Recycling of Lithium from Secondary Raw Materials and Further

Lithium-relief.eu

RELiEF Project

Life cycle perspectives on secondary Lithium sources

ANISH PATIL – EXPLOITATION (TECH CONCEPTS)

JOANA GOUVEIA – LCA ACTIVITIES (INEGI)

25-06-2025

Funded by the European Union

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2. Global Approach
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4. Cluster Hub interaction for regulatory environment
5. Stakeholder Perspectives on EU Regulatory Frameworks
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3. Lithium market
4. RELiEF Life Cycle Approach
5. LCA results for process design
6. Main recommendations

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Part I: Exploitation

Anish Patil

Tech Concepts

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RELiEF introduction

- Recover Li from potential **secondary sources** in order to **reduce unrecovered Li**
- Reduce **Li waste** and **transform** recycled Li into high value **battery-grade material**.
- Establish an integrated Li **recycling facility** with continuous processing to produce battery materials.
- Contribute to **decrease** the **dependency** of the **EU** on imported **battery** chemicals and raw **materials**.

Secondary lithium resources – both **solid** and **liquid**.

- Liquid – wastewater from recycling industries / organics from pharma
- Solid – mine tailings and lithium alloy waste

Challenges

- These waste streams are currently not valorised, because the content of lithium is very low
- Main challenge is to find high efficiency processes to make the recovery of lithium cost effective

Global Approach

Preliminary pre-treatment to remove hazardous components from the solid/liquid secondary streams

Leaching of lithium so that it liberates lithium from the solid matrix

Lithium is thereafter recovered as a multi element solution.

The extracted lithium from the purified solution is then turned into recycled lithium hydroxide

Validation of lithium hydroxide as a relithiation agent for an end-of-life LFP cathode material

Production of lithium metal to used as a anode in next generation batteries

Life cycle inventory of the innovative processes developed in RELiEF, through a Digital Data Platform (DDP) that maps physical, monetary and social data of the developed circular processes as an enabler for environmental and cost analysis models.

Materials for batteries – Cluster Hub

- The Cluster Hub “Production of raw materials for batteries from European resources” is a knowledge exchange ecosystem for partners involved in different European projects working on materials and batteries
- The platform facilitates collaboration among research institutes, industry and innovation stakeholders driving the recycling of batteries and the production of raw materials for battery applications from primary and secondary resources available in Europe.
- RELiEF has used the Cluster Hub platform to strengthen the interaction with external stakeholders

Cluster Hub Interaction to understand the perspective wrt regulatory environment

- Mentimeter was used as an online interactive session (~20 questions) facilitation tool, while the audience were asked questions about various plans, acts, regulations to understand their perspective.
- Whether these laws/acts complement or contradict each other?
- Are they confusing or conducive?
- What “measures” or “incentives” are the most critical to be achieve the objectives.

The **Green Deal Industrial Plan** enhances the competitiveness of Europe's net-zero industry and is accelerating the transition to climate neutrality. It does so by creating a more supportive environment for scaling up the EU's manufacturing capacity for the net-zero technologies and products required to meet Europe's ambitious climate targets.

The **Net-Zero Industry Act** is an initiative stemming from the Green Deal Industrial Plan which aims to scale up the **manufacturing of clean technologies** in the EU.

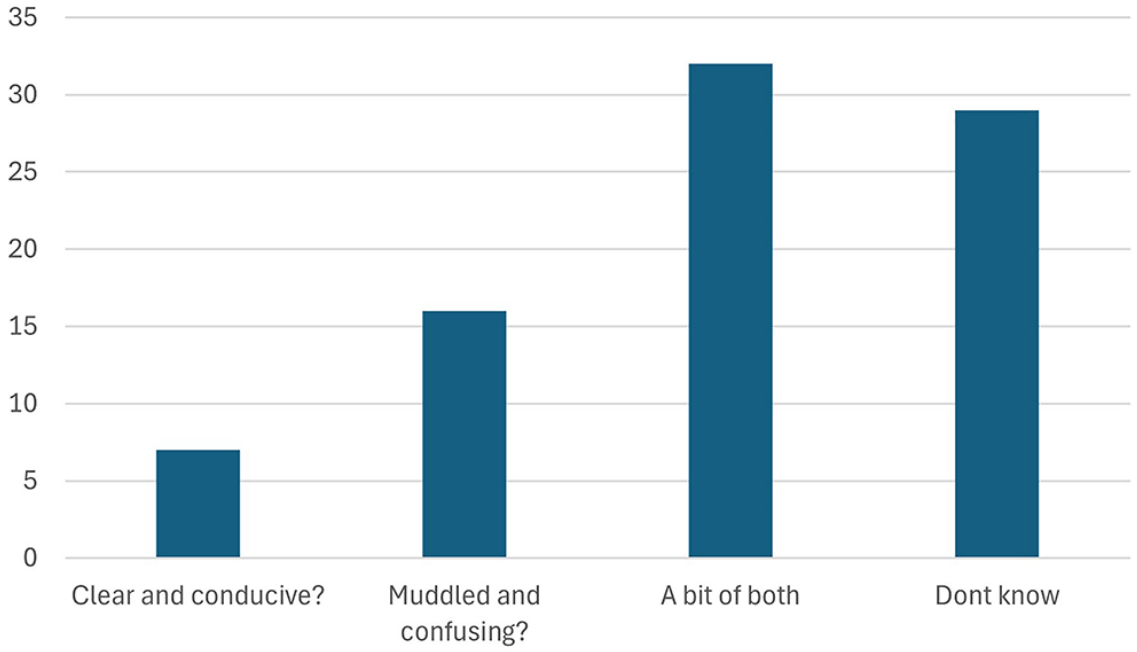
Critical Raw Materials Act will ensure that the EU can rely on strong, resilient, and sustainable value chains for **critical raw materials**.

EU battery regulation is part of The European Green Deal. It focuses on creating a **circular economy for battery materials** in Europe. In addition, it improves the **safety and performance of batteries**.

