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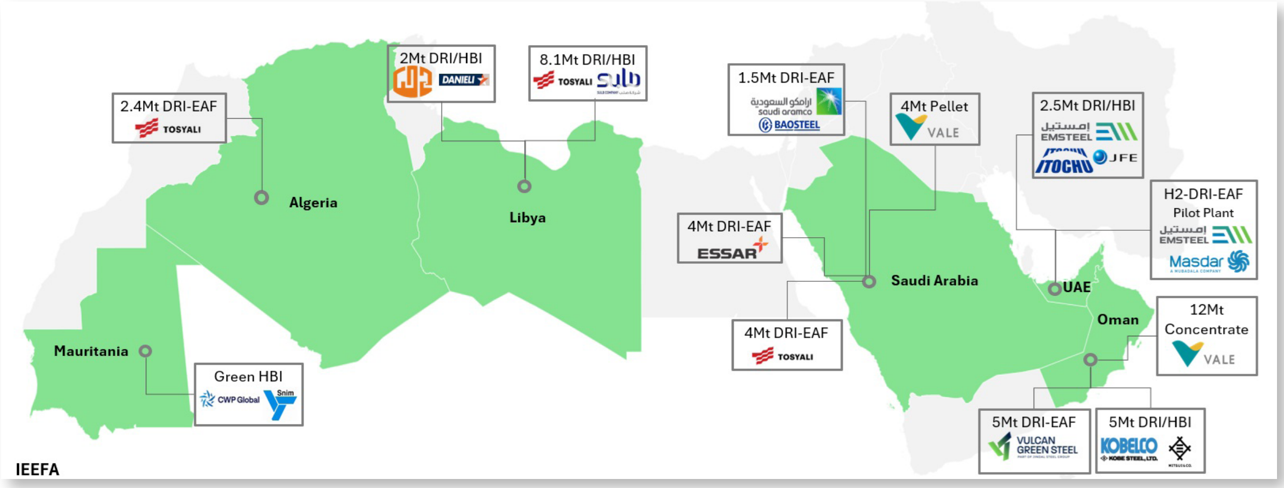
Practical steps to position MENA as a green steel leader

- *Recent announcements on developing low-emissions iron and steel capacities in the Middle East and North Africa (MENA) highlight the region's potential to become a global leader in steel decarbonisation.*
- *MENA steelmakers must rapidly incorporate renewables into their energy mix to substantially lower indirect (Scope 2) emissions. For direct (Scope 1) emissions, they have an ideal opportunity to transition from gas to hydrogen gradually and transform gas-based DRI plants into hybrid systems.*
- *With carbon capture unable to make iron and steel truly low carbon, increasing the allocation of green hydrogen to steel production in the region is essential. MENA producers could become key offtakers for green hydrogen projects.*
- *Tighter international regulations on low-emissions steel production and trade present a valuable opportunity for MENA to become a key supplier of green iron. The green premium also may incentivise MENA steelmakers to fast-track their shift to low-emission products.*

Steelmakers across the globe are rapidly embracing direct reduced iron (DRI) technology to significantly reduce their carbon footprints. The DRI-electric arc furnace (EAF) pathway not only delivers substantially lower carbon emissions than the traditional blast furnace-basic oxygen furnace (BF-BOF) route but also unlocks the potential to produce truly green steel using green hydrogen. Steelmakers in the Middle East and North Africa (MENA) have positioned themselves as global leaders in low-carbon iron and steel production, with a strong track record of utilising DRI technology over four decades.

World Steel Dynamics projects global DRI capacity will reach 175 million tonnes per annum (mtpa) by 2030, with the EU and MENA regions contributing 20mtpa and 69mtpa, respectively. Wood Mackenzie further estimates that by 2050, global demand for DRI will reach 320mtpa, with global trade reaching 75-85mtpa. MENA is expected to become a major exporter, contributing 35-40mtpa.

Figure 1: MENA low-emissions iron and steel initiatives



Recent announcements of low-emissions iron and steel projects in the MENA region indicate the green iron and steel transition has gained momentum. Much of the recent movement in new DRI capacity developed has been in the Middle East, but impetus is building in North Africa.

