NICER PROGRAMME & INNOVATE UK

CIRCULAR ECONOMY FOR SMEs

Minviro

MINELOOP

INTEGRATING HIGH-RESOLUTION CIRCULAR ECONOMY METRICS WITHIN LIFE CYCLE ASSESSMENT SOFTWARE TO DRIVE RESOURCE CIRCULATION AND REDUCE CRITICALITY OF KEY TECHNOLOGY METALS

The Challenge: What We Were Trying to Achieve

A successful net-zero transition significantly relies on the electrification of energy and transportation industries. Technologies that produce and transfer cleaner energy such as wind turbines, solar photovoltaics, and battery storage systems depend on critical raw materials (CRM) including but not limited to lithium, cobalt and rare earth elements (REEs).

To realise 2050 net-zero targets, the UK needs 600% more critical raw minerals (CRM) inputs by 2040. Primary extraction of CRMs often causes damage to ecosystems and contributes to climate change and biodiversity loss. In this setting, sourcing critical metals from discarded products could supply a third of the UK's REE demand by 2035.

MineLOOP integrates environmental impacts of circular options (reuse, repurpose, remanufacture, recycling) into the overall life cycle impacts of a product and highlights the impact reduction contribution of different options with their potential primary raw material substitution and avoided burdens. By informing circularity decisions with environmental results via life cycle assessment, MineLOOP methodology incentivises implementing a circular economy rather than sending materials to landfill as end-of-life wastes. The new approach would ultimately be integrated into Minviro's LCA softwares for public (producers/manufacturers/academics) usage in the raw materials and battery sectors.

The Approach: How We Tackled the Challenge

Life Cycle Assessment (LCA) systematically measures supply chain impacts and identifies those with the lowest environmental impact, including circular flows (secondary resources). Minviro develops LCA software products for non-experts, enabling the mineral value chain to improve their understanding of environmental footprints and credentials. However, LCA is methodologically bounded by a functional unit, where all flows within the system boundary serve only that function. This causes an 'allocation' issue in LCA when circular flows are under consideration, because in circularity a 'waste' flow will be circled back to the 'input' bundle (in recycling, for example). Since the allocation approach in circularity LCAs is unestablished, we needed to extend our research and adopt different approaches for different applications. This was prone to miscalculation risks and misjudging recycling 'credits' and benefits.

To tackle these issues, we decided to separate MineLOOP methodology for materials and products based on the discussions with our advisory partner Met4Tech. Because material circularity and product circularity have different options and scenarios that should be considered, we needed to change our approach as well. Consulting with our advisory partner helped us to frame our goal and scope in a more concise manner.

We have also attended various circular economy and metal recycling conferences and talks to gather feedback from industrial partners and professionals, which enabled us to prioritise our task lists and deliver a right-to-the-point tool in the end.

Unexpected Outcomes: What We Learned Along the Way

We have learned that in addition to the complexities of recycling processes, LCA in this space requires extensive research and interpretation to adopt the best available and applicable approach.

One of the unexpected routes we had to take during the project phase was tailoring our methodology for material-based and product-based circularity scenarios and delivering different MineLOOP frameworks. This was raised in our discussions with Met4Tech.

Another surprising outcome is the perception of high environmental performance from recycling and

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circular options. Our work in the metal and battery recycling space showed that the 'credits' claimed from recycling are often not as high as one would expect no matter what the recycling LCA approach is. The benefits must be communicated in an impact sense, but also in the relief for primary supply chain stresses, to fully comprehend 'benefits'.

Key Learning: What We Would Do Differently Next Time

We'd strongly suggest sparing enough time and a rigorous feedback loop for the pre-implementation research phase to fully understand the hidden implications of the project or methodology. This project taught us how to reshape the framework of the methodology and background calculations without derailing the aim and scope of the project. We had to be agile and concise to adjust different approaches for different applications.

The Outcome: What We Achieved and How It Has Impacted the Business, Society and Key Stakeholders

This project enabled us to understand and calculate the environmental impacts of different recycling scenarios through different LCA approaches reflecting various cases. Thanks to research behind this project, we started providing LCA results to clients with end-of-life impacts and potential benefits of recycling and other circularity options such as repurposing and reuse. We will continue our growth in the circularity business and help improving businesses and research projects with environmentally informed decision-making tools.

Economic Benefits:

- MineLOOP creates demand for lower-impact CRMs (even at higher prices), making impacts visible to industry/consumers through benchmarking. For plants where margins are extremely small (e.g. new NdFeB magnet supply-chains from imported waste-mineral sand [LCM,2021]) MineLOOP quantitatively evaluates/optimises site design (as-well-as for new mines/refineries/gigafactories/recycling-plants), ensuring outputs are low-impact and cost-competitive.
- Methodology used in MineLOOP reduces the complexity of recycling LCAs. This is not only in the raw materials sector, but also applicable in all recycling applications, providing a room for expansion in Minviro's own company profile and can also inform novel approaches in circular economy such as industrial symbiosis.
- MineLOOP encourages the understanding of environmental impacts in the circular economy space, thus aligning circular activities with sustainability principles (which are currently not truly aligned scientifically). This has a potentially positive impact on shaping future circularity incentives and policies shaped by government and organisations in a more environmentally-aware state.

Environmental Benefits:

- MineLOOP enables users to correctly estimate (for feasibility studies and emerging processes) the potential impacts and benefits of recycling routes for metals and other materials. This will eventually inform and enable environmentally-sound recycling routes and guide the industry in the right direction.
- Negatively, increasing recycling infrastructure has environmental impacts: MineLOOP calculates trade-off impacts (whole systems thinking) so each option can be compared.
- Applications of MineLOOP methodology for other circularity options such as reuse and repurposing opens the room for discussion about the environmental trade-offs of different circularity choices with informed decisions.

Social Benefits:

- Developing resilient secondary supply chains in the UK creates new socioeconomic opportunities around the UK in the manufacturing and raw materials industries.
- The complexity and resource demand of recycling processes alongside other circularity options requires rigorous research and development activities, attracting high-skilled talent from around the world and benefiting UK's research space.

Regional Benefits:

- Minviro's close connections to Camborne School of Mines in Cornwall and Met4Tech's research domain supports Cornish mining education and mining activities in the region by creating an opportunity for an environmentally informed mining culture and community.

Looking Forward: Next Steps and Future Directions

The first next step in our list is delivering product-based circularity journey in our MineBIT battery LCA tool where users can measure and compare impacts of different circularity options for lithium-ion batteries. We will explore and integrate novel recycling routes for batteries in our databases and keep informing the industry and research in this space.

Our methodology is also not restricted to only metals, it can be applied to different materials and products in the economy. This creates an opportunity for Minviro to explore different recycling markets, including plastics, construction and more. Watch this space!

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