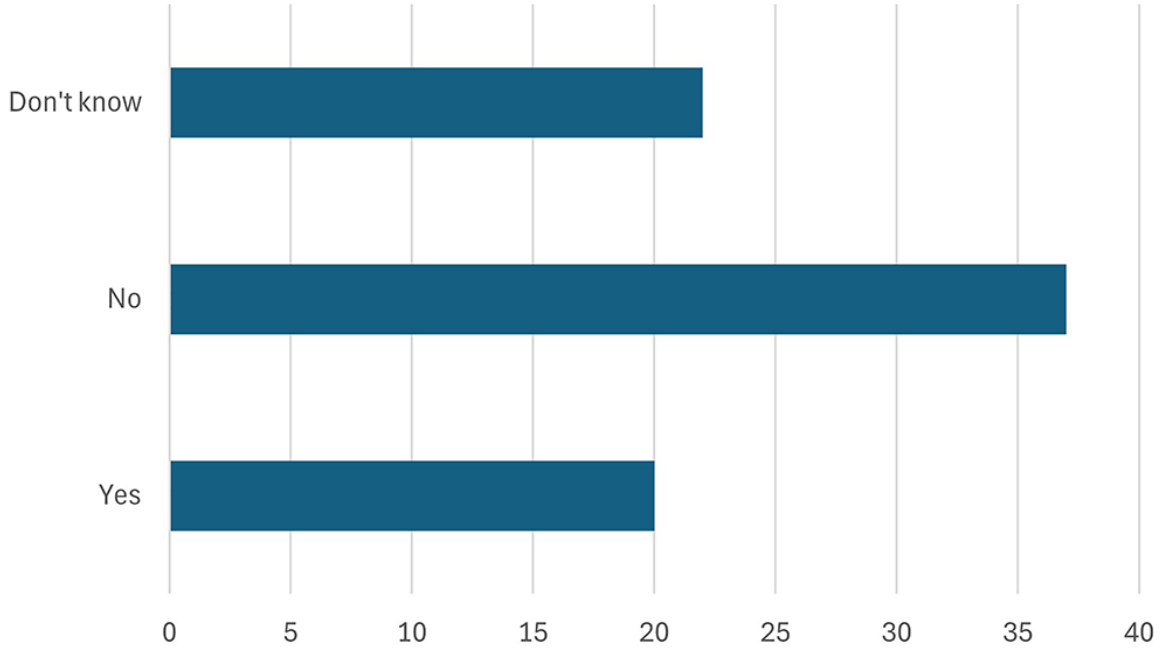
Stakeholder Perspectives on EU Regulatory Frameworks

- Paper published by TC - Stakeholder Perspectives on EU Regulatory Frameworks: Navigating Critical Raw Materials, Battery Innovation, and Recycling Challenges
  - https://doi.org/10.12688/openreseurope.19634.1
- 4 interactive workshops during different cluster (and cluster project) events, with more than 100 respondents
- Central Research Problem
  - Despite their shared objectives, the implementation of the Green Deal Industrial Plan, Net Zero Industrial Act, Critical Raw Materials Act, and European Battery Regulation 2023 raises questions about their coherence and effectiveness as a unified policy framework.
- Specifically, the two research questions are:
  - Do these initiatives complement each other in achieving the EU's climate and industrial goals, or do they create unintended contradictions or redundancies?
  - How do different stakeholders perceive and interact with this regulatory framework, and how does this influence its overall success?

Few highlights from the paper



Perception of the EU regulatory climate



Will the NZIA targets be achieved.

Findings indicate that while these policies, frameworks, acts – although they are very relevant and all share common objectives, they exhibit overlaps and inconsistencies that create barriers to investment and innovation.

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Part II: LCA for technology ecodesign in Li recovery from waste streams

Joana R. Gouveia

INEGI

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1. Sustainability in RELiEF

INEGI leads the Sustainability activities, aimed to:

- Assess **the environmental, costs and social impacts** of the RELiEF technologies
- Determine the main hotspots and **provide targeted sustainability improvement actions**
- Integrate the sustainability aspects and develop a **circular business model**

Anchored PhD thesis

Life Cycle Sustainability Assessment of new Circular Valorisation Streams for the next-gen Lithium-based Energy Storage Systems

2. RELiEF secondary Li recovery

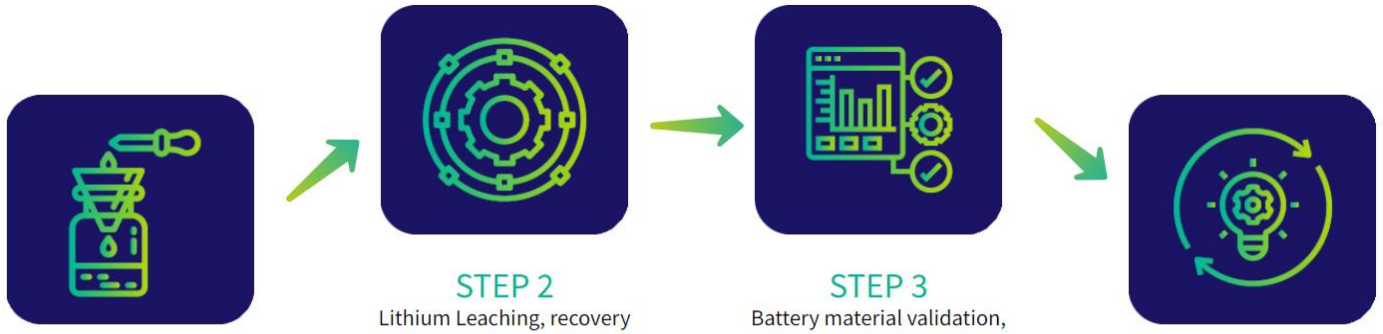
Global LITHIUM DEMAND is constantly **INCREASING**

LIMITED AVAILABILITY and HIGH ENVIRONMENTAL IMPACT

RELiEF technology for Innovative recycling:

Give **New Life** to **Li market** by **RECYCLING unused secondary Lithium sources**

Global approach:

