TRANS ZERO WASTE

Upgrading of low-quality iron ores and mill scale with low carbon technologies

Research for novel technological approaches

Newsletter

Showcasing Circularity in Steel Production: ISQ at the Cyprus ’25 Conference

As part of our ongoing commitment to advancing sustainability in industrial processes, ISQ had the opportunity to participate in the 12th International Conference on Sustainable Solid Waste Management – Cyprus ’25, held in June 2025. In collaboration with LIST, we presented a poster outlining a key deliverable of the TransZeroWaste project: the circularity indicators framework developed within Task 5.1 of WP5.

This framework is designed to assess how efficiently steel-producing partners manage their material flows, both under current operating conditions and in future scenarios involving new recycling pathways under development by the project. By quantifying circularity performance, the framework aims to highlight strengths, identify bottlenecks, and uncover synergies that could drive more effective waste valorisation strategies within the steel industry.

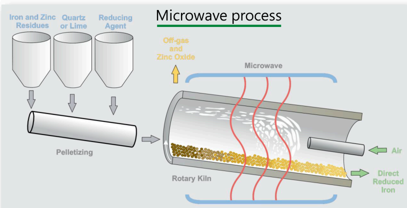
Beyond its immediate application in TransZeroWaste, the framework offers a replicable model for researchers and professionals working across industrial sectors. As the EU and global community continue to raise the bar on environmental targets, such tools will be essential to ensure that technological innovation translates into real, measurable sustainability gains.

The poster (no. 127), along with a short oral presentation, is available through the official conference website: https://cyprus2025.uest.gr/poster.html

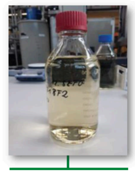
How can you measure circularity in the steel sector?

Circularity Framework for Assessment of Novel Steel Waste Valorisation Technologies

Background: The steel industry faces significant pressure to reduce polluting emissions and to transition towards more sustainable production methods. The **TransZeroWaste** project is developing advanced technologies to assist in this: hot microwave pelletising, cold pelletisation and briquetting, and hydrometallurgy for mill scale de-oiling. However, these must be evaluated using robust circularity indicators to ensure real environmental benefits.



Magnet loaded with oily scale



Cleaning agent after recovery

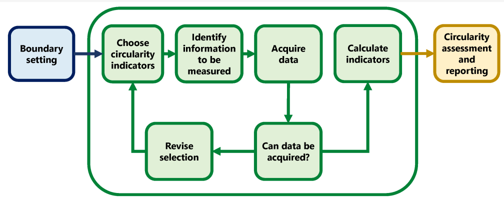
Agglomeration trials with tablet press

Hot microwave pelletising

Methods

1 Comprehensive review of existing circular economy frameworks, standards and publications. This included peer-reviewed literature, industrial guidelines, and recently published norms – particularly the ISO 59020 (ISO 2024) standard. Initial compilation of **72** circularity indicators.

2 Filtering down to **11** indicators. Key considerations:
a) applicability to different steel production routes;
b) the capacity to reflect changes in resource flows when the new technologies are introduced;
c) alignment with industry standards and best practices for circular economy assessment;
d) feasibility of data collection at both pilot and industrial scale



Circularity framework definition and application steps. Adapted from ISO 59020 (ISO 2024)

Results

	Indicator	Calculation	Objective
1	Circularity Index (CI) (Cullen 2017)	$\beta = 1 - \frac{energy\ required\ to\ recover\ material}{energy\ required\ for\ primary\ production}$ $\alpha = \frac{recovered\ EoL\ material}{total\ material\ demand}$ $CI = \alpha\beta$	Maximize
2	Reuse Potential Indicator (RPI) (Park and Chertow 2014)	$RPI = A + B/C$	Maximize
3	Circular process feedstock intensity (CPFI) (Lokesh et al. 2020)	$CPFI = \frac{M_{raw\ mat}}{M_{main\ prod} + M_{co\ prod} + M_{re\ mat}}$	Minimize
4	Circular process waste factor (CPWF) (Lokesh et al. 2020)	$CPWF = \frac{M_{tot\ w}}{M_{main\ prod} + M_{co\ prod} + M_{re\ mat}}$	Minimize
5	Circular process energy intensity (CPEI) (Lokesh et al. 2020)	$CPEI = \frac{E_{fos\ d} + E_{ren\ d} - E_{int\ d}}{M_{main\ prod} + M_{co\ prod} + M_{re\ mat}}$	Minimize
6	Recycled content (RC) (Graedel et al. 2011)	$RC = (j + m)/(a + j + m)$	Maximize
7	Recycling process efficiency rate (Graedel et al. 2011)	$Recycling\ process\ efficiency\ rate = g/e$	Maximize
8	Old scrap ratio (OSR) (Graedel et al. 2011)	$OSR = (g)/(g + h)$	-
9	Ratio water reuse or recirculation (WRR) (ISO 2024)	$R_{WRR} = (V_{TWU})/(V_{TWW})$	Maximize
10	Energy intensity (EI) (ISO 2024)	$I_{EI} = (E_{TIE})/(n_{PU})$	Minimize
11	Water intensity (WI) (ISO 2024)	$I_{WI} = (E_{TIW})/(n_{PU})$	Minimize

A - actual reuse quantity (yearly); **B** - further use potential quantity. (yearly); **C** - total quantity of given by-product generated (yearly); $\mathbf{M_{raw.mat}}$ – mass of raw materials; $\mathbf{M_{main.prod}/M_{Prod}}$ – mass of main products; $\mathbf{M_{co.prod}}$ – mass of co-products; $\mathbf{M_{re.mat}}$ – mass of recycled materials; $\mathbf{M_{TotW}}$ – total mass of waste; $\mathbf{E_{FosD}}$ – fossil derived energy used; $\mathbf{E_{RenD}}$ – renewable energy used; $\mathbf{E_{IntD}}$ – internally derived energy used; **j** – scrap used in fabrication (new and old); **m** – scrap used in production (new and old); **a** – primary metal in ore; **g** – recycled EoL metal (old scrap); **e** – EoL metal collected for recycling; **h** – scrap from manufacturing (new scrap); $\mathbf{V_{TWU}}$ – total water used; $\mathbf{V_{TWW}}$ – total water withdrawn; $\mathbf{E_{TIE}}$ – total inflow energy; $\boldsymbol{n_{PU}}$ – number of produced units; $\mathbf{E_{TIW}}$ – total inflow of water.

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