Breakthrough Energy

Cleantech for Europe

With analyses led by SYSTEMIQ

CLEANTECH REALITY CHECK

MANUFACTURING - STEEL

Forging a Competitive Future

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What is green steel ?

Steel production accounts for 4-6% of annual CO_2 emissions in the EU, 80% of which originates from primary steel or iron-making processes.

The blast furnace-basic oxygen furnace (BF-BOF) route accounts for ~60% of EU crude steel production, relying on metallurgical coal as a reducing agent, sintered iron ore feedstocks, scrap steel, limestone flux, and hot-air blast injected at temperatures exceeding 1,200°C. This integrated steelmaking process emits 1.8–2.2 tCO_2 per tonne of steel, contributing to the sector's 25% share of EU industrial emissions.

The remaining 40% is produced through secondary steelmaking, utilising scrap steel and other ore-bearing metallics in electric arc furnaces (EAF), emitting ~0.5 tCO_2 per tonne of steel.

Direct Reduced Iron (DRI) is Europe's foremost decarbonisation pathway, offering a scalable transition from natural gas to green hydrogen while leveraging existing infrastructure. With at least 5 Mt of hydrogen-DRI capacity already funded, it outperforms alternatives like CCS and electrolysis in technical readiness, job retention, and export competitiveness

Key take-aways

- The EU steel industry has the potential to service the growing global demand for steel products as a market leader in low-carbon technologies, such as hydrogen-based direct reduced iron (H2-DRI) technology and electric arc furnaces. Yet, the sector faces major challenges despite more than €10 billion in public funding and 10 Mt of H2-DRI capacity reaching Final Investment Decision as of December 2024.
- The steel industry is a cornerstone of the European economy, directly employing 310,000 individuals while indirectly supporting 2.2 million jobs across various sectors. Beyond its economic contributions, the industry is pivotal in bolstering Europe's industrial autonomy, particularly within critical supply chains, including defence.
- Low-carbon primary steel currently carries a 20-40% cost premium, and projects face potential delays due to concerns about policy inconsistency, demand for low-emissions products, and falling profitability.
- To accelerate green steel adoption, the EU must maintain robust carbon pricing policies, simplify and expedite permitting, target public funding to FoaK deployments, ensure competitive low-carbon electricity and low-carbon electrolytic hydrogen prices, and stimulate demand through green product standards and procurement mandates, such as the ones covered in the Net Zero Industrial Act (NZIA), in key sectors like automotive and construction.

PRIMARY STEELMAKING

FORGING A COMPETITIVE FUTURE

STRATEGIC IMPORTANCE FOR EUROPE

- Steel decarbonisation is crucial for Europe to achieve its 2030 and 2050 climate goals, accounting for 4-6% of total CO2 emissions and 25% of industrial CO2 emissions annually.[1,2]
- Transitioning to green steel production is vital for maintaining Europe's economic competitiveness, preserving 2.6 million jobs, and safeguarding the €152 billion annual contribution to the EU economy against global overcapacity and rising production costs.[1]
- Low-carbon steel is fundamental to enabling clean technology value chains in Europe, supporting the expansion of renewable energy infrastructure and meeting the growing demand for green materials in the automotive and construction sectors. It is also essential to non-energy sectors, including defence, where strategic autonomy is valued.

CURRENT PROGRESS OF IRON & STEEL IN THE EU

OFF-TRACK — ON-TRACK

STATUS : OFF TRACK Decarbonising European steel is crucial for reducing emissions, preserving jobs, and maintaining technological leadership. European governments have provided unprecedented public support to the sector for capital expenditures, but operational costs (especially energy) remain a serious concern. Decisions on first-of-a-kind (FoaK) projects are facing delays, with project developers citing low confidence in the current CBAM design to level the playing field and insufficient premiums for low-emissions production as challenges to investment decisions. Currently ~50% of the 10Mt H2-DRI capacity at FID is at risk of delays and cancellation following statements from project developers.

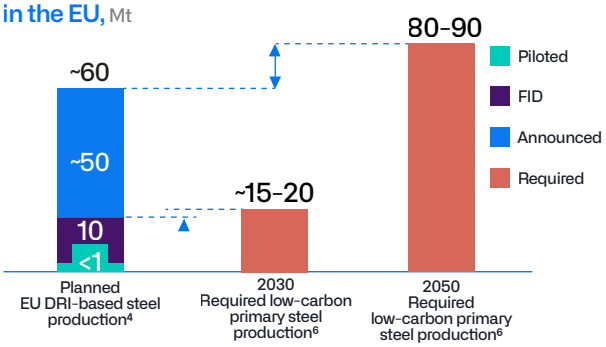
REQUIRED : 15-20 Mt of low-carbon primary steel required by 2030[3]

PROGRESS : ~10 Mt H2-DRI steel capacity has reached FID.[4,5] However, **~50%** of this capacity is at risk of delays and cancellation following statements from project developers[5]

