Life Cycle Assessment (LCA) and eco-design: towards optimized refractory materials for a green steelmaking process

Sarah Badioli[1,2], Thibault Champion[2], Léna Roumiguier[2], Marielle Dargaud[2], Angélique Léonard[1]
1. University of Liège, Chemical Engineering research unit – PEPs, Belgium, https://www.chemeng.uliege.be/
2. Saint-Gobain Research Provence, Performance Ceramics and Refractories – PCR, France, https://www.ceramicsrefractories.saint-gobain.com/

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Objectives:

Investigate, model and quantify the environmental burdens generated by the production and the usage of refractory materials in the steelmaking through a life cycle perspective.

- Find the most sustainable option for both producers and users

In relation to three pillars of circular economy:

- **design the loop**: modelling and optimising relevant production routes of several refractories in an eco-design perspective;
- **slow down the loop**: optimising environmental footprint of the refractories once applied in the steel industry;
- **close the loop**: integrating recycled materials in the production route.


Figure 1. Mullite-alumina bricks


Figure 2. Electric Arc Furnace (EAF)

Methodological novelty

Provide methodological approaches for the LCA challenges of:

- Emerging technologies (prospective LCA)
- Shift of the impact of refractory to the steel production
- Data quality analysis

Context:

State-of-the-art of Life Cycle Assessment of refractory materials.

- Field of research relatively new and not well investigated yet
- Selection of the refractories related to the iron and steel industry