Turkish steelmaker Tosyali, in collaboration with the Libya United Steel Company for Iron and Steel Industry (SULB), will establish the world's largest DRI facility, with a capacity of 8.1mtpa. The first phase of this mega project, with a capacity of 2.7mtpa, will use Midrex Flex technology, and is expected to produce hot briquetted iron (HBI) for neighbouring markets and the EU.

In another memorandum of understanding (MoU), Tosyali will collaborate with Saudi Arabia's National Industrial Development Center (NIDC) to build a flat steel plant with a capacity of 4mtpa in the Ras Al-Khair industrial zone. The plant will utilise two Midrex Flex DRI plants, with a capacity of 2.7mtpa.

Libyan Iron and Steel Company (LISCO) signed an MoU with Danieli to produce 2mtpa DRI/HBI both for domestic use and export to Italy via offtake agreements with steelmakers. Danieli has also submitted a proposal to the Egyptian government to establish an integrated steel mill at a cost of US$4 billion. The proposal includes a DRI facility and hydrogen plant to produce low-emissions steel for the EU market.

Green hydrogen developer CWP Global has announced plans to use hydrogen from its 30 gigawatt (GW) AMAN project in Mauritania to produce green HBI for export to Europe. AMAN Green Energy has also signed an MoU with SNIM, Mauritania's largest iron ore producer, to collaborate on this project and produce the first green iron by 2030. Earlier this year, European Commission president Ursula von der Leyen mentioned Mauritania as a key supplier not only for green hydrogen but also for green iron, saying, "Mauritania is blessed with resources, that is space, sun and wind. With the right investment and infrastructure, this country can harness over 350GW of renewable energy only from wind and sun. But if we have clean energy coming into the game, the processing into green steel could stay here in Mauritania."

China's Baosteel has announced plans to increase its investment in BAP Al-Khair Steel Company, the new joint venture with Saudi Arabia's PIF and Aramco, to maintain its 50% share. The new company aims to produce low-emission thick plates using DRI-EAF technology.

Vale has taken another step towards establishing three mega hubs in MENA (in Saudi Arabia, UAE and Oman), signing a partnership agreement to build a 12mtpa iron ore concentrate plant in Oman, to begin operations by 2027. This plant will supply Vale's pelletising plant and future agglomeration facility in the region. Vale operates a pelletising facility with a capacity of 9mtpa.

Table 1: MENA low-emissions iron and steel initiatives

Co-operating Companies		Plant Description	End User	Commencement/ Technology
UAE	EMSTEEL, ADP, ITOCHU and JFE Steel	2.5mt DRI/HBI in Abu Dhabi	JFE Steel, other Asian steelmakers	2027 (Gas→H_2)
UAE	EMSTEEL and Masdar	H_2-DRI-EAF Pilot Plant	UAE	2024 Green Hydrogen
Oman	Vulcan Green Steel (Part of the Jindal group)	5mt DRI-EAF plant	Middle East, Europe and Japan	2026 (Gas→H_2) Energiron Zero Reformer
Oman	Kobe Steel, Mitsui & Co. and OPAZ	5mt of H_2 ready DRI/HBI	Asia and Europe Market	2027 (Gas→H_2) Midrex Flex
Saudi Arabia	Aramco, Baosteel and PIF	Integrated steel plate mill, 1.5mt (H_2 ready DRI-EAF)	Middle East Market	2026 (Gas→H_2)
Saudi Arabia	ESSAR Group and Saudi Arabia's NIDC	4mt H_2 Ready Flat Steel Integrated Mill	Saudi Arabia	Waiting for final approvals (Gas→H_2)
Saudi Arabia	Tosyali and Saudi Arabia's NIDC	4mt H_2 Ready Flat Steel Integrated Mill	Saudi Arabia	Midrex Flex (Gas→H_2)
Algeria	Tosyali Algerie Phase 4	2.4mt DRI-EAF	Algeria	Increase percentages of hydrogen in the future
Libya	Tosyali and SULB	8.1mt H_2 ready DRI/HBI	EU and North Africa	Midrex Flex (Gas→H_2) First stage 2.7mt
Libya	LISCO and Danieli	2mt H_2 ready DRI/HBI	Libya and Italy	Energiron Zero Reformer
Mauritania	CWP and SNIM	Green HBI	Europe	Feed from the AMAN hydrogen project
Vale and EMSTEEL, Saudi Arabia's NIDC, and Oman's MOCIIP		Three mega hubs in Saudi Arabia, UAE and Oman	Domestic consumption in the region	• 4mtpa pellet in Saudi Arabia • 12mtpa concentrate in Oman

