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GreenHeatEAF newsletter #5

Gradual integration of renewable non-fossil energy sources and modular heating technologies in EAF for progressive CO_2 decrease

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The call topic is related to modular and hybrid heating technologies in steel production.

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The year 2025 ended with a renewed awareness of the environmental and economic impacts associated with conventional steel production, both via the integrated cycle route and the Electric Arc Furnace (EAF) pathway.

This progress was made possible through the completion of a Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) baseline study, representing the reference analysis for demonstrating the potential impact reductions achievable through the integration of non-fossil fuels and renewable carbon sources into Electric Arc Furnace (EAF) processes.

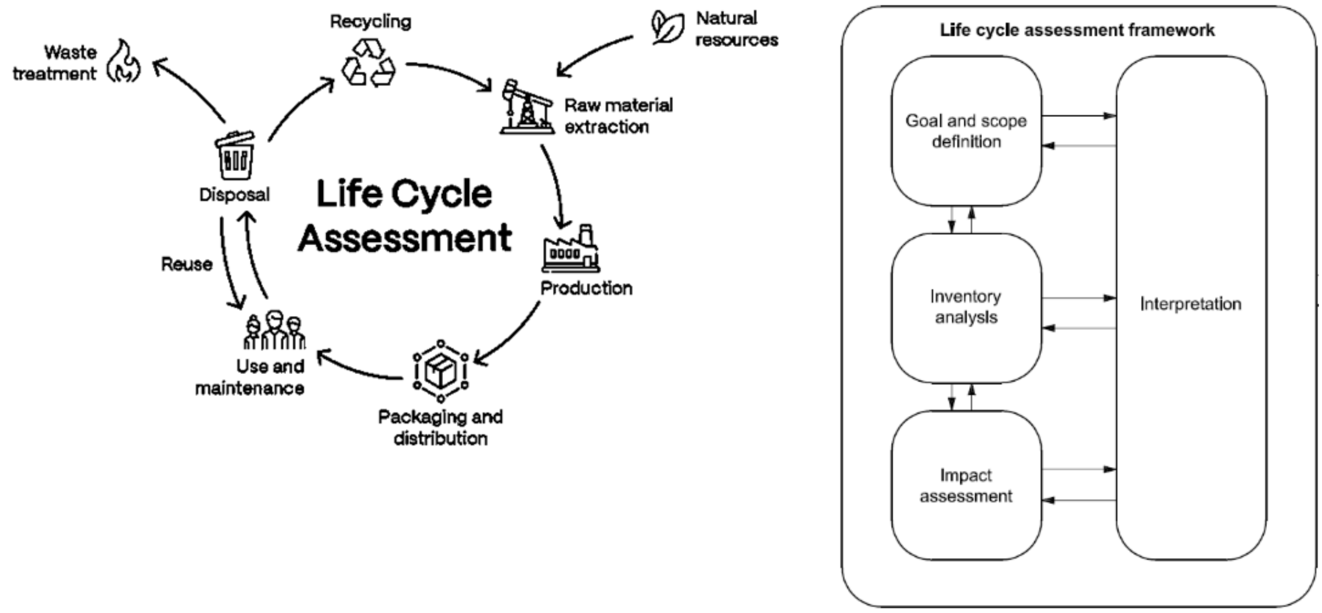
A new challenge for the application of LCA and LCC

LCA and LCC stand out as prominent methods for evaluating the potential environmental and economic impact of steelmaking. Based on data collected at the end of 2024, the first results were shared in mid-2025, followed by final validation in the second half of the year. A brief explanation of the two methods and key results are here provided.

LCA is an analytical and systematic methodology used to evaluate the potential environmental impact of a product or service throughout its life cycle (see Figure 1.a). According to ISO 14040, the LCA framework operates with four separate phases (see Figure 1.b): i) Goal and scope definition; ii) Life Cycle Inventory (LCI) analysis; iii) Life Cycle Impact Assessment (LCIA) and iv) Life cycle interpretation. The LCA methodology considers a wide range of impact indicators addressing both natural systems and specific global and regional environmental issues (e.g. greenhouse effect, water footprint, non-renewable resources, etc.). This operational procedure is based on the concept of Life Cycle Thinking (LCT): a way of observing and assessing, in this case, the environmental impacts generated in all the stages through which a product or service reaches its function. LCA plays a relevant role in decision support, for the ambition of a complete coverage of environmental dimensions and for the identification of hotspots and possible trade-offs, avoiding burden shifting among life cycle stages or impact categories.

Embedded within the broader LCT paradigm, LCC complements environmental LCA by addressing the economic dimension of sustainability, thereby supporting a more holistic decision-making framework. LCC is a methodological approach that evaluates the total economic cost associated with a product or service throughout all stages of its life cycle: from acquisition and operation to end-of-life management.

"GreenHeatEAF contributes to gradual replacement of fossil fuels and fossil carbon materials with non-fossil gases and renewable C-sources. Therefore, GreenHeatEAF contributes to lowering NG, anthracite and coal exploitation, by decreasing GHG emissions through the use of sustainable gases (i.e., green Hydrogen, preferably internally produced) and materials (zero-impacting biomass)."



(a) *(b)*

Figure 1. a) Life cycle stages of a generic product. Source: Swiss Federal Office for Environment (2022); b) LCA framework according to ISO 14040. Source: ISO 14040:2006

The LCA results highlight key environmental hotspots, including high-emission processes such as coke and briquette production, electricity-intensive operations and the use of environmentally impactful raw materials such as lime, dololime copper and ferroalloys. The dominance of Climate Change, Particulate matter, Resource Use (fossils, minerals and metals) and Human Toxicity categories across all case studies underscores the critical role of upstream material sourcing and energy consumption patterns.

LCC analysis shows that raw material procurement is the main cost driver in EAF-based steelmaking, followed by energy and labor costs. Economic results align with the environmental hotspots, confirming the need to reduce fossil fuel dependence and enhance material efficiency.

Dissemination activities

These preliminary results have been successfully presented by the researchers of Sant'Anna School of Advanced Studies at important international scientific conferences (see Figure 2), such as the 12th International Conference on Life Cycle Management in Palermo, Italy (LCM 2025), the 7th European Steel and Application Days (ESTAD 2025) in Verona, Italy and the 20th International Symposium on Waste Management, Resource Recovery and Sustainable Landfilling in Santa Margherita di Pula, Italy (SARDINIA 2025).

Figure 2. Presentations held by partners of the project within relevant scientific events.