Integrated economic and environmental assessment as driver for innovation of metallurgical systems for the recovery of metals from low grade input materials

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Introduction
Low-grade primary ores and secondary industrial residues often yield significant amounts of (critical) metals. As deposits of raw materials in Europe are not easily accessible or are depleted after years of exploitation, these low-grade resources could serve as reliable new sources of metals. Traditional pyro- and hydrometallurgical methods do not suffice to exploit metals from these resources. Within the METGROW project, the main aim is to valorise the low-grade resources by implementing novel methodologies in a metallurgical system, with a zero waste approach in which valorisation of all outputs of the raw materials is achieved. In order to reach that aim, a decision support system including a multi-criteria analysis that integrates Life Cycle, Risk and Techno-Economical Assessment (LCA-RA-TEA) will be performed as an iterative process to support process development. Importantly for the LCA-RA-TEA is to align the goal and scope of the studies.

Goals
• Assessing environmental and economic impacts and risks of novel metallurgical systems under investigation in METGROW+
• Zero-waste concept to valorise all outputs.
• Developmental support of metallurgical technologies: Steering and decision making

Methodology
As the different UOs are still under development, complete flow sheets are not yet available. The LCA-RA-TEA assessment will therefore use the preliminary lab scale data of the different UOs and model these to industrial scale. Data regarding raw input material, chemical reactions, process chemicals, outputs and equipment needed will be requested for in silico UO simulations at industrial scale. This will provide information on all material flows and on the economical investment and operational costs of each operational unit. Assessment of potential flow systems will be predicted by adding impacts of the involved UOs, corrected for the mass flow. Similarly, the RA for human health and environment will be performed for the predicted exposure during the UOs.

Life Cycle Assessment
Goal: Minimizing the environmental impact of products/processes
Method: ILCD2011
Impact categories (IC): The 15 default Product Environmental Footprint (PEF) categories
Outcome: Identify key ICs of each UO and metallurgical flow system.

Risk Assessment
Goal: Ensure safe production and use for man and environment.
Endpoints: • Human health
• Ecotoxicity (water, sediment, soil)
Outcome: Risk management measures to limit exposure to hazardous substances in each UO and during use of valorised matrix materials.

Techno-Economical Assessment
Goal: Increasing the social and economic returns on investments
Economical impacts: • Net Present Value
• Internal Rate of Return
• Payback period
Outcome: Economic investment appraisal of each UO and metallurgical flow system.

Outlook
We propose a methodology that focuses on the economical, environmental and risks aspects for the development of novel metallurgical flow systems consisting of the combination of unit operations. A multi-criteria assessment will weight all these parameters and give feedback to the technology developers to: (i) steer the development of the individual unit operations (ii) help to optimise the metallurgical flow sheets. By applying this methodology in a iterative approach starting in the early phase of the technology development, we want to achieve a more efficient technology development with regard to economic and environmental performance, to ensure efficient implementation of novel technologies in industry.