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Blue hydrogen: A false hope for steel decarbonisation

- *The value of hydrogen in the steel sector lies in its potential to reduce carbon emissions by replacing fossil fuels in the production process. However, using blue hydrogen – produced from fossil fuels with partial carbon capture – offers no climate benefit.*
- *Blue hydrogen faces significant problems, including the underperformance of carbon capture technology; methane emissions and the resultant difficulty meeting stringent global emissions standards; and opposition from end-users who reject fossil-based materials in their value chain.*
- *Deploying blue hydrogen poses a strategic risk for steelmakers, potentially missing the shift to truly green steel and the growing market for low-emissions materials.*

The hype around hydrogen burst in 2024, with a more realistic attitude taking shape regarding hydrogen's applications and the cost and location of its production. Since the beginning of last year, there has been a trend towards clarifying hydrogen's role, narrowing its application to key areas such as iron and steel where electrification may not be able to decarbonise the sector completely.

However, the cost of producing green hydrogen is higher than previously estimated, which has led to the cancellation of some projects. Furthermore, the scale of renewable energy and supporting infrastructure needed to power electrolysers for decarbonising steel mills is enormous.

Today, hydrogen is predominantly produced from fossil fuels, especially gas, in which case it is known as "grey hydrogen". This mature technology is the cheapest way to produce hydrogen but emits a significant amount of carbon dioxide (CO_2). Reducing emissions from grey hydrogen production requires carbon capture and storage (CCS) technology – grey hydrogen coupled with CCS is referred to as "blue hydrogen". However, CCS has a record of underperformance, raising doubts about its practicality and effectiveness in achieving significant carbon reduction.

Countries like Germany and Japan, along with corporates such as POSCO and Salzgitter that require substantial hydrogen for iron and steel decarbonisation, are considering blue hydrogen as a potential alternative to green hydrogen (produced using renewable energy and electrolysis). Some are even planning to import it from regions