# LIFE CYCLE ASSESSMENT AND ECO-DESIGN: TOWARDS OPTIMIZED REFRACTORIES TO SUPPORT LOW-$CO_2$ STEELMAKING

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## Objectives and context

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
- Support the transition to the green steel

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.

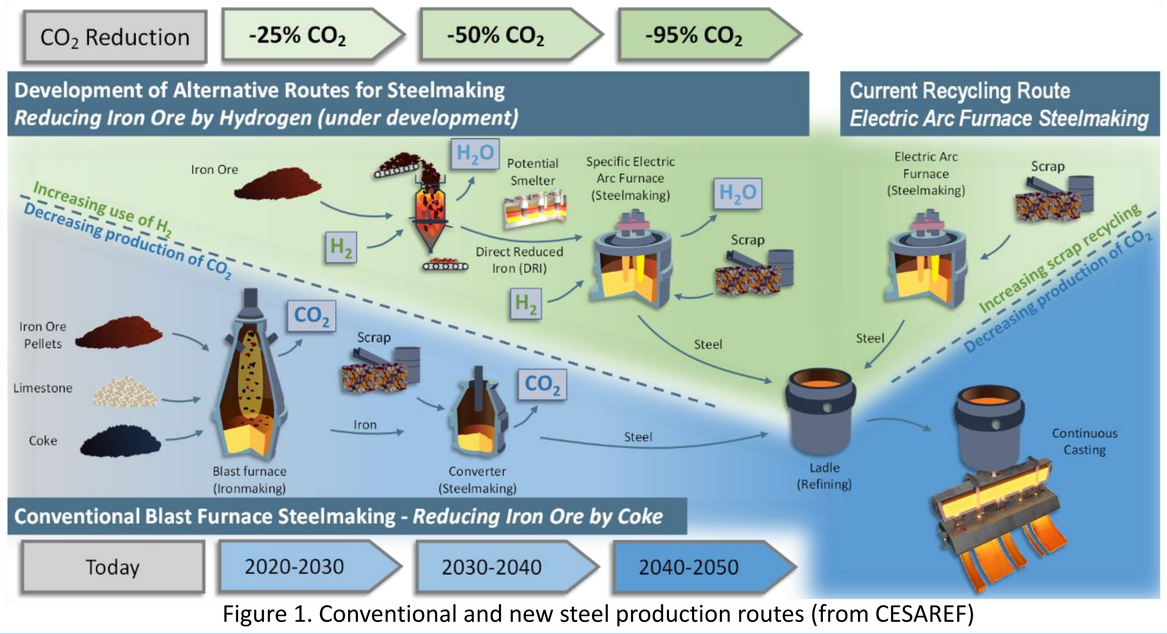


Figure 1. Conventional and new steel production routes (from CESAREF)

## Methodology

### LCA: Life Cycle Assessment

Scientific multi-step methodology for a systematic analysis of the potential environmental impacts of a product or a service during its life cycle.

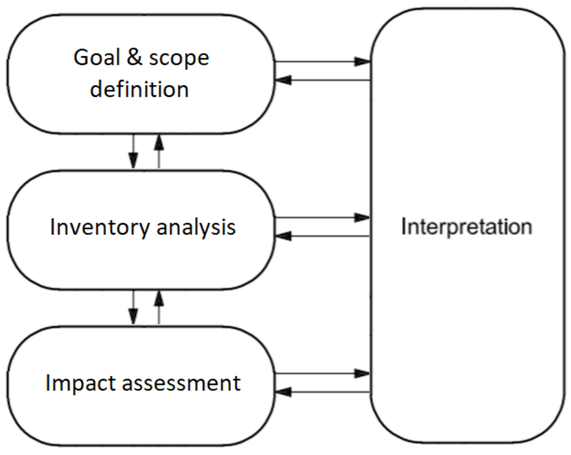


Figure 2. Life Cycle Assessment Framework (from ISO 14040, ISO 14044)

### Structure of the project

The 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 refractory life.