POLICY UNCERTAINTY, LOW CONSUMER WILLINGNESS-TO-PAY AND FALLING MILL PROFITABILITY ARE DELAYING FIRST-OF-A-KIND (FOAK) PROJECT DECISIONS

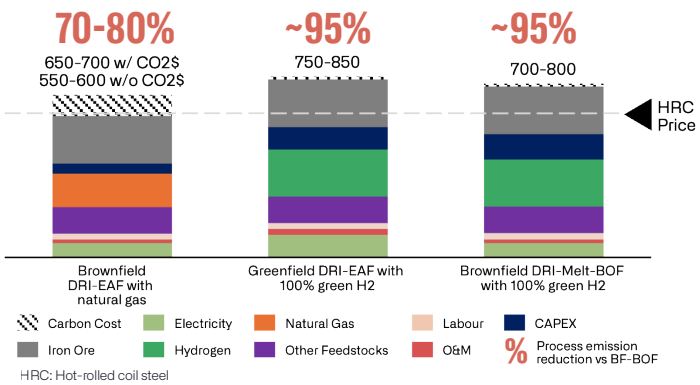
- The EU hosts >50% of global low-carbon steel projects (60+ initiatives as of 2024), with 10 Mt of hydrogen-DRI (H_2-DRI) capacity reaching Final Investment Decision (FID).[4] However, ~50% of approved projects face delays or cancellations, driven by high hydrogen costs (€5–6/kg vs target of €3/kg) and potentially limited scrap availability. Scrap supply constraints could limit both primary and secondary steelmaking growth.
- European governments allocated >€10 billion in public grants to accelerate steel decarbonisation projects.[6] However, only 12% of EU blast furnaces have approved retrofit plans, in contrast to over 40 greenfield DRI projects.

Low-carbon primary steel production capacity in the EU, Mt



BRIDGING THE COST PREMIUM FOR LOW-CARBON STEEL IS CHALLENGING, WITH ELECTRICITY PRICE AND CARBON PRICING BEING THE MAIN LEVERS TO SOLVE THE BUSINESS CASE

Levelised Cost of Steel (LCOS) by production technology in 2030[7], €/tonne crude steel



- The planned phase-out of "free allocation" of allowances in the ETS could increase the cost of steel produced via conventional BF-BOF technology by ~€120–200/tonne of steel, narrowing this cost premium within the EU.
- Trade measures, such as the CBAM, can provide some protection against the import of cheaper, more emissive steel products from outside the EU.
- Improving the competitiveness of EU industrial power prices is critical to closing the remaining cost premium and competing with low-carbon producers internationally.
- Additional supply and demand-side policy support (e.g., guarantees, mandates, etc) will be needed to bolster the investment case for new projects in the near term.

PRIMARY STEELMAKING

FORGING A COMPETITIVE FUTURE

ENABLERS – WHAT IS GOING WELL

CARBON PRICING SET TO CLOSE THE COST PREMIUM GAP

The ETS's declining cap is driving carbon prices up, and the withdrawal of free allowances will reduce the premium gap between low-carbon and existing production routes. Carbon pricing within the ETS and the upcoming Carbon Border Adjustment Mechanism (CBAM) will provide protection from cheaper imported higher emissivity steel if the agreed timeline is adhered to.

INITIAL DEMAND SIGNALS AND ADVANCED MARKET COMMITMENTS

Voluntary commitments and long-term offtake agreements from companies in steel-intensive end use markets have seeded initial demand signals for steel companies to invest in low-carbon technologies. These signals provide rising (though insufficient) confidence of durable demand for deeply decarbonised primary steel for project developers.

FOUNDATIONS FOR LOW-CARBON TECHNOLOGY ARE IN PLACE

The EU is a leader in low-carbon steel innovation and pioneer projects, accounting for the majority of announced projects worldwide. Although many DRI-based projects will initially operate using natural gas, the commitment to DRI-based technology is the first step in the transition to low-carbon feedstocks, processes and steelmaking when deployed in combination with EAF steelmaking and in parallel to scrap-based EAF technology.[8]

BARRIERS – WHAT IS NOT GOING WELL

HIGH ELECTRICITY AND LOW-CARBON HYDROGEN PRICES UNDERMINE EU COMPETITIVENESS

Electricity costs (~35–50% of H_2-DRI production costs) average €66/MWh in the EU—significantly higher than competing regions like China and the US (€43–50/MWh), challenging the competitiveness of EU EAF production. Low-carbon hydrogen costs remain prohibitively high at €5–6/kg, far exceeding the target of €2–3/kg needed for H_2-DRI to compete with BF-BOF production routes.[7] Long lead times for permitting and grid connections also add cost. Without substantial reductions in electricity taxes, grid fees, or expanded renewable and nuclear capacity, low-carbon steelmaking will struggle to achieve cost parity by 2030.