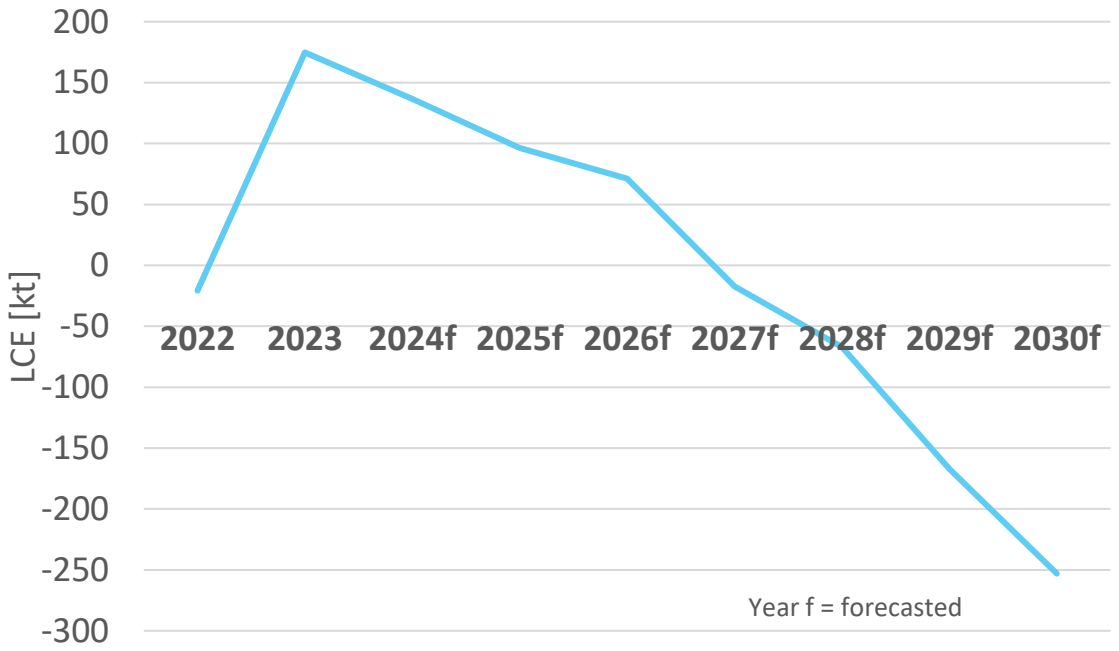


RELiEF KPIs:

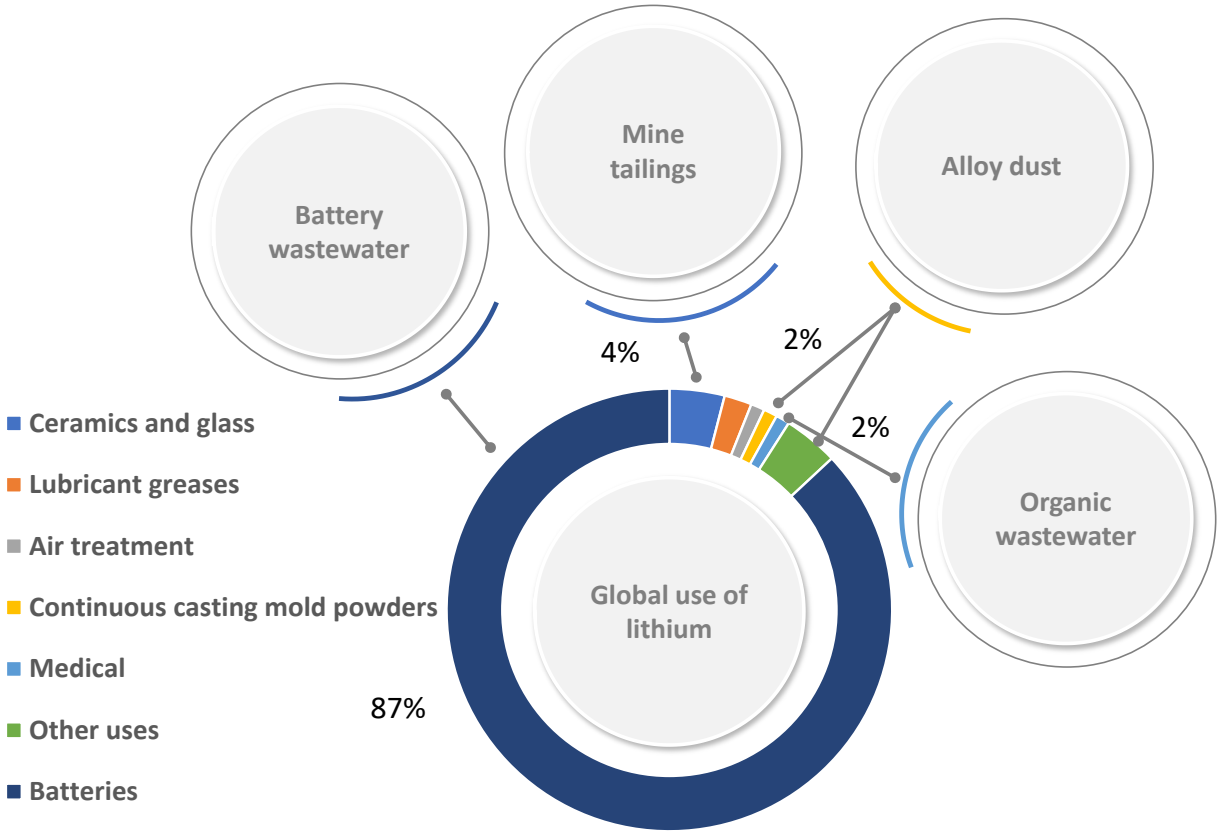
- **>40% impacts** (waste generation, water use, water pollution, energy consumption, chemicals use and CO_2 emissions)
- **20% reduction on lithium material** for primary battery precursors
- Engagement of at least 3 policy makers from EU member states

3. Lithium market

Lithium supply-demand balance[1]



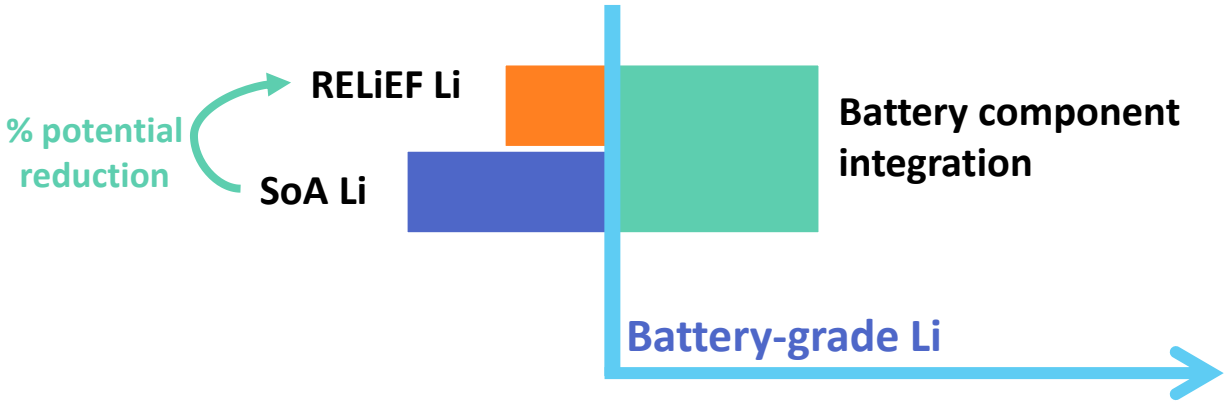
Global use of lithium and Li containing wastes[2]