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

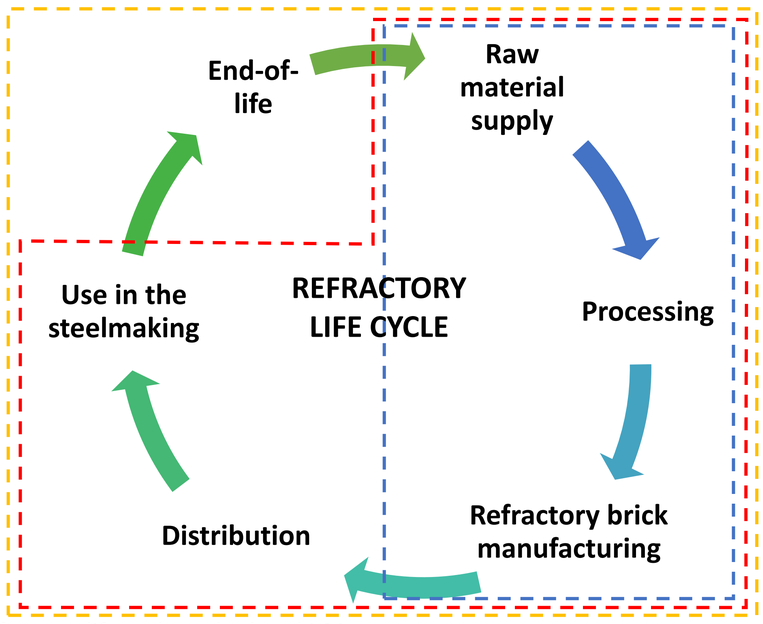


Figure 3. Refractory life cycle and related LCAs

| Tools |
|---|
| Software LCA FE (previously GaBi) |
| Primary data, Ecoinvent 3.9.1 |
| EF 3.0 impact assessment method |

## Goals

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

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

## Materials

| Application | Composition | Production route | Type of product |
|---|---|---|---|
| EAF - Slag line | Magnesia-carbon | Tempered brick | Model |
| | Alumina | Fused cast brick | Commercial |
| (DRI shaft furnace) | Mullite-Alumina | Sintered brick | Commercial |

