

Integrating life cycle thinking into the sustainable design of emerging battery technologies: insights from the TALISSMAN project

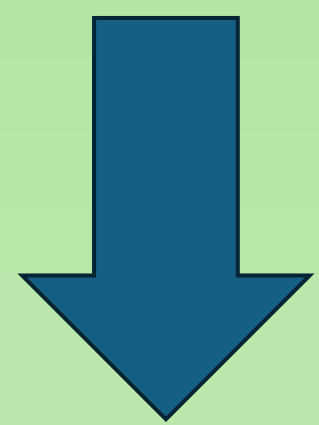
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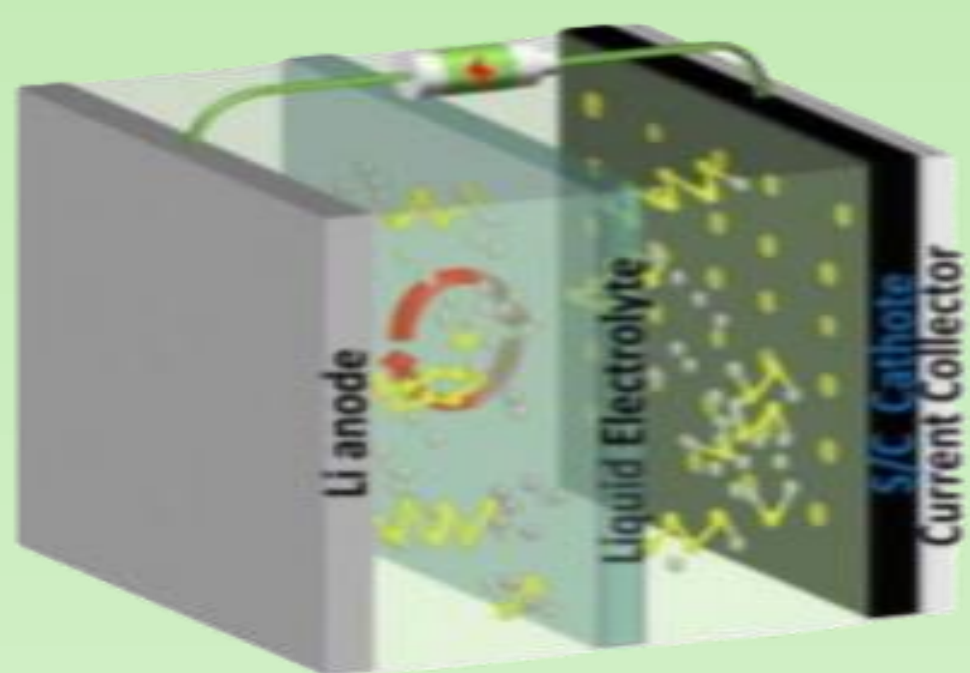
BACKGROUND

The Horizon Europe-funded project TALISSMAN focuses on the development of next-generation lithium-sulfur (Li-S) batteries, integrating technological innovation with eco-design, circularity, and recyclability principles. From material sourcing to end-of-life recycling, the project will embed life cycle thinking from the earliest stages of development. This approach aims to support the design of batteries that are resource-efficient, safe, and aligned with EU sustainability targets.

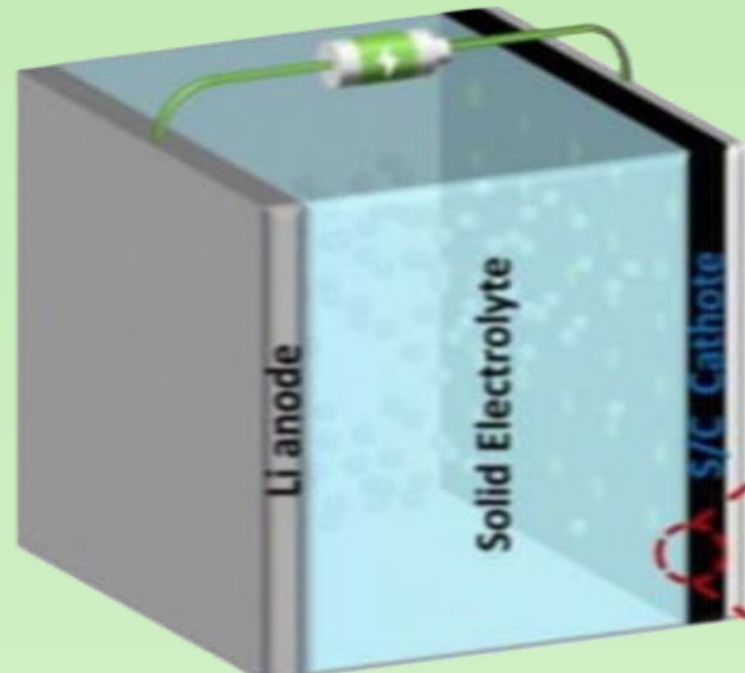


TALISSMAN investigates two Li-S battery architectures:

- **GPB** (Gel polymer battery): Li-S cell employing a quasi-solid gel polymer electrolyte (GPE).
- **SSB** (Sulfur solid-state battery): Li-S cell employing a sulfide-based solid-state electrolyte (SSE)



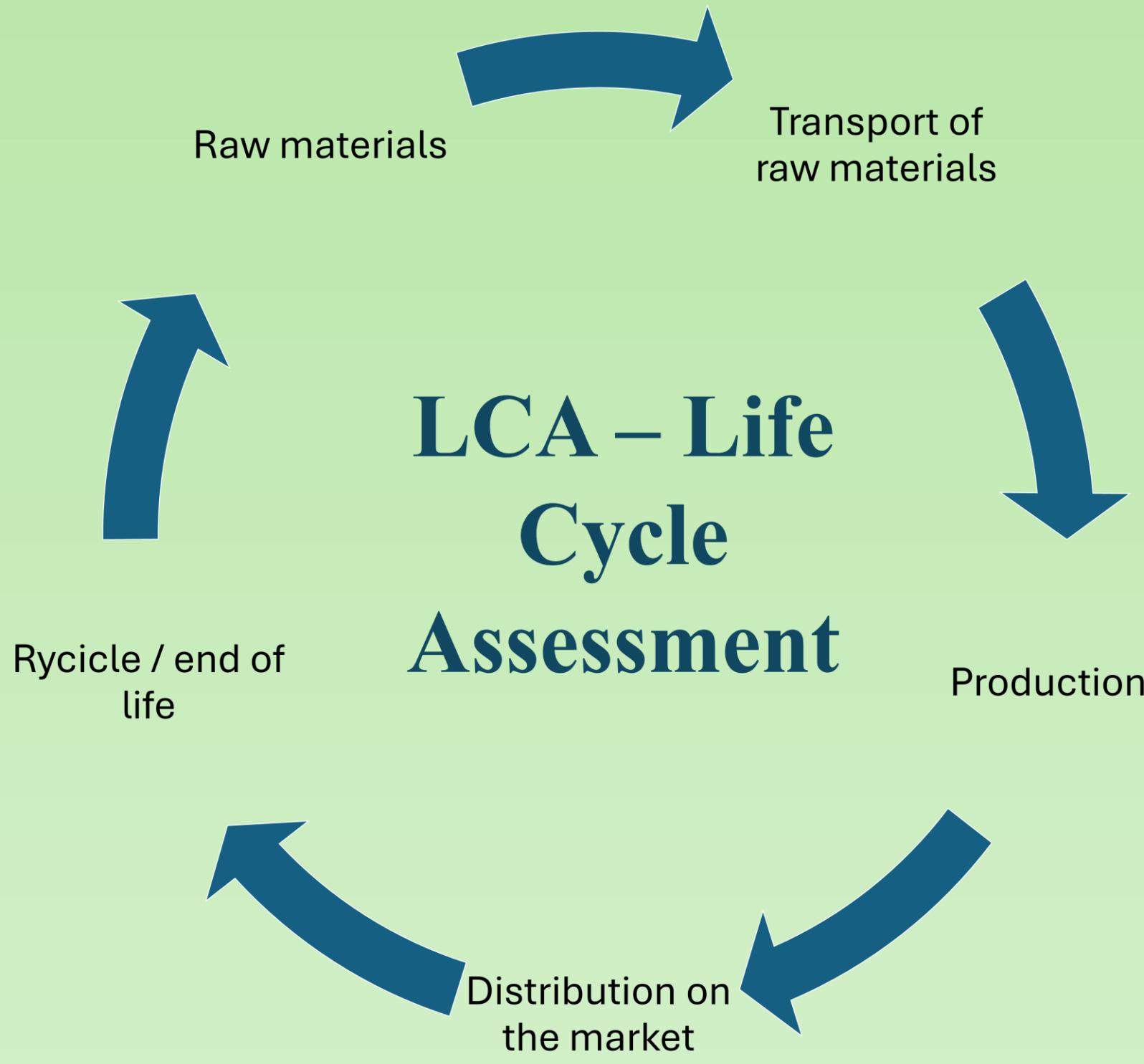
GPB



SSB

INTRODUCTION

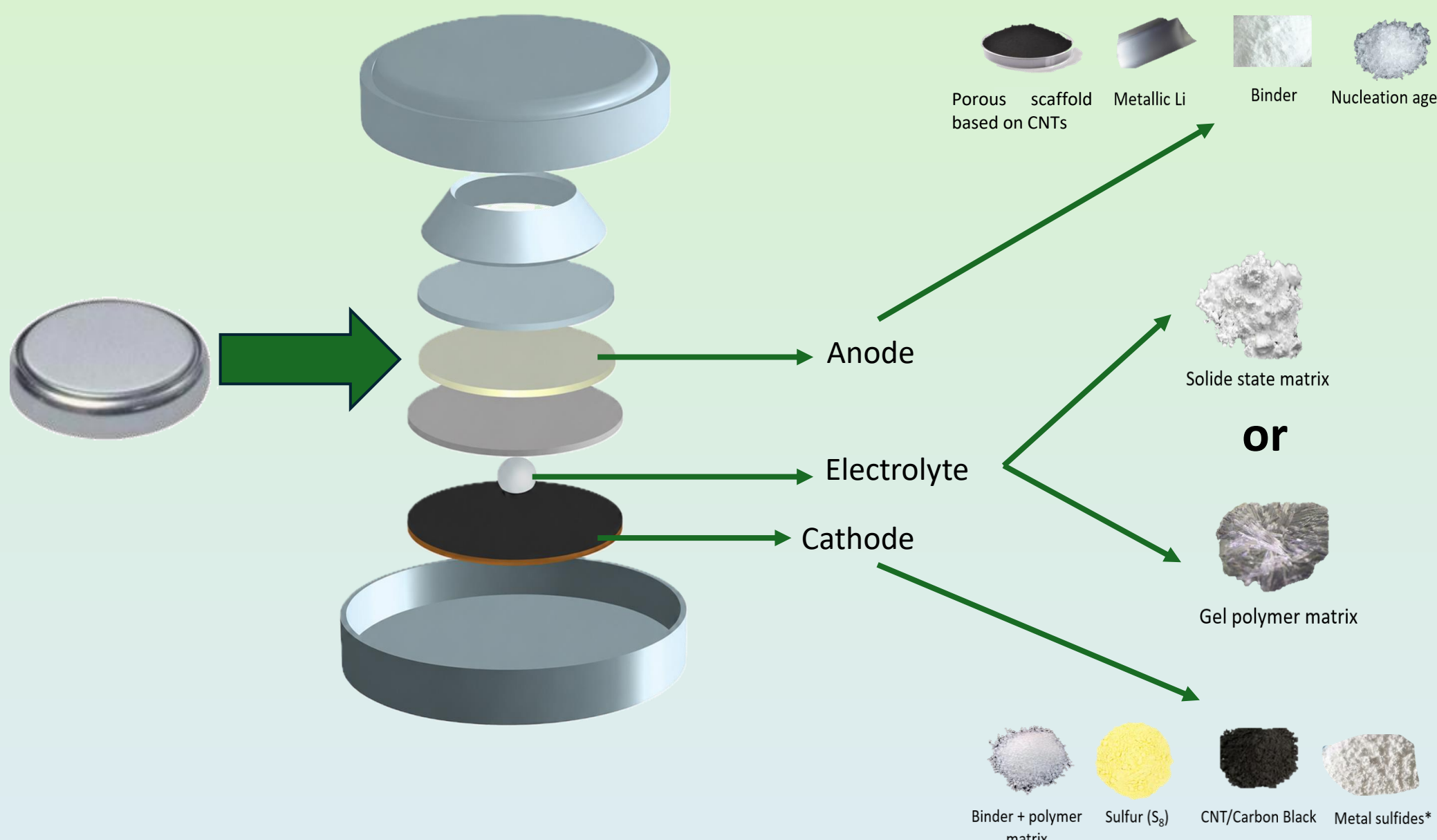
Integrating **life cycle thinking** into early-stage research is key to identifying potential hotspots and to help steering sustainable design. **Prospective Life Cycle Assessment (pLCA)** enables the evaluation of emerging technologies under future industrial-scale scenarios. By identifying potential environmental hotspots and trade-offs, pLCA can guide material selection, cell design, and process development. **This work aims to identify good practices and methodological recommendations from the literature and to collect life cycle inventories at lab-scale to support the robust implementation of pLCA for emerging Li-S battery technologies within a life cycle thinking framework.**