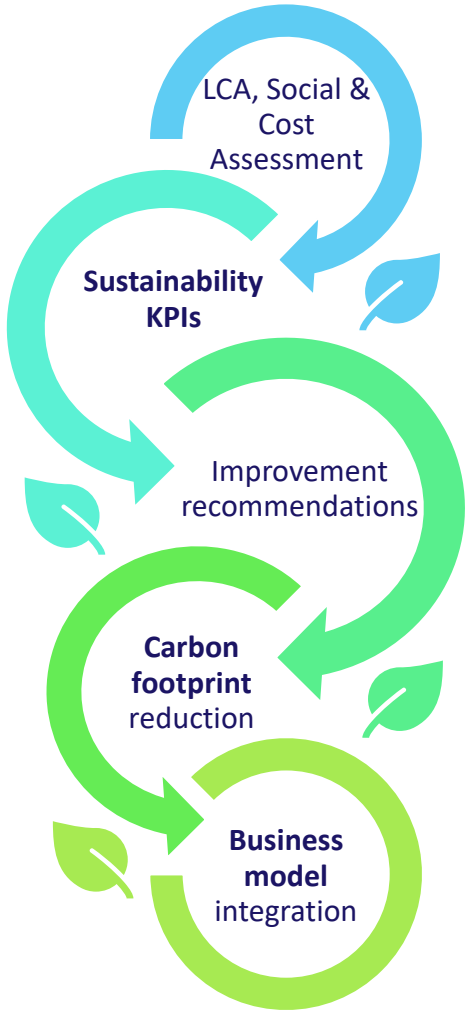


[1] Fastmarkets. (2024). Webinar Battery Raw Materials Global Outlook 2025. https://www.fastmarkets.com/webinars/battery-raw-materials-global-outlook-for-2025/
[2] U.S. Geological Survey. (2024). Mineral commodity summaries 2024: U.S. Geological Survey. https://doi.org/10.3133/mcs2024

4. RELiEF Life Cycle Approach

Focusing on what matters in the end for the final product output:



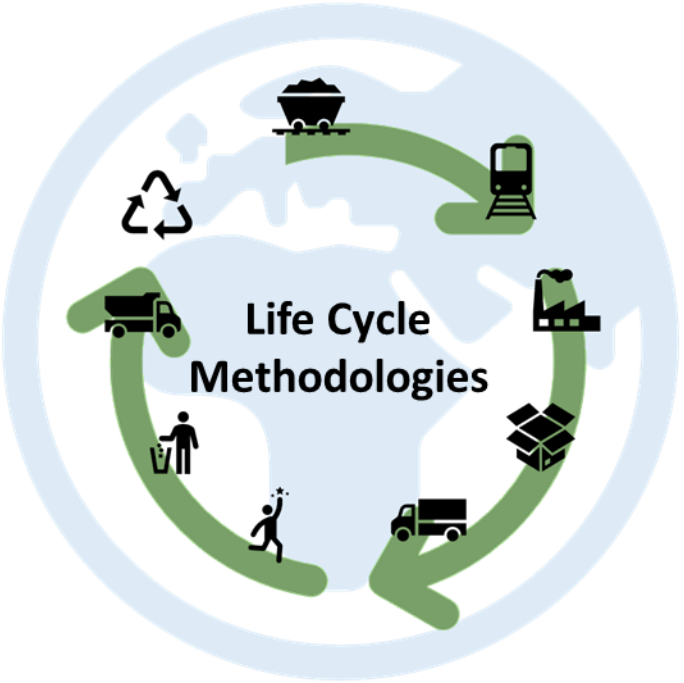


Functional unit for RELiEF technology validation*:

"1 kg of battery-grade lithium carbonate produced"
Purity level to be reached: **> 99.5 %**
Average yearly production

