Title

Criticality-Driven Sustainability Assessment and Thermodynamic Optimisation for Advanced Materials, Production and Circular Recovery (Cluster 4 & Cluster 6)

Short Description

The Industrial Ecology Group at the Energaia Institute from the University of Zaragoza and led by Alicia Valero Delgado offers advanced expertise in critical raw materials assessment, ecodesign strategies, life cycle assessment (LCA), and exergy-based simulation of mining and metallurgical processes. We seek to contribute to HORIZON-CL4-2026-01-MAT-PROD-14 and HORIZON-CL6-2026-01-CIRCBIO-03 by strengthening sustainability assessment, material selection and optimisation of production and recovery systems.

Full Description

The Industrial Ecology Group, led by Prof. Alicia Valero Delgado, provides systemic and quantitative methodologies to support sustainable materials development, advanced production systems, and circular recovery of critical raw materials (CRMs).

Our contribution bridges **materials innovation (Cluster 4)** and **advanced recovery from WEEE (Cluster 6)** through thermodynamic resource accounting, criticality assessment and process optimisation.

---

1. Criticality Assessment for Advanced Materials and Secondary Resources

We develop dynamic and thermodynamic-based criticality methodologies that:

- Quantify supply risk and geopolitical exposure
- Integrate thermodynamic rarity and physical scarcity
- Assess vulnerability of advanced materials to CRM constraints
- Compare primary and secondary sourcing strategies

For **MAT-PROD-14**, this enables criticality-informed material selection and substitution strategies.
For **CIRCBIO-03**, it supports prioritisation of target metals in WEEE recovery systems.

---

2. Ecodesign and Circularity Integration

We support integration of sustainability into product and material design by:

- Identifying critical material hotspots
- Evaluating substitution and dematerialisation options
- Assessing durability, modularity and recyclability
- Analysing how design choices affect end-of-life recovery performance

This creates a feedback loop between advanced materials development and future recycling efficiency.

---

3. Life Cycle Assessment (LCA) of Products and Processes

We conduct comprehensive environmental and resource assessments at:

- Material level
- Production process level
- Product system level
- Recycling and recovery system level

Our work includes:

- Attributional and consequential LCA
- Integration of criticality indicators into LCA
- Scenario modelling for 2030–2050 deployment
- Comparative assessment of innovative vs. conventional technologies

For MAT-PROD-14, we evaluate sustainability of novel materials and production routes. For CIRCBIO-03, we benchmark advanced recovery technologies from WEEE.

---

4. Thermodynamic Simulation and Process Optimisation

A distinctive capability of our group is exergy-based simulation of mining, metallurgical and recycling processes. We:

- Model extraction, refining and recovery pathways
- Quantify irreversibilities and material dissipation
- Identify thermodynamic bottlenecks
- Optimise energy and material efficiency
- Benchmark alternative production or recycling routes under consistent physical metrics

This provides a physically grounded basis for improving process efficiency and long-term resource productivity.

Role in the Consortium

We are interested in:

- Leading or co-leading a Work Package on sustainability and criticality
- Leading tasks on LCA and environmental benchmarking
- Leading thermodynamic modelling and optimisation
- Contributing to impact assessment aligned with the Critical Raw Materials Act and EU industrial strategy

Our added value lies in combining **criticality science, industrial ecology and thermodynamic process modelling**, ensuring that advanced materials and recycling innovations are robust from environmental, strategic and physical-resource perspectives.