.org/

From linear to circular - shift from linear materials flows into circular loops

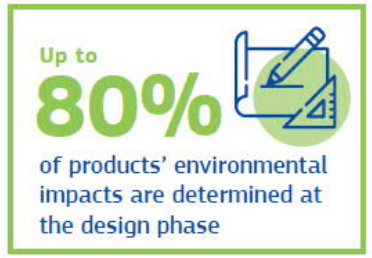
‘ A circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems.’
https://www.ellenmacarthurfoundation.org/circular-economy/what-is-the-circular-economy

- Shifting from liner loops into circular loops is complex and multidimensional.
- We need to change the way of thinking: rethink the big picture of how we use resources, produce and consume goods.
- This requires holistic system-level approach, new tools and methods for system-level analysis, co-creation and data sharing.



Source: Ellen MacArthur Foundation

”Design is the key”



https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan.pdf

‘Design is key to the first principle of circular economy, “design out waste and pollution.”
→ almost everything needs to be redesigned in accordance with the principles of the circular economy.’
https://www.ellenmacarthurfoundation.org/explore/circular-design

Circular economy aspects need to be included as design criteria's at the very beginning of the products’ life cycle: **during the design and material development phases.**

= Circular design aims at optimising the solution from different perspectives across the value chain instead of sub-optimizing.

VTT Research topics and solutions for metals and minerals circular economy

We develop solutions for:

Closing the mineral side streams loops, zero-waste strategies
Recovery of valuable metals
Mineral residue valorisation (e.g. construction applications, ceramics, chemicals)
CO_2 capture and binding into construction materials

Circular-by-design data-based concepts and new business models
Methods and tools for collecting, analysing, refining and using data for circular innovation and business opportunities
Digital tools for circularity and traceability

We create excellence in:

Understanding of mineral side streams properties, processing and valorisation possibilities (Technical viability)

Economic viability, regulatory and sustainability boundaries

Characterization expertise:

- experience more than 60 industrial mineral side stream materials
- e.g. composition (chemical, mineralogical), structure (particle size and shape, crystallinity)
- e.g. reactivity, thermal properties, leachability, phase transformations, density

Design & modelling:

- design for experiments (DOE)
- material flow analyses (MFA)
- thermodynamics, kinetics
- microstructure based finite element modelling (FEM) –modelling

Processing facilities (lab-scale + pilot scale):

- hydro-metallurgy, powder technology
- crushing, milling, mixing, separation, compaction, granulation
- calcination, melting

Economic and environmental assessment:

- Techno-economic analyses (TEA)
- Life Cycle Assessment (LCA)
- Life Cycle Cost (LCC) analysis

Expertise on legislations, regulations, standards

Metals and materials recovery:
https://www.youtube.com/watch?v=PsHWaNihbSM
Powder piloting:
https://www.youtube.com/watch?v=rG0nnb2fZow

CeraTAIL

Novel synthesis methods for porous ceramics from mine tailings*

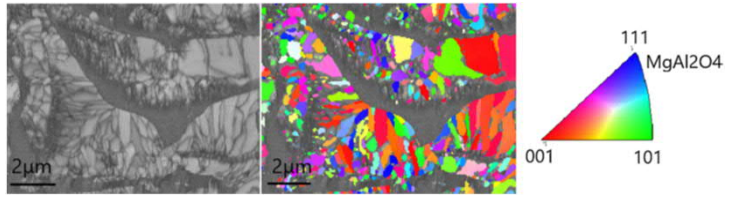
PROJECT TARGET: investigate Finnish inert mine tailings possibilities as a raw material for ceramics industry.

RESULT HIGHLIGHT - Ceramic coatings demonstrated by thermal spray technology using magnesite rich mine tailings together with aluminum anodizing process as raw materials for powder manufacturing.

Ceramic coatings showed the electrical insulation capability at the same level but considerably lower wear rate than for primary magnesium aluminate coatings.