*Pilot-line validation in TRL 4-5

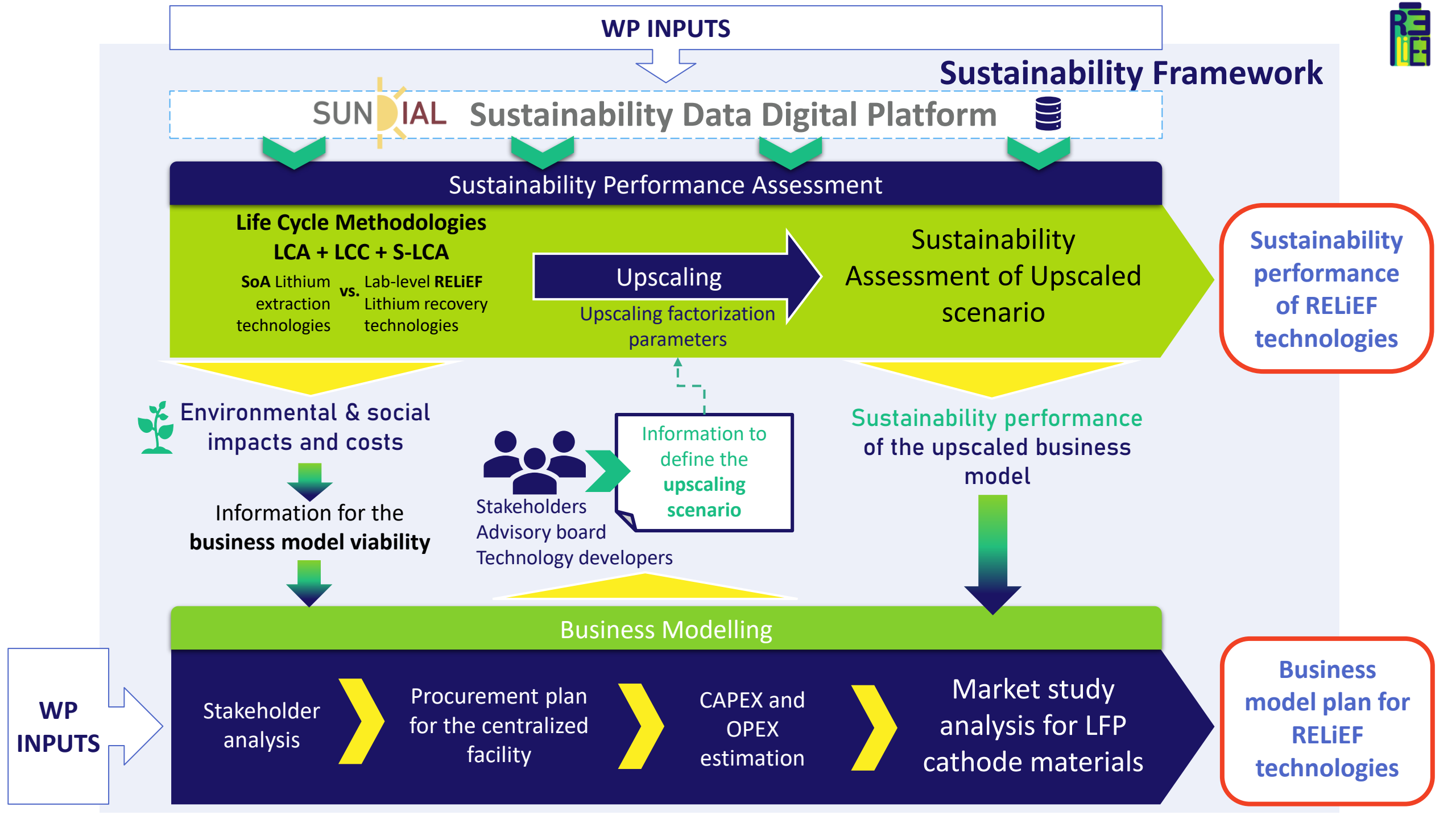
4. RELiEF Life Cycle Approach



Life Cycle Inventory
powered by
SUNDIAL

Environmental Performance
Costs
Social impacts

- S**treamlined** data collection in a **confidential manner**
- **Facilitated** decentralized **data collection** with a **lower effort** to build robust data models
- Enabled **automated** data collection for **enhanced efficiency and accuracy**
- Adequate and effective for **underdeveloped technologies** data collection

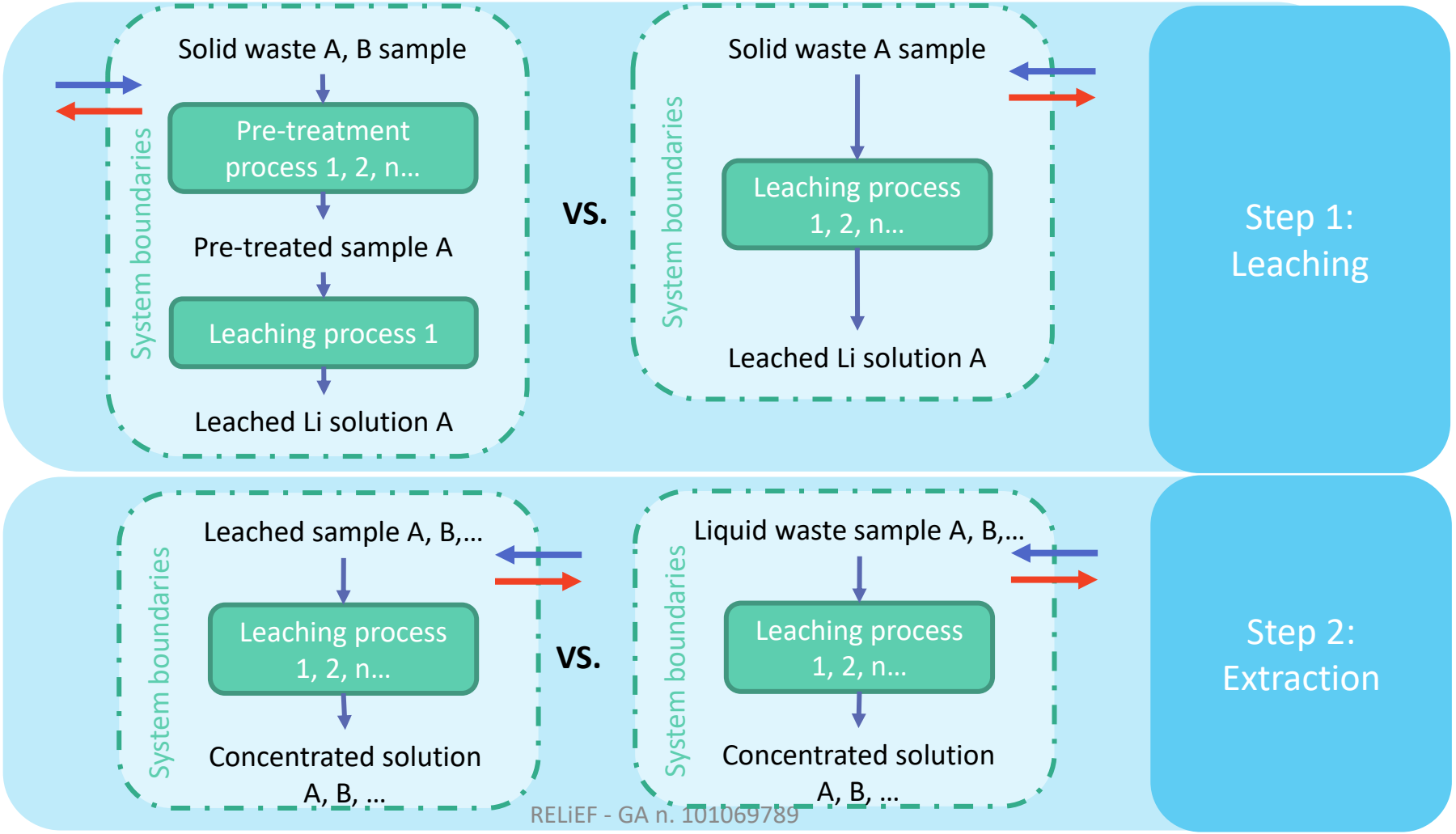

WP INPUTS
Sustainability Framework
SUNDIAL Sustainability Data Digital Platform
Sustainability Performance Assessment
Life Cycle Methodologies
LCA + LCC + S-LCA
SoA Lithium extraction technologies
vs.
Lab-level RELiEF Lithium recovery technologies
Upscaling
Upscaling factorization parameters
Sustainability Assessment of Upscaled scenario
Sustainability performance of RELiEF technologies
Environmental & social impacts and costs
Information for the business model viability
Stakeholders
Advisory board
Technology developers
Information to define the upscaling scenario
Sustainability performance of the upscaled business model
Business Modelling
WP INPUTS
Stakeholder analysis
Procurement plan for the centralized facility
CAPEX and OPEX estimation
Market study analysis for LFP cathode materials
Business model plan for RELiEF technologies