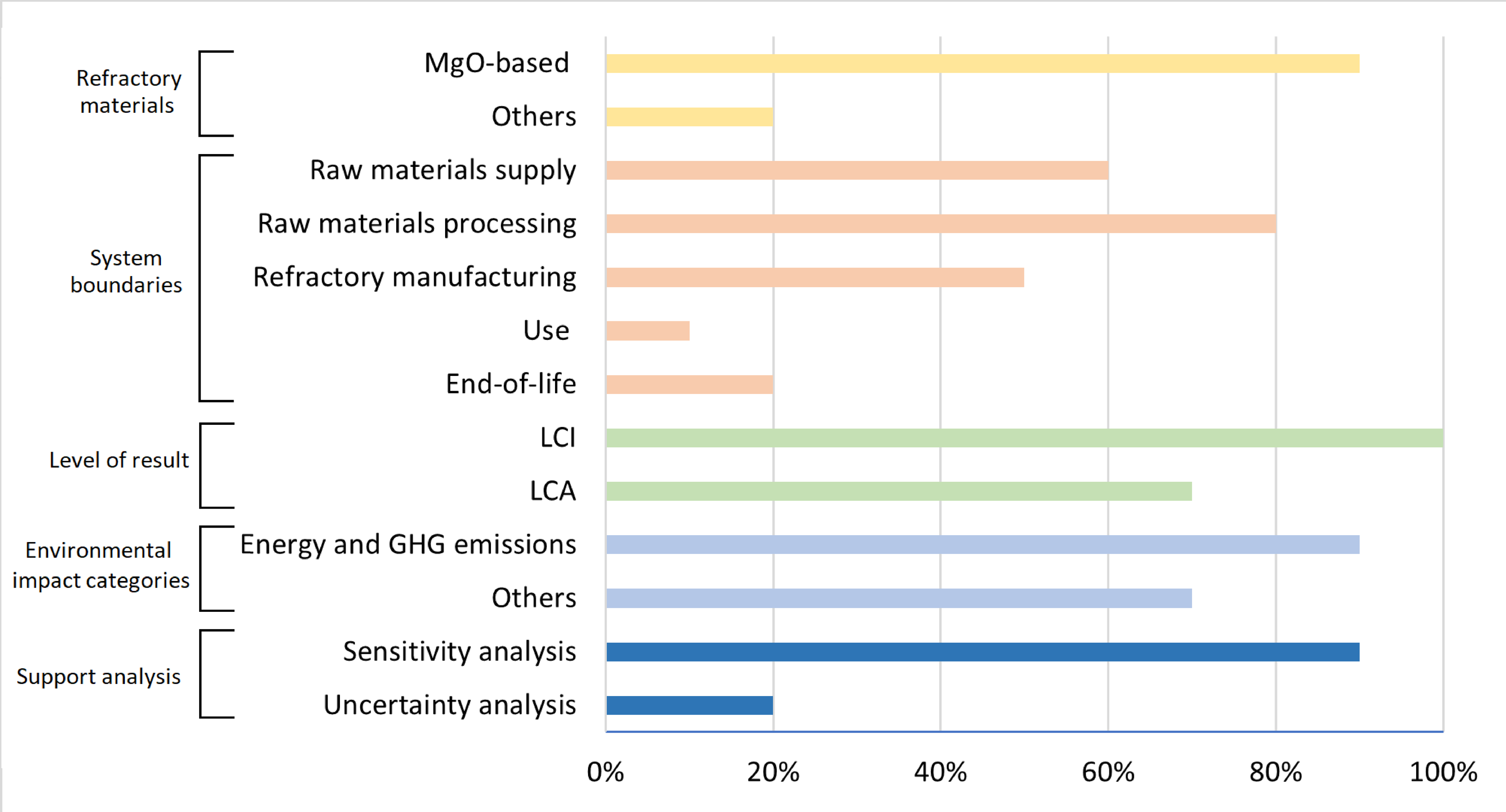

Figure 3. Literature review of LCAs on refractories

Goals

Filling the actual **gaps of the LCAS** of refractories

- Analysis of the entire life cycle (cradle-to-gate)
- Full modelling of 3 production routes (curing, sintering and fused casting)
- Enhancement of the eco-design conception and the recyclability potential
- Improvement of the LCA database with process level data collection

Materials and method:

Materials

Reminding the **green steel** goal, the emerging technology of hydrogen based Direct Reduction of Iron (H_2 DRI) coupled with the Electric Arc Furnace (EAF) has been identified as one of the most mature technological routes capable of reducing CO_2 emissions.

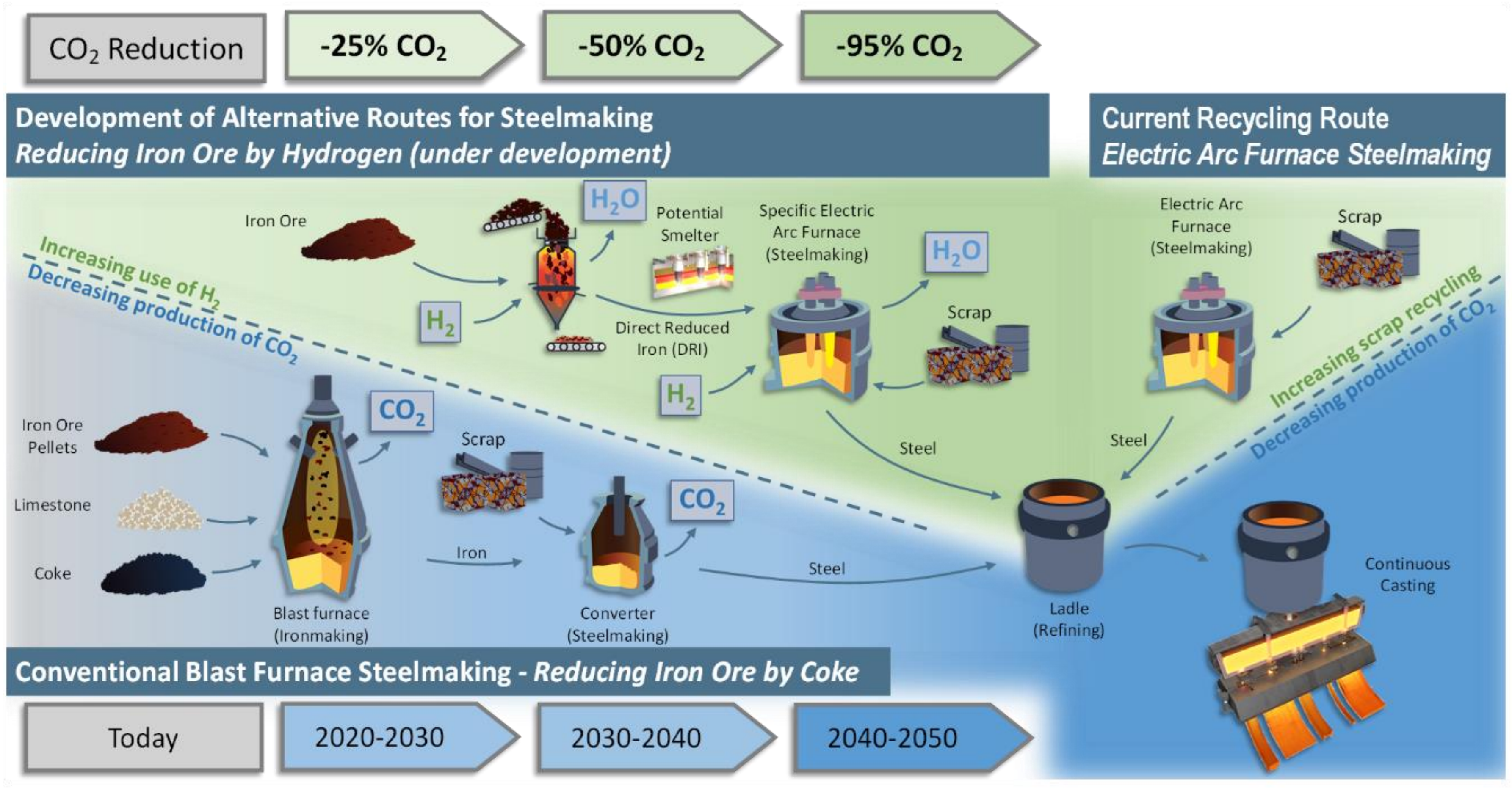

Figure 3. Conventional and new steel production routes

Comparative LCAs are proposed for two couples of refractories used as the lining of the most critical areas in terms of corrosion of these technologies:

Application	Lining area	Refractory	Production route
Hydrogen-based DRI	Tuyere	Mullite-alumina	Sintered brick
		Alumina-silica	Fused cast brick
EAF with DRI and scrap feed	Slag line	Magnesia-carbon	Cured brick
		Under discussion	

Method

The **Life Cycle Assessment** (LCA) methodology is a scientific multi-step procedure which has become a standard environmental evaluation tool [2 ,3]. It allows a systematic analysis of the potential environmental impacts of a product or a service during its entire life cycle.

Goal and scope
Software LCA FE (previously GaBi)
Primary data, Ecoinvent 3.9.1 database
EF 3.1 impact assessment method

The overall life cycle of the refractory is studied in three steps:

- **Expansion** of the system boundaries with the gradual inclusion of all the stages of the life cycle of the refractory.

LCA 1	Cradle-to-gate
LCA 2	Cradle-to-grave
LCA 3	Cradle-to-cradle

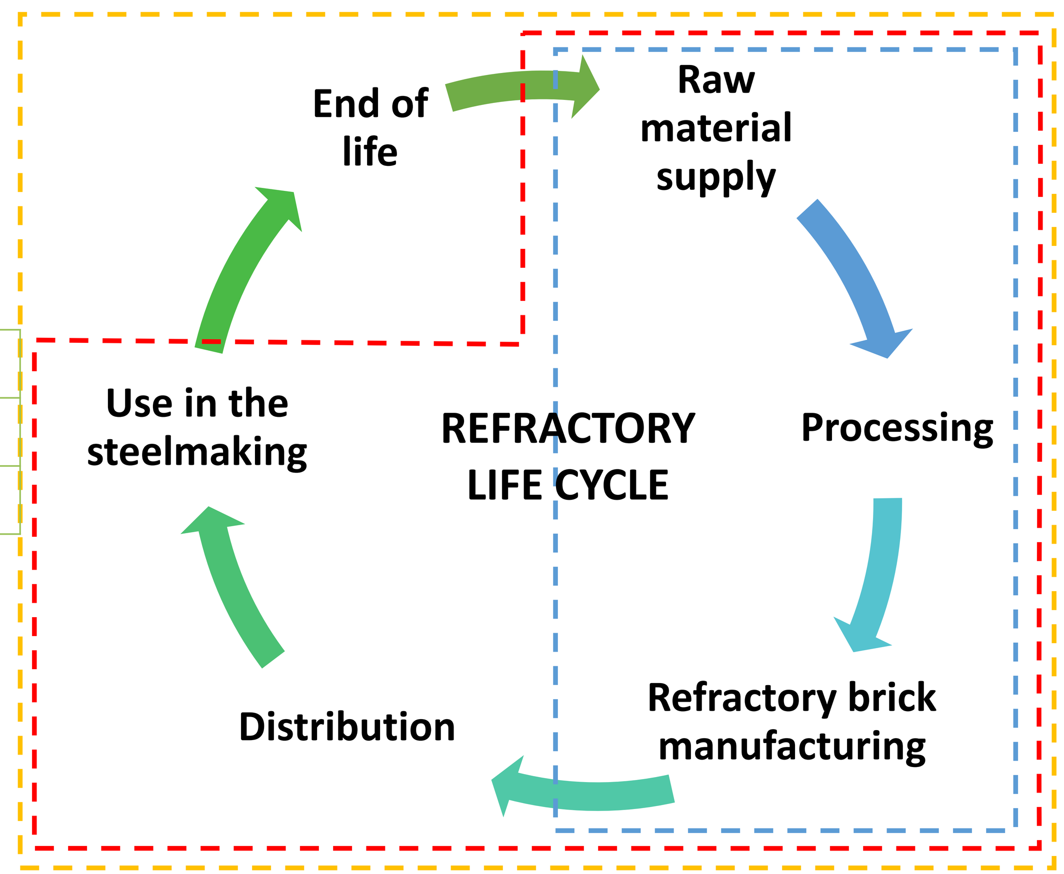

Figure 5. Refractory life cycle and related LCAs

CESAREF PhD 01 :

Sarah BADIOLI
MSCA Doctoral candidate
mail: Sarah.Badioli@uliege.be

Industrial and Academic supervisors:

Prof. Angélique Léonard — Liège université, Chemical Engineering

Thibault Champion — Saint-Gobain

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