Sources: Company announcements, IEEFA
Note: The National Industrial Development Center (NIDC), Ministry of Commerce, Industry and Investment Promotion (MOCIIP), Public Authority for Special Economic Zones and Free Zones (OPAZ), Public Investment Fund (PIF), Libya United Steel Company for Iron and Steel Industry (SULB), Société Nationale Industrielle et Minière (SNIM), Libya United Steel Company for Iron and Steel Industry (SULB), Libyan Iron and Steel Company (LISCO)

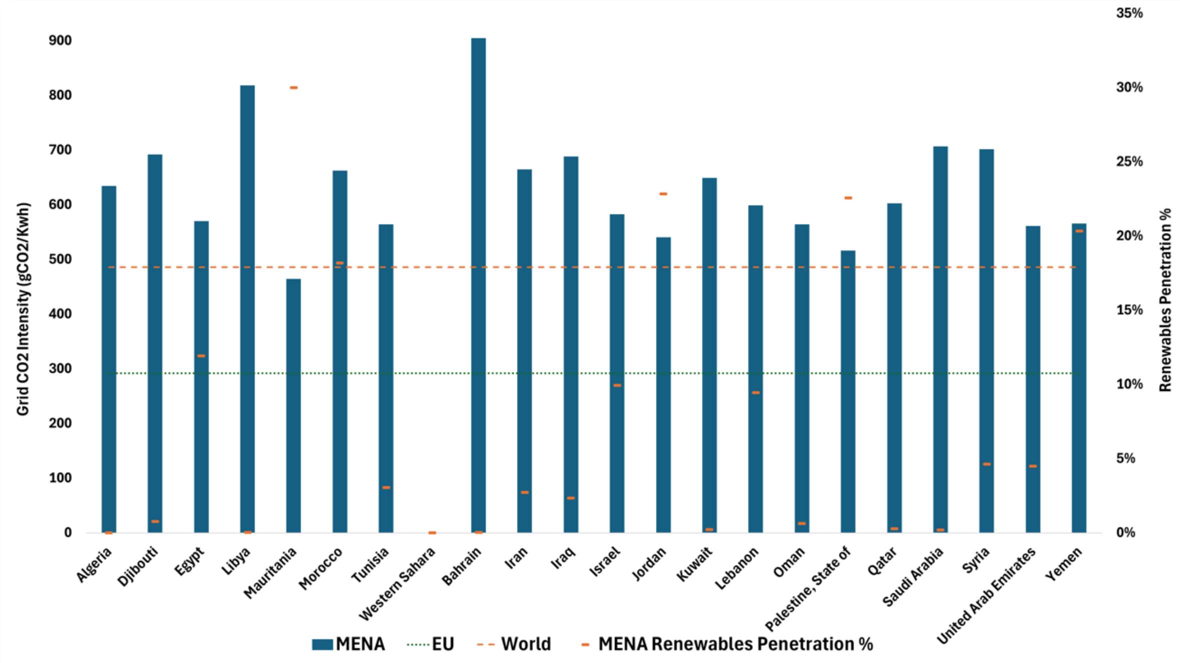
While new plants are being designed to be hydrogen-ready and are set to transition to green hydrogen in the future, the region already has opportunities to play a significant role in this emerging market with its existing capacities. Given the limitations and barriers to developing the green iron and steel value chain in other regions such as the EU, MENA steelmakers must take decisive actions to position themselves at the forefront of this race. Existing gas-based DRI-EAF facilities must urgently prioritise the gradual reduction of Scope 1 and 2 emissions to align with the stringent international criteria for low-emissions steel production.

Reducing Scope 2 emissions

DRI-EAF emissions originate from two major sources: direct emissions from using gas (or coal in coal-based DRI) in the iron ore reduction process; and indirect or Scope 2 emissions, which account for the CO_2 emissions from electricity consumption. While the emissions from most MENA nations' grids are very high due to the reliance on fossil fuels for electricity generation, and the low penetration of renewables, the region has exceptionally high potential to produce renewable energy.

The fossil fuel-based grid's carbon intensity in MENA countries exceeds the global average. According to Ember data, MENA's average CO_2 emissions were 650 grams of CO_2/kWh in 2022 whereas the global average was 486g. The averages within the EU and G7 were lower at 292g and 362g, respectively.

