



Contribution ID: 267

Type: **Oral Presentation**

Techno-Economic Assessment of H₂-DRI and NG-DRI-CCS Processes for Low-Emission Iron Production

Wednesday, October 8, 2025 2:20 PM (20 minutes)

The transition of the iron and steel industry to low-emission systems is mandatory for meeting the global targets of greenhouse gas emission reduction. As the sector still heavily relies on fossil fuels, the shift is particularly challenging. Hydrogen-based direct reduced iron (H₂-DRI) has gained increasing attention, and it is currently considered one of the most promising options for zero-emission iron production. Alternatively, natural gas-based DRI plants equipped with carbon capture and storage (NG-DRI-CCS) could play a relevant role, in presence of a CO₂ infrastructure and/or in absence of substantial and low-cost availability of renewable energy sources (RES). This may be the case in Europe, where full-scale CCS projects are advancing in the cement, lime, petrochemical and waste-to-energy sectors, offering the opportunity of CCS clusters.

This work aims to provide a consistent techno-economic comparison of H₂-DRI and NG-DRI-CCS systems, by evaluating their material (feedstock, products and CO₂), energy and economic balances. The two processes are simulated using Aspen Plus® for a representative plant size of 2 MtDRI/y, designing configurations that include electrification wherever possible to minimize residual emissions and improve efficiency. The integration with RES, electrolysis and storage units is investigated via mixed-integer linear programming (MILP) optimization, to properly account for the cost of renewable electricity in different locations. For the CO₂ balances, the analysis considers direct and indirect contributions, adopting a life-cycle approach (e.g., solar panel manufacturing and natural gas supply chain leakages).

Preliminary calculations indicate a cost of CO₂ avoidance of 50-100 €/tCO₂ in case of NG-DRI-CCS, while values for H₂-DRI results in 150-300 €/tCO₂ with short-term technology costs and between 0 (i.e., cost parity) and 100 €/tCO₂ with long-term cost projections. The outcomes of this study contribute to a deeper understanding of the feasibility of H₂-DRI and NG-DRI-CCS systems for different locations, and under different technology development scenarios.

Primary authors: Ms GUAZZI, Sara (Department of Energy, Politecnico di Milano); Mr FICILI, Marco (Department of Energy, Politecnico di Milano); Prof. CAMPANARI, Stefano (Department of Energy, Politecnico di Milano); Prof. COLBERTALDO, Paolo (Department of Energy, Politecnico di Milano); Prof. ROMANO, Matteo Carmelo (Department of Energy, Politecnico di Milano)

Presenter: Ms GUAZZI, Sara (Department of Energy, Politecnico di Milano)

Session Classification: Direct Reduction & Alternative Ironmaking

Track Classification: CO₂ mitigation in iron and steelmaking