METHODOLOGY

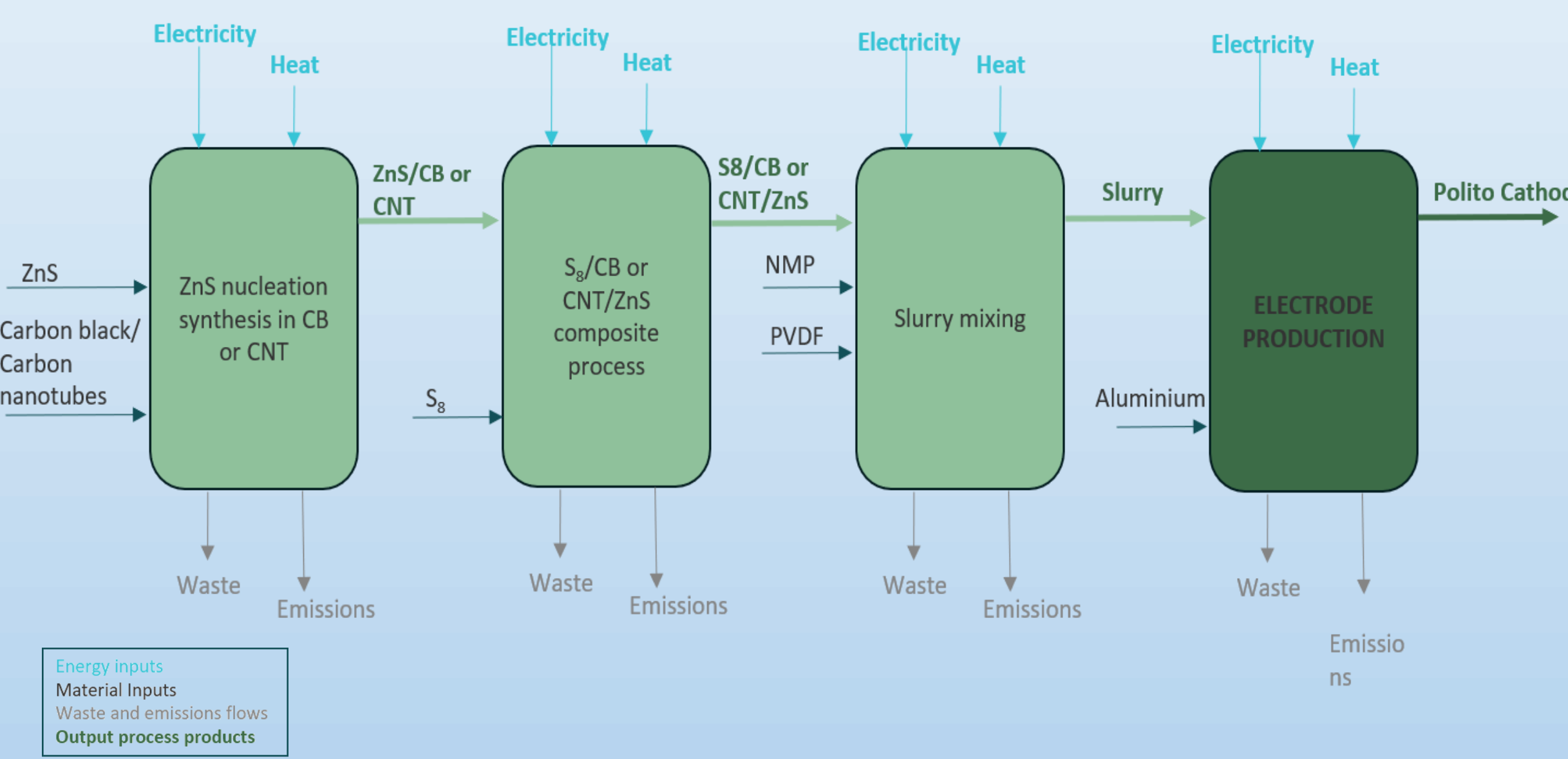
STEP 1

The cell architecture was defined by the identification and characterization of each individual component. Experimental data were collected at laboratory scale for the **anode**, **cathode**, and **electrolyte** (solid state/gel polymer). These data provide the basis for the subsequent scale-up to a representative production at industrial level.