Figure 2: CO_2 Intensity of electricity grids in MENA countries (gCO_2/kWh)



Sources: Ember, IEEFA

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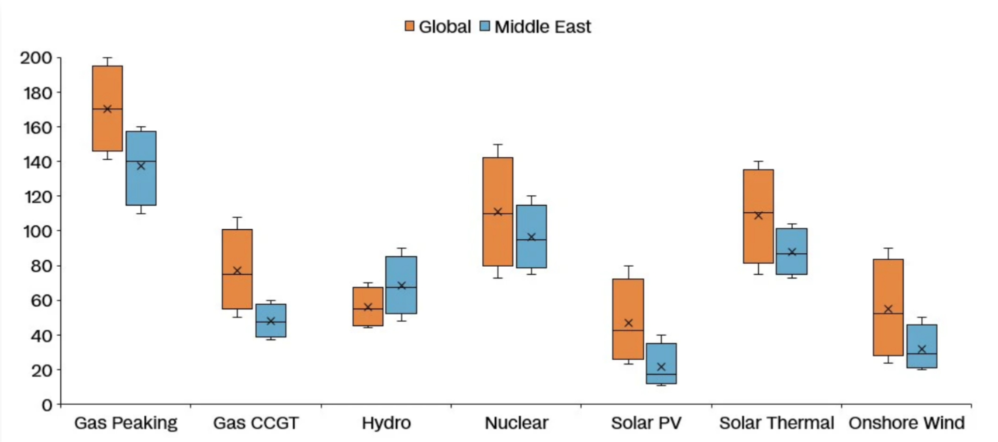
MENA's green transition in the steel sector can start by shifting gradually from fossil fuel-based electricity to renewables. Assuming 1.1 megawatt hours per tonne (MWh/t) of crude steel for an integrated gas-based DRI-EAF plant (including pelletising, DR plant, EAF and hot strip mill (HSM)) and considering average grid emissions, the Scope 2 emissions will be 715kg of CO_2 in MENA and 320kg for the EU.

EMSTEEL is committed to transitioning to low-emission electricity sources. In 2023, the company primarily sourced its electricity from nuclear (1.52 terawatt hours/TWh) and solar (0.53TWh) power, resulting in a reduction of Scope 1 and 2 emissions to 720kg of CO_2 equivalent (CO_2e) per tonne of steel – a 33% decrease on 2021.

Scope 2 emissions will become increasingly critical as producers strive to make their products competitive in the future, particularly with the introduction of stricter regulations such as Europe's Carbon Border Adjustment Mechanism (CBAM). Under EU carbon pricing, every additional 100kg of CO_2e costs about €7, and this is expected to double by 2030.

Despite the high emissions from MENA's power grids, the region possesses outstanding renewable energy potential. Saudi Arabia is achieving the world's lowest levelised cost of electricity (LCOE) from solar at just US$10.4/MWh. MENA can generate renewable energy from solar and wind sources at costs well below the global average. MENA's photovoltaic potential is the highest in the world, with minimal seasonal variability, offering a consistent and reliable energy supply. This remarkable natural advantage significantly eases the transition to clean energy and green steel compared with other regions.

Figure 3: LCOE range in the Middle East vs global average ($/MWh)



Source: [Rystad Energy's Renewables & Power Solution](), May 2024
Note: The LCOE range is for capacities over 100MW and based on the reported average LCOE in the past five years.

Gradual substitution of gas with hydrogen

Steelmakers in the MENA region have a significant opportunity to cut emissions by transforming their fleet of gas-based DRI plants into hybrid systems as a stepping stone towards a full switch to hydrogen. Although maintaining a continuous supply of green hydrogen around the clock is a considerable challenge, there is a clear pathway to producing lower-emissions iron by gradually replacing gas with hydrogen in existing DRI plants. This partial substitution not only allows for smaller facility sizes but also results in reduced capital costs, making the transition process more feasible.

Both of the major providers of gas-based DRI technology worldwide state clearly that it is feasible to inject hydrogen into existing furnaces. Midrex, the largest supplier of DR shafts, maintains that up to 30% of gas can be replaced with hydrogen without modifying equipment. The new technology variant, Midrex Flex, can use 100% gas or hydrogen, allowing for various ratios of either gas without fundamental changes to equipment.