Table 1
The main identified minerals of the talc ore tailings sample (% total volume).

Mineral	Sample vol%
Magnesite, $MgCO_3$	80.0
Talc, $Mg_3Si_4O_{10}(OH)_2$	9.4
Chlorite, $(Mg,Fe)_3(Si, Al)_4O_{10}$	4.9
Dolomite, $CaMg(CO_3)_2$	1.8



Karhu, M., et al. Mining tailings as a raw material for glass-bonded thermally sprayed ceramic coatings: microstructure and properties. Journal of the European Ceramic Society (2020), https://10.1016/j.jeurceramsoc.2020.04.038

* funded by Academy of Finland, MISU programme

Founded by the European Union's H2020 Programme

REslag

Turning waste from steel industry into valuable low cost feedstock for energy intensive industry

RESULT HIGHLIGHT - VTT and Renotech Oy developed a method for the partial replacement of refractory ceramic raw material with steel industry slag.

Tested and validated against commercial refractory materials up to 1200°C, thermal conductivity values of slag based castables show higher thermal insulation capability than commercial ones.

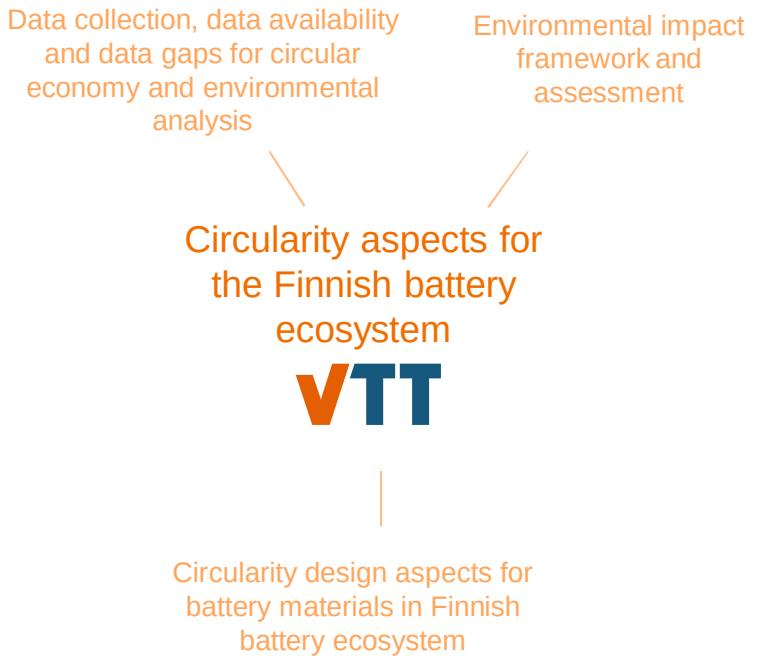
Test components manufactured as a result of piloting, components were installed for test use in two different industrial environments in Finland and in Spain.

https://www.vttresearch.com/media/news/valuable-product-from-steel-industry-slag

Karhu, M et al. Ferrochrome slag feasibility as a raw material in refractories: evaluation of thermophysical and high temperature mechanical properties. Waste and Biomass Valorization (2020), DOI: 10.1007/s12649-020-01092-4.

BATCircle2.0 Finland-based Circular Ecosystem of Battery Metals*

- BATCircle 2.0 is a key project in Business Finland's Smart Mobility and Batteries from Finland programs.
- BATCircle 2.0 consortium consists of six research organizations and 15 companies.
- The research in work packages includes the whole life-cycle of battery metals and minerals from production to recycling.
- WP5 dedicated to Circular battery materials value system:
  - Creating increased understanding and potential in circularity, new business opportunities.