5. LCA results for process design (lab-level)
System boundaries

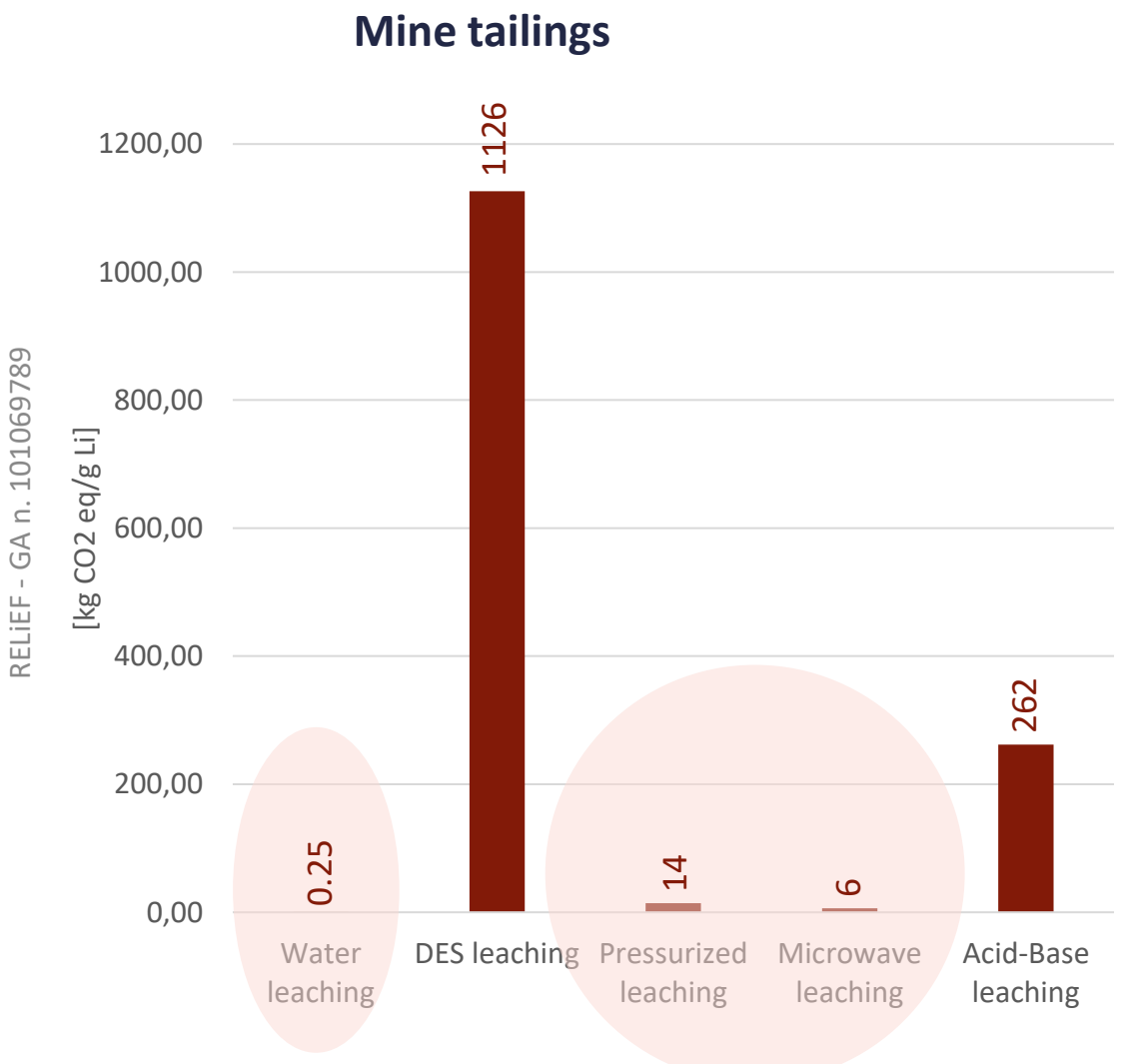
For each step, **several technologies were developed**

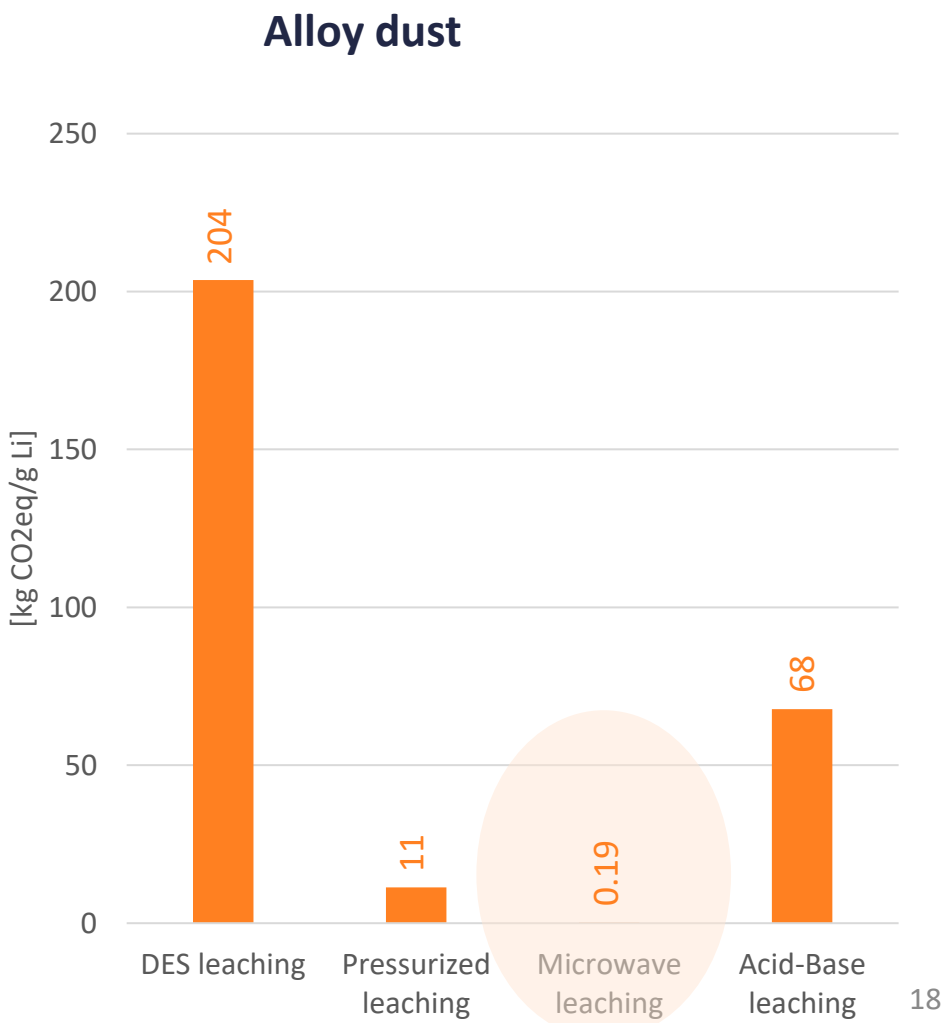
Solid samples:
- Mine tailings (PEG)
- Al/Li alloy dust (LS-dust)

Liquid samples:
- Battery Wastewater (B-WW)
- Pharmaceutical wastewater (OS)

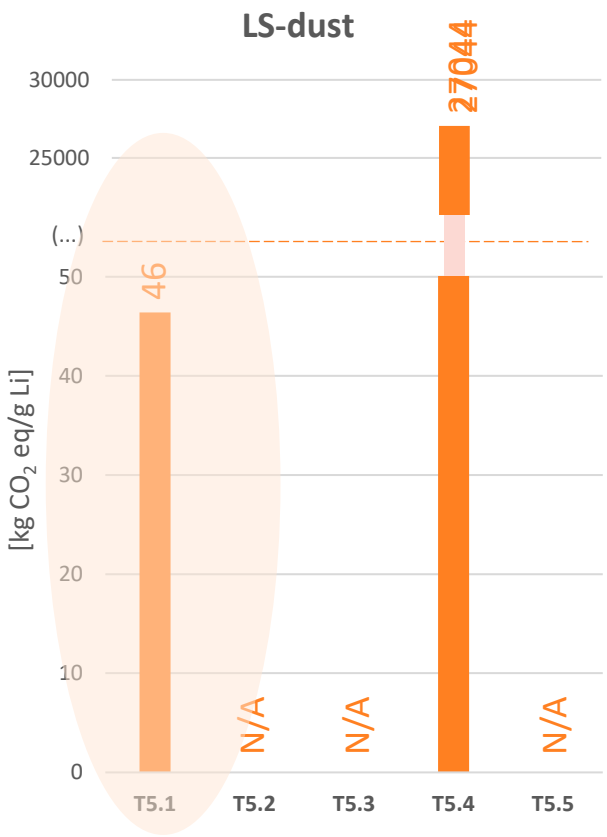


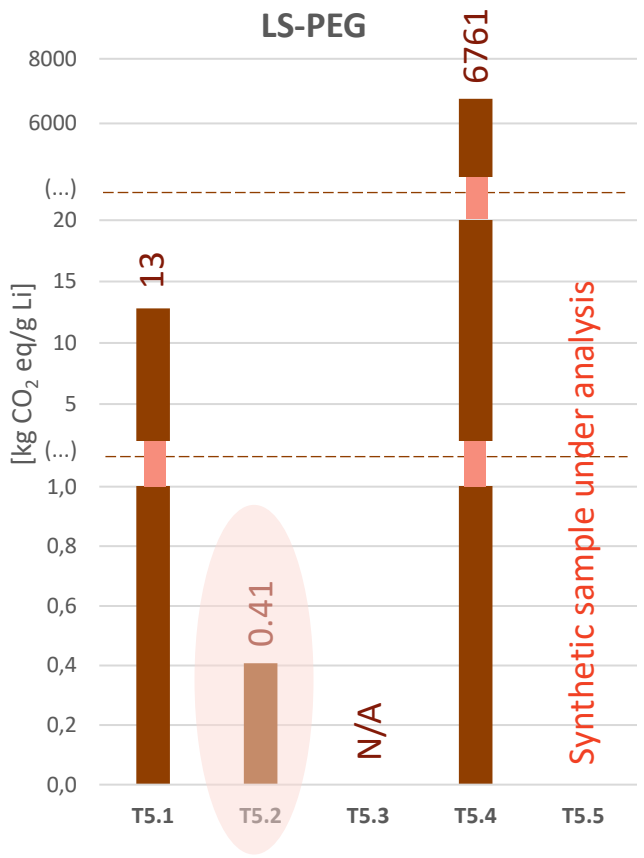
5. LCA results for process design (lab-level)
LCA results – Leaching pathways

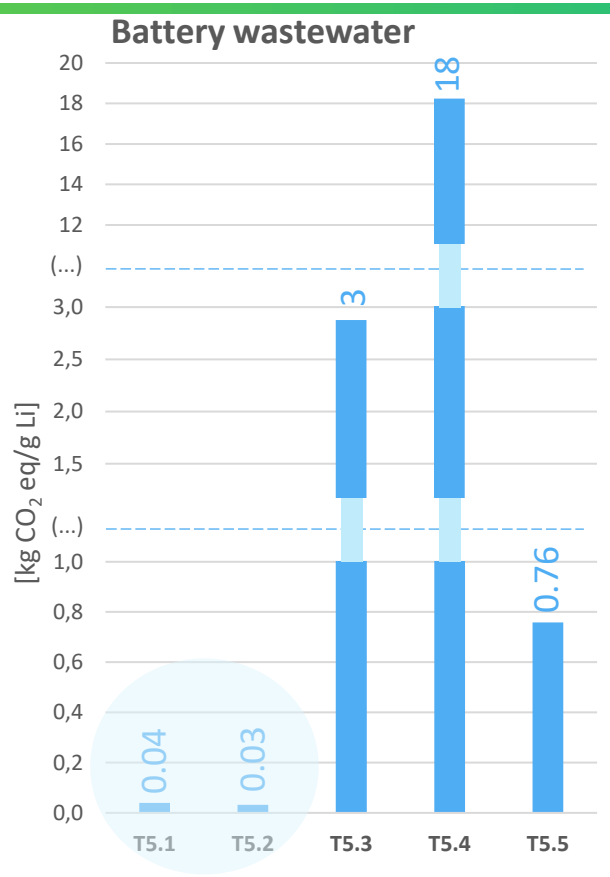


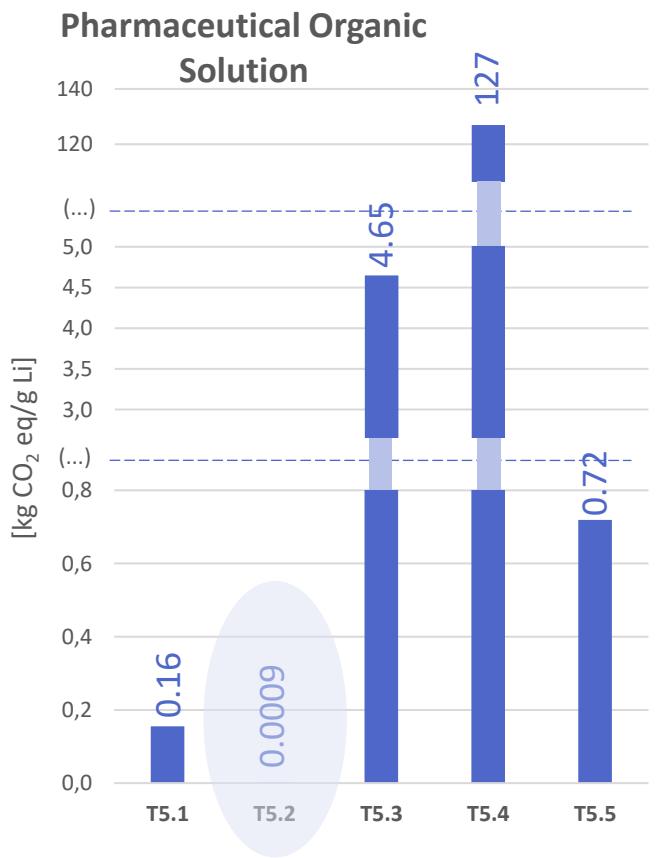


5. LCA results for process design (lab-level)
LCA results – Extraction pathways





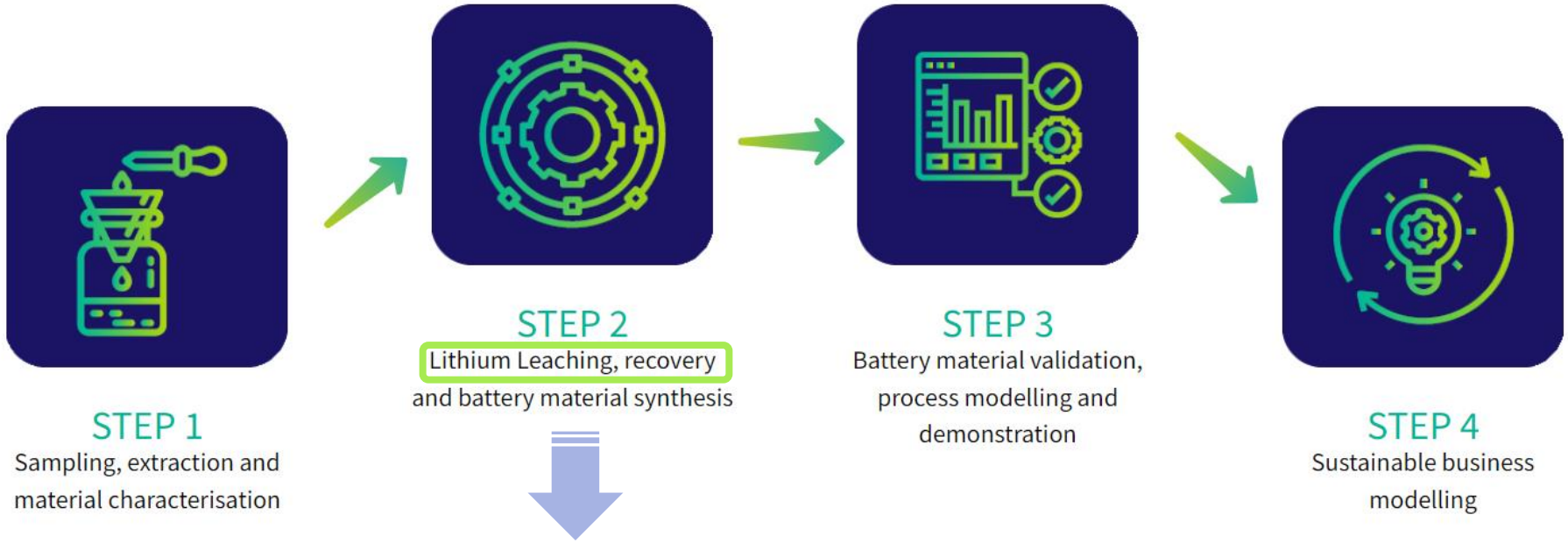




T5.1 – Electrodialytic separation
T5.2 – Membrane electrolysis // Electrochemical ion pumping (OS only)
T5.3 – Selective ion exchange separation
T5.4 – Selective separation with 3D printed adsorbents
T5.5 – Solvent extraction → LUT

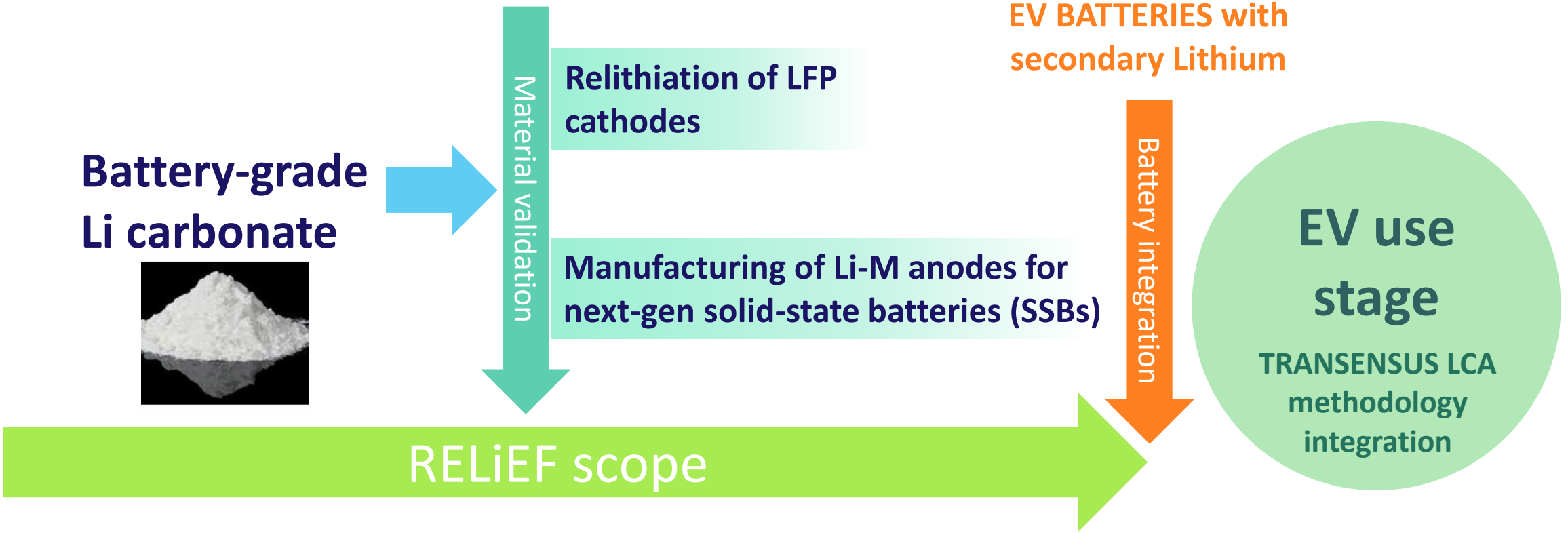
Geographical conditions: Belgium
Database for background information: ecoinvent v3.10
Software: Simapro v9.6.0.1
Method: ReCiPe 2016 Midpoint (H) V1.09 / World (2010) H

6. Main recommendations



- Focus on increasing efficiency
- Decrease electricity consumption
- Reloop the remaining sample back into the process

7. TRANSENSUS Integration



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Thank you

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