Midrex highlighted that by replacing 30% of gas with green hydrogen, direct emissions can be reduced from 500kg to 350kgCO2/t DRI. This carbon reduction combined with using renewables to power EAFs can significantly reduce the total emissions from the DRI-EAF pathway.

Figure 4: Reduction of CO2 emissions by injecting hydrogen in Midrex DR shafts

	NG (No added H_2)	NG replacement by H_2 (Energy Basis)			
		30%	50%	80%	100%
Natural Gas Consumption (Nm³/t)	275-300	190-215	140-165	50-80	0*
H_2 Consumption (Nm³/t)	0	250-300	450-500	700-750	850-900*
H_2 / CO	1.6	2.8	4.5	10.5	N/A
CO_2 Emissions from flue gas (kg-CO_2/t-DRI)	500	350	250	100	From heater burners only (If fueled by C_nH_m) 0 If fuelled by 100% H_2

Source: Fueling the Future of Ironmaking: MIDREX Flex, March 2024

Danieli and Tenova, the developers of the Energiron technology, confirm that their plants are hydrogen-ready and compatible with various blends of hydrogen. Energiron reportedly can use a hydrogen blend of up to 80% in the short term with an unchanged plant configuration.

MENA nations have a long history of operating DRI technologies from both major providers, making it essential for regional producers to prioritise the replacement of gas with hydrogen. Recent announcements indicate new plants in the region are opting for more flexible variants of these technologies, designed to be more adaptable to hydrogen as a reducing agent. Vulcan Green Steel and LISCO have selected the Energiron Zero Reformer while Tosyali has chosen Midrex Flex for projects in Saudi Arabia and Libya as have Kobe Steel & Mitsui for their Oman project.

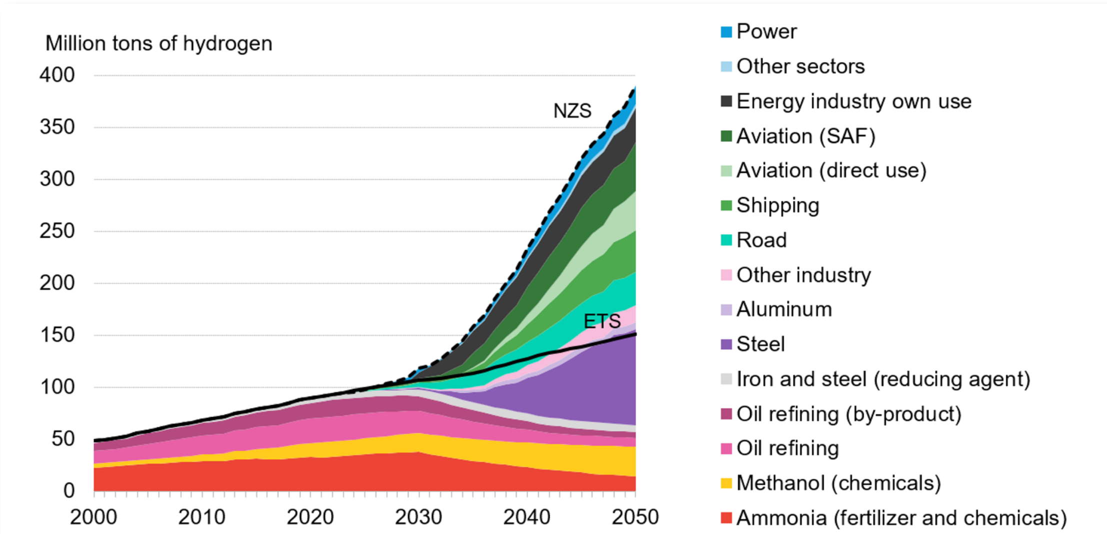
EMSTEEL is the first steelmaker in MENA to announce the partial replacement of gas with green hydrogen in its in-situ facilities. In collaboration with Masdar, the company has been working on a pilot project to utilise green hydrogen in its first direct reduction plant. This trial could mark the beginning of a gradual transition for plants in the MENA region, encouraging more companies to follow suit with greater confidence.