*Business Finland funded Co-Innovation project

BATCircle official (aalto.fi)

Circular Design Network Project

Project: Circular Design Network (CircDNet)
Coordinator: VTT, paivi.kivikyto-reponen@vtt.fi
Consortium: Aalto University, GTK, Luke, SYKE and VTT
Funding: Special funding for RDI partnership networks 2020; 1 995 734 € Academy of Finland + consortium funding
Schedule: 1.1.2021 (1.7.2020) -31.12.2022
Description: The climate change, marine plastics and other urgent environmental issues call for rapid responses. In addition to the on-going stepwise development of existing value chains and operations, we need solutions that are circular by design and have the potential to change our mode of operation more rapidly and at the system level. As a first step, we need data and system understanding of the cycles and value. At the moment circular data is scattered, siloed, in many forms and formats, and it cannot be easily utilized. **Aalto, GTK, Luke, SYKE and VTT have started collaboration to understand the practical data needs and gaps at the system level, to develop new ways of collecting and validating data, and new methods to process and refine data into system level understanding and models**. We will build a network that comprises the data users, providers, developers and the solution providers and users in selected cases, and together demonstrate circular designs based on system understanding.

Circular Design Network

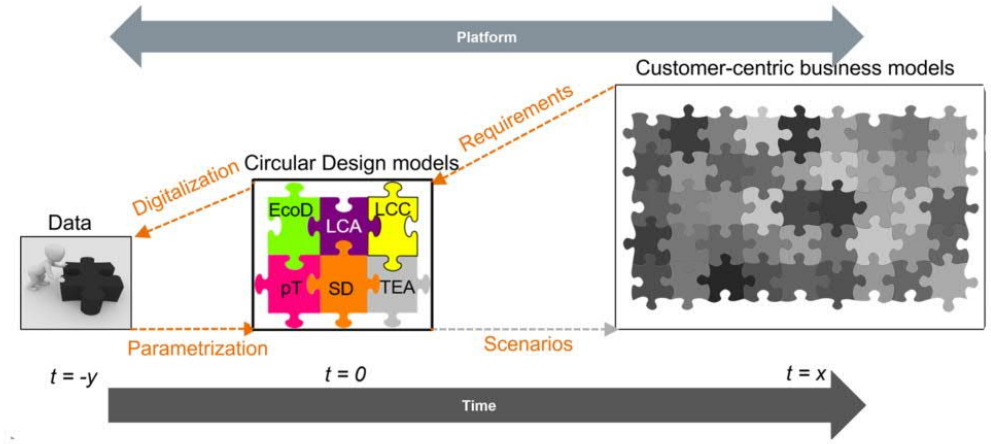
Circular Design Network

circinnovation.com

Circular Design Network
Funded by Academy of Finland
337713, 337714, 337715, 337716, 337717

VTT Circular Design modelling concept *

WHY? Shift from linear economy to circular one requires holistic system-level understanding, and development of new methods and tools to evaluate the impacts and to optimize different design criteria already at early design stages. Designers and decision makers at different levels in organisations need **digital tools for quick and easy evaluation of the impact of different circular design choices**.



WHAT?

Combine VTT's wide-ranging expertise into a unified entity covering business models, system dynamics, life cycle assessment (LCA), life cycle cost assessment (LCC) and material modeling tools.

HOW?

- Integration of different assessment tools and design criteria's (environmental, cost, performance).
- Development of easy access and use demonstration platform to test the effects of different design choices.
- VTT Modelling Factory is a virtual working space for circular solutions, https://modellingfactory.org

* VTT own funded project

https://www.vttresearch.com/en/news-and-ideas/material-design-solutions-circular-economy

https://www.vttresearch.com/en/news-and-ideas/digital-tool-platform-enhances-vtts-role-collaborative-circular-design-birds-eye

https://www.vttresearch.com/en/news-and-ideas/circularity-and-beyond-benefiting-integrated-life-cycle-assessment-lca-and-life

VTT

beyond

the obvious

Marjaana Karhu
marjaana.karhu@vtt.fi
+358405365926
www.linkedin.com/in/marjaana-karhu/