SLOW PROGRESS OF RETROFIT PROJECTS COMPARED TO GREENFIELD BUILDS

Despite receiving over €10 billion in public subsidies,[8] only 12% of EU blast furnaces have approved retrofit plans for carbon capture and storage (CCS), compared to over 40 greenfield DRI projects. Retrofitting existing assets faces significant barriers, including high upfront costs (€1.2–2 billion per plant) and declining steel consumption across Europe is calling these investment into question.[9]

INSUFFICIENT DEMAND FROM KEY STEEL-INTENSIVE SECTORS

Demand for green steel remains insufficient across key sectors such as construction, automotive, appliances, and heavy machinery—(collectively ~ 80% of EU steel consumption). Ongoing economic slowdowns and the influx of cheap imports (up by 12% in 2024) threaten the business case for green steel. Without stronger policy mandates or public procurement reforms, the market risks stagnating before reaching critical mass.

ACTION AGENDA – WHAT NEEDS TO BE DONE

1. **Ensure policy ambition and continuity for investor confidence.** If implemented consistently, the EU ETS and CBAM are projected to close the green cost premium by the early 2030s. However, exports will remain uncompetitive without an export rebate, and potential circumvention loopholes must be addressed. Delays or dilution would put already-announced projects at risk.
2. **Accelerate affordable low-carbon energy access.** Fast-track permitting, prioritising grid access for lower-carbon steel plants and related low-carbon power and expanding the use of guarantees and risk-reduction instruments to facilitate long-term power purchase agreements (PPAs) to provide low-carbon energy access. Reduce electricity taxes and grid fees, alongside accelerated investments in renewable energy infrastructure. Consider options to incentivise industrial customers to provide voluntary demand flexibility services and explore EU-wide indirect CO_2 cost compensation. Target low-carbon electrolytic hydrogen cost reduction via the European Hydrogen Bank and infrastructure scaling through coordination of the Connecting Europe Facility, IPCEI Hy2Infra, and REPowerEU Hydrogen Backbone.
3. **Develop solutions to improve market financing conditions by earmarking ETS revenues.** Expand financial mechanisms such as Contracts for Difference (CfDs), financial guarantees, and credit-linked guarantees to de-risk investments in decarbonisation technologies. Leverage ETS revenues—expected to exceed €200 billion by 2030—to provide targeted support for both capital expenditure (CAPEX) and operational expenditure (OPEX) for FoaK green steel projects.
4. **Stimulate demand through green product standards and public procurement.** Introduce standardised low-carbon criteria for public procurement under the NZIA and the forthcoming Clean Industrial Deal (CID) to mobilise demand. Create lead markets targeting a proportion of green steel use in automotive manufacturing and construction projects before 2030, supported by transparent labelling systems, tax incentives for product purchase and harmonised standards.

"The technology for green steel is here and investments in decarbonisation are taking place. To secure these ongoing and future industrial investments, the EU must maintain its course with the Green Deal and the enacted Fit for 55 package. We welcome the Clean Industrial Deal as a complement to the Green Deal and see the potential to increase Europe's competitiveness, innovation and number of investments"

Maria Persson Gulda, Chief Technology Officer, **Stegra**

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References

[1]Based on EUROFER's 2024 Annual Report
[2] Based on the Future of Steelmaking, Roland Berger (2021)
[3] World Steel in Figures 2024 – World Steel Association
[4] Based on Mission Possible Partnership's Green Project Tracker and Global Energy Monitor's Global Steel Plant Tracker (2024).
[5] 3-5 Mt (50% of 10 that reached Final Investment Decision) are considered at risk is based on ThysenKrupp and ArcellorMittal's organizational announcements on company performance the impact towards sustainability commitments.
[6] Based on EU's portion of required low-carbon steel supply-demand projection in a Carbon Cost scenario, which is aligned with 1.5°C Scenario, from Mission Possible Partnership's Steel Sectoral Transition Strategy and the assuming 30% of this low-carbon steel production route is achieved via H^2-DRI by 2030 as per required to reach 2050 90% decarbonisation target in EUROFER's Low Carbon Roadmap Pathways to a CO^2 neutral European Steel Industry report, assuming BF-BOF route produces 1.9 to 2.3 $MtCO^2e$ per tonne of steel produced.
[7] Majority of the 50 Mt projects announced will use natural gas as a short-term energy/feedstock source before transitioning to Green H^2 based production, based on expert interviews
[8] Based on EU State Aid given to steel producing companies in 2023-2024, from GMK Center European countries granted €10.5 bln for decarbonization of the steel sector in 2023-2024 — GMK Center.
[9] Cost of production is based on Agora Industry, Wuppertal Institute and Lund University (2024): Low-carbon technologies for the global steel transformation. A guide to the most effective ways to cut emissions in steelmaking.
[10] Based on 2030 Landed Cost of Hydrogen (LCOH) calculation from multiple low-carbon electrolytic hydrogen producing regions to Germany by Aurora Energy Research (2023) Aurora Energy Research publishes study on the cost of imported hydrogen: Bayern Innovative