Given the limited ability of carbon capture and storage (CCS) technology to reduce CO2 emissions from steel production, hydrogen emerges as the superior solution to dramatically cut emissions and pave the way to carbon neutrality in the MENA region. EMSTEEL has been using CCS technology since 2016 but has not achieved significant success in carbon reduction, similar to other CCS facilities globally, with only about 26% of total plant emissions captured. In the eight years since this CCS facility began operations, no other commercial-scale CCS plants for steelmaking have come online anywhere in the world. After reducing its Scope 2 emissions by purchasing low-emissions electricity, EMSTEEL is shifting to hydrogen, a more reliable solution to tackle direct emissions in the sector.

Close the loop: Steel as a key hydrogen offtaker

The iron and steel sector is expected to be the primary end-user of green hydrogen projects in coming years in a net zero scenario by 2050, yet MENA needs more green hydrogen specifically developed for the steel sector. Most green hydrogen projects under development in the region target ammonia production for both domestic use and export purposes. BloombergNEF's New Energy Outlook 2024 emphasises the role of the steel sector as the initial hydrogen consumer in the energy transition, accounting for nearly a quarter of the total 390mt of consumption by 2050. If MENA wants to improve its position as a supplier of green iron and steel, it must act quickly and establish more dedicated hydrogen plants for ironmaking.

Figure 5: Hydrogen demand by sector and application in Net Zero Scenario



Source: BloombergNEF

The Bloomberg Hydrogen Supply Outlook 2024 shows that despite the surge in low-emissions hydrogen production, there remains a significant gap in meeting most government targets. The report indicates that total production of low-emissions hydrogen will reach 16.4mt by 2030, with 9.6mt green hydrogen and 6.8mt blue hydrogen, based on fossil fuel and CCS technologies. The steel sector's share of this capacity is 275,000t, all of which is green hydrogen, with the largest capacities being developed in the Nordics for projects such as Stegra (formerly known as H2 Green Steel) and SSAB HYBRIT.

Green hydrogen development appears to be slower than anticipated. One of the challenges for hydrogen developers is securing purchasers for their products. While MENA holds significant potential for green hydrogen production, the process of reaching a final investment decision (FID) has been very slow. This is primarily due to high production costs and uncertainties around offtakers. According to BNEF data, nearly 90% of all announced hydrogen projects do not have contracted buyers.

In April 2024, Oman's government awarded the second round of development rights for land in Dhofar for hydrogen projects. Meanwhile, the consortiums that were awarded rights in the first round of the Hydrom auctions have yet to reach FID.

Low-emissions steel producers have recently achieved success in preselling their products through offtake agreements, with Stegra (H2 Green Steel) leading the way by securing numerous mid- to long-term contracts. Notable partners include car manufacturers Volvo, Mercedes, BMW and Porsche, as well as major companies such as Cargill and IKEA.

German steelmakers ThyssenKrupp and Salzgitter AG have also signed agreements to supply green steel to automakers. Beyond the EU, projects such as Vulcan Green Steel in Oman have secured offtake agreements with Volkswagen and signed MoUs for low-carbon steel supply.

New analysis from Transport & Environment (T&E) revealed that by 2030, shifting to 40% green steel would add only €57 to the price of electric vehicles (EVs). By 2040, transitioning to 100% green steel would increase the price by just €8, compared with using carbon-intensive steel. This explains why carmakers are eager to offtake green steel, as it has a minimal impact on their final costs.

While demand for green steel looks promising from the end-user perspective, the green hydrogen industry is struggling to reach a final investment decision (FID). To overcome this hurdle, collaboration between steelmakers and hydrogen developers is essential.

The UAE, which aims to produce 1.4mt of hydrogen by 2031, may need more hydrogen to meet its 25% carbon reduction in hard-to-abate industries. Its hydrogen needs for domestic market and export could reach 2.7mt in the next decade, including domestic iron and steel demand of 0.6mt.

Green hydrogen and renewables developer CWP Global is exploring opportunities to produce green iron to meet the growing demand for hydrogen. CWP has signed agreements with SNIM in Mauritania and the Corner Brook Port Corporation (CPBC) in Canada to produce green iron alongside its green hydrogen facilities.

The German government has signed an agreement to produce 10,000t of green hydrogen in Morocco, to be sent to Germany for the production of 50,000t of green steel by 2028 or 2029. This green hydrogen will be distributed to offtakers through an international public tender, expected to commence in late 2024.