### Production

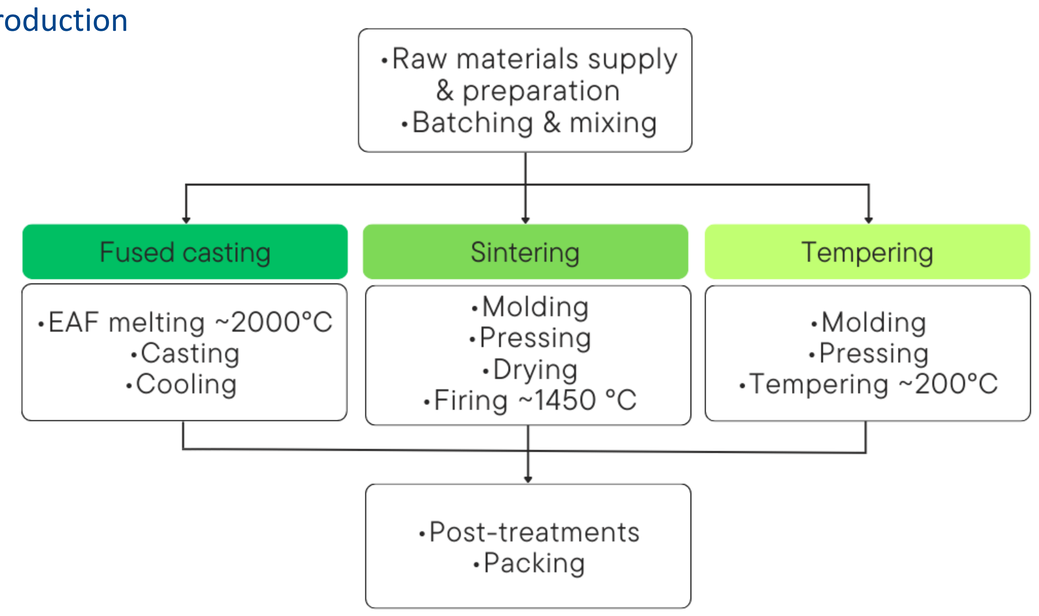


Figure 4. Flowchart of the chosen production routes for shaped refractories

### Environmental performance in use

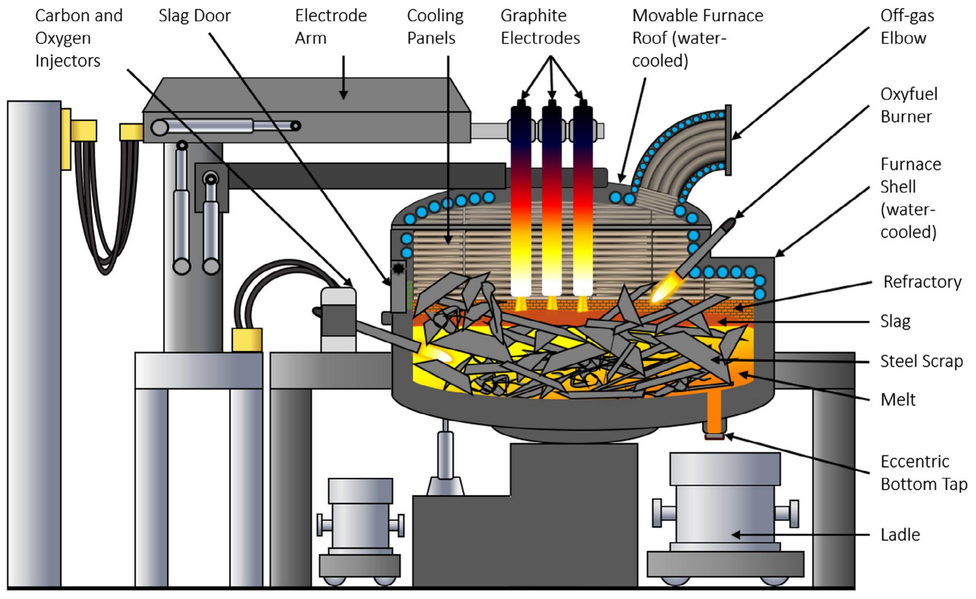


Figure 5. Electric Arc Furnace, EAF (from Hay et al.[1])

### Possible recycling routes

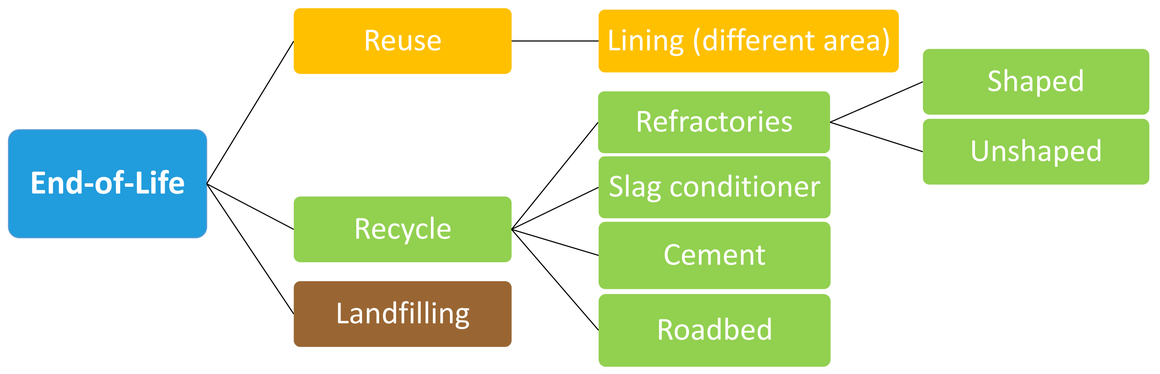


Figure 6. Most common End-of-life management routes of refractories

[1] Hay, T.; Visuri, V.-V.; Aula, M.; Echterhof, T. (2021) A Review of Mathematical Process Models for the Electric Arc Furnace Process. *Steel Res. Int.*, 92(3), 2000395



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