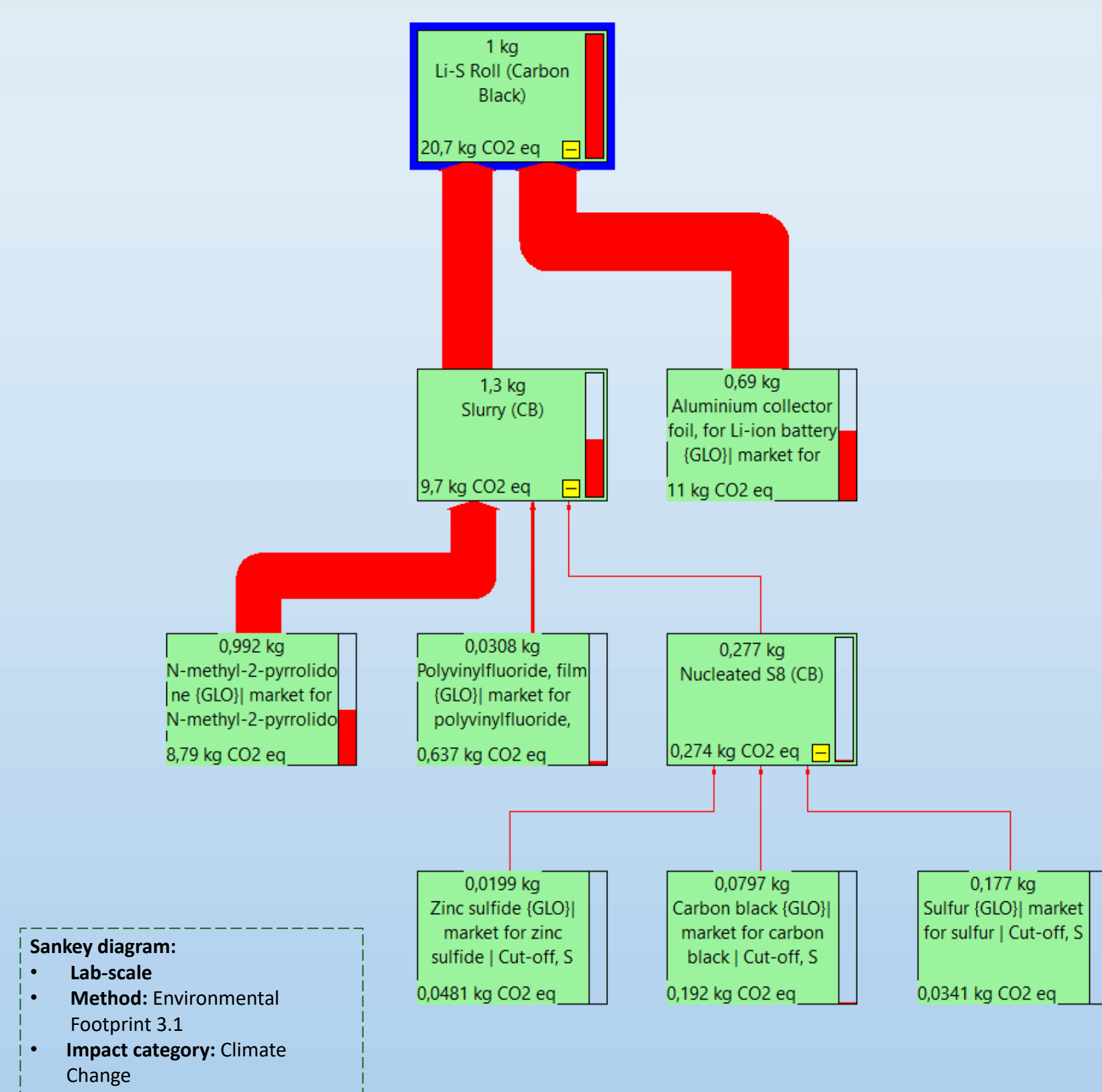
STEP 2

Dedicated **production process flowcharts** were developed for each cell component. These flowcharts illustrate the main manufacturing steps, material inputs, energy requirements, and outputs. Separate process routes were defined for the **anode**, **cathode**, and **gel polymer electrolyte/solid state electrolyte**, accounting for the specific battery configurations investigated.



STEP 3

The collected inventory data were implemented in SimaPro to build the LCA datasets. Environmental impacts were first assessed for individual cell components at **lab-scale** and will subsequently be integrated for the complete Li-S cell, based on the defined **cathode composition** and foreground production processes.



CONCLUSIONS

- **The limited availability** of literature data for emerging Li-S technologies highlights the need for a systematic screening of materials and manufacturing processes.
- **Life Cycle Inventory (LCI)** was developed for the Li-S cell, covering materials and manufacturing processes
- A systematic assessment supports the definition of **guidelines for future industrial-scale production**, considering both cell performance and the raw materials involved

NEXT STEPS

- Complete the **industrial-scale inventory**
- Refine **energy and material consumption** using scale-up assumptions
- Complete the **full-cell pLCA**
- Identify **environmental hotspots**
- Extend the assessment from **cradle-to-gate** to **cradle-to-grave**, including circularity scenarios

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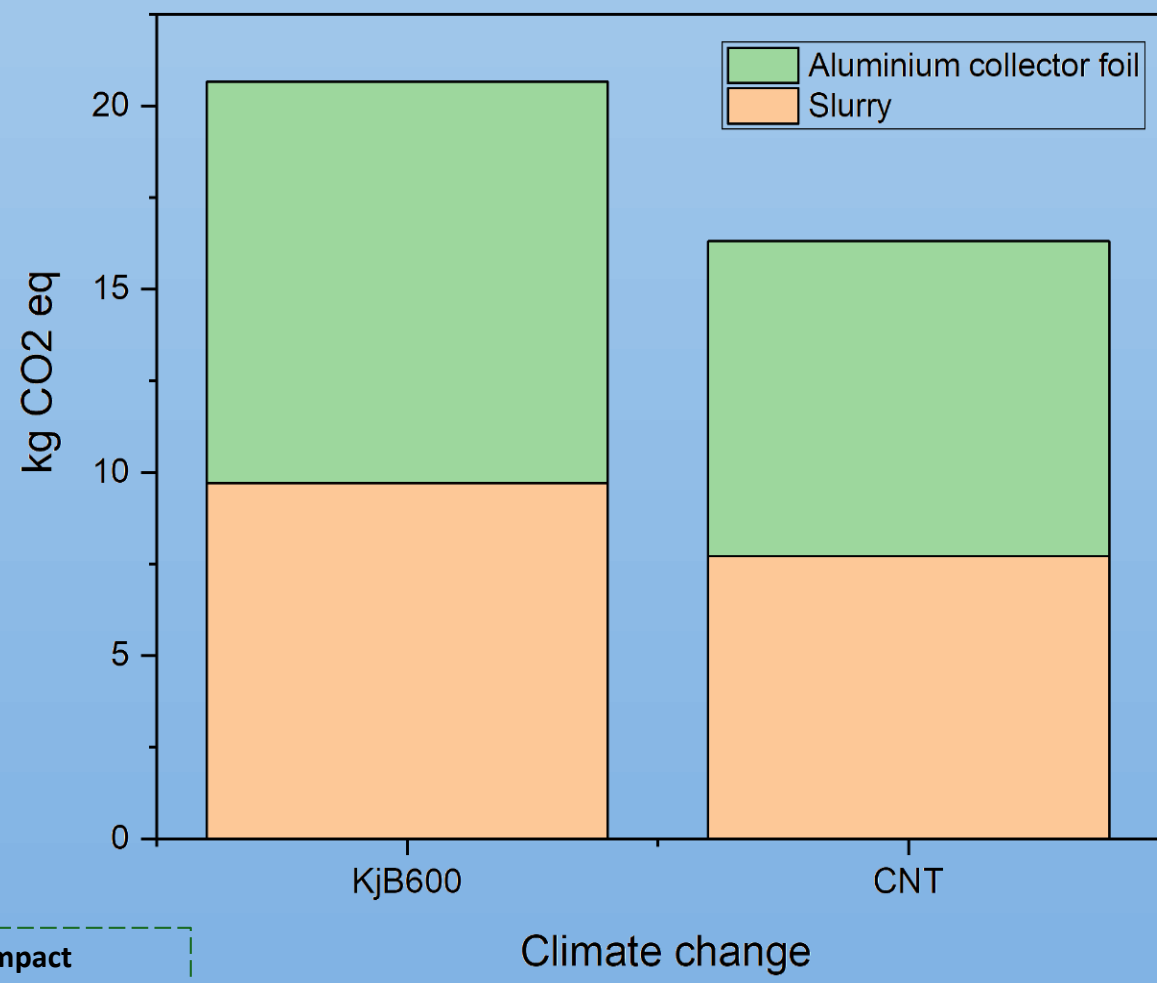


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Climate change impact contribution chart: Carbon Black vs CNTs