Salzgitter AG has signed an offtake agreement with Uniper SE to supply 20,000tpa of green hydrogen from 2028. Uniper will build a 200MW electrolyser to support the Salzgitter Low CO_2 Steelmaking (SALCOS) project, which requires up to 150,000tpa of green hydrogen in its first stage.

Quinbrook Infrastructure Partners has announced plans to produce green iron in Queensland, Australia. The renewable energy investor plans for the US$2.3 billion project to be an offtaker from the CQ-H2 green hydrogen plant, which is being developed at the same site.

These collaborations between hydrogen developers and steelmakers must be significantly scaled up. Strengthening this partnership is crucial in the MENA region, as it presents a win-win scenario for both industries, ensuring mutual benefits in the transition to cleaner technologies.

CBAM: A challenge for the EU and an opportunity for MENA

By applying the Carbon Border Adjustment Mechanism (CBAM), the EU's free carbon allowances for steelmakers are set to be gradually removed from 2026. This new scheme introduces stringent restrictions on steel exporters to the bloc, compelling them to accelerate their decarbonisation efforts.

Despite its ambitious decarbonisation goals, producing green hydrogen and renewables in the EU remains more costly compared with other regions such as MENA. Consequently, EU nations must rethink their strategies and place greater emphasis on importing low-emissions raw materials from other areas to achieve their climate targets.

Although the EU is firmly committed to decarbonising its steel sector, some steelmakers remain reluctant to import green iron from regions with more favourable conditions. Their hesitation stems largely from concerns over the long-term viability of steelmaking within the EU and the risk of significant job losses.

However, Agora Industry research underscores that a decoupling strategy presents a compelling win-win opportunity for both trade partners. The analysis shows that steelmakers in regions where green hydrogen costs are high (e.g. the EU) can sustain their operations and safeguard jobs. Meanwhile, exporters stand to gain significantly by creating new jobs in the hydrogen value chain, increasing the value of their products.

Additionally, EU steelmakers have received billions of euros in grants to accelerate the transition within the EU, rather than relocate ironmaking to other regions. This commitment raises concerns about the viability of export markets, despite studies indicating the feasibility of importing green iron.

Exporting hydrogen proves to be highly inefficient, and separately transporting iron ore and hydrogen for green iron production would undermine the core advantages of the transition to low-emissions steel. Rystad's recent report shows importing H_2-DRI from Oman is more cost-effective than producing it domestically in Germany. Additionally, another study shows producing steel from locally sourced DRI in Germany adds 21% to costs compared with importing HBI from South Australia. Market forces will ultimately shape the viability of producing green iron in MENA for export.

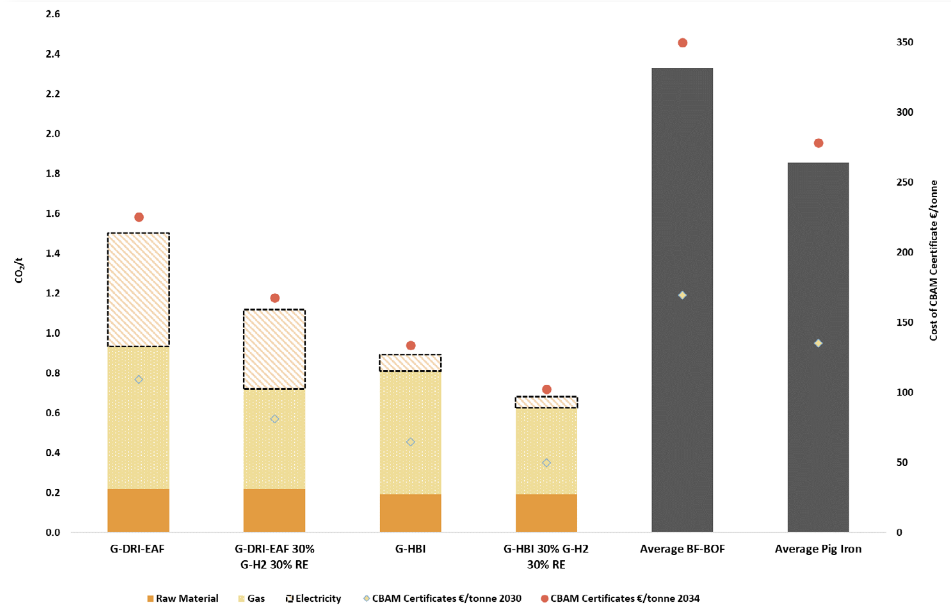
The EU aims to produce and import 10mt of green hydrogen by 2030, yet with green hydrogen consumption at a mere 110,000t in 2023, these initial targets appear increasingly unattainable.

The EU ETS carbon price in September 2024 was about €70/tCO_2 and in the shorter term by 2030, it is estimated to reach €147 before rising to €200-€250 as the CBAM is phased in completely. Given the high carbon prices, MENA producers will have an advantage over their Asian competitors in exporting low-emissions iron and steel to the bloc.

With comparatively lower emissions, MENA primary steelmakers may require fewer CBAM certificates than their competitors. This could potentially shift trade flows of iron and steel to the EU, even though MENA nations currently have low export volumes to the bloc.

By the end of the decade, the partial substitution of gas with green hydrogen and the increased use of renewables to power steel mills in MENA will be critical to improving their exports to the EU and staying competitive in the new green steel market.

Figure 6: MENA iron and steel CO_2 emissions and CBAM certificates required by 2030 and 2034



Source: IEEFA
Note: Gas-based Direct Reduction-Electric Arc Furnace (Gas-DRI-EAF), Green Hydrogen (G-H2), Renewables (RE), Blast Furnace-Basic Oxygen Furnace. Emissions (tCO2/tonne): Iron Ore Pellets 0.137, Pig Iron 1.855, Steel (BF-BOF) 2.33, Electricity 0.65 (tCO2/MWh), Natural Gas 0.056 (tCO2/GJ). Consumptions: Gas 11GJ/t(DRI/HBI), Iron Ore Pellet 1.385 t/t (DRI/HBI), Pellet 1.6t/tSteel, EAF electricity 0.750MWh/tSteel, DRI electricity 0.125MWh/tDRI. Carbon Price: 150 (€/tCO2), Proportion of reported emissions obliged to buy CBAM certificate by 2030=48.5% & 2034=100%.

Given the high carbon intensity of MENA grids, prioritising low-emissions iron production for export, such as DRI/HBI, is strategically advantageous. Ironmaking in DR shafts demands less electricity than steelmaking via EAFs, making it a more sustainable option in the short term. As MENA gradually shifts to cleaner grids powered by renewables, this transition period presents an opportunity for collaboration between EU steelmakers and MENA ironmakers. The diverse opportunities and capabilities across regions underscore the inevitability of decoupling ironmaking and steelmaking processes, paving the way for a more integrated and efficient global steel supply chain.

Green premium opportunities

The "green premium" refers to the additional amount buyers are willing to pay for low-emission steel over and above the final price. To capture the green premium in the market, emissions for primary green steel may need to be below 400kgCO_2/t finished steel, far lower than the CO_2 emissions from MENA's gas-based steel production. While MENA steelmakers can comply with the "stick" of regulations such as CBAM using existing technology, securing the "carrot" of the green premium is more challenging, and will require further efforts to reduce emissions.

As the market works toward a consensus on the definition of green or low-emission steel, indices are emerging to quantify the added value of these products. In May, Fastmarkets launched a green steel price index in the US, setting a maximum CO_2 emissions threshold of 700kgCO_2/t hot rolled coil (HRC), including Scope 1, 2 and 3 emissions. In Asia, Fastmarkets' green steel threshold is 1.3tCO_2/t steel while Europe's limit is 1t. On 10 May 2024, Fastmarkets reported green steel import prices, relative to the HRC index, cost and freight (cfr) to Vietnam, at $204-$340/t. Meanwhile, the domestic green steel differential, ex works (exw) in Northern Europe, was $150-250/t as of 9 May 2024.

The green premium is likely to be a short to mid-term "carrot" for early movers producing low-emissions steel. Some experts anticipate that by the 2030s, the premium may diminish as the supply of low-emission products increases and grey steel prices rise due to carbon prices, reducing the price gap. Furthermore, the criteria for qualifying for the green premium may become stricter, tightening the allowable CO_2 intensity.

In the years ahead, the green premium will be a key driver of the steel sector's transformation. MENA steelmakers can meet the thresholds of some indices by gradually shifting to low-emissions electricity and replacing gas with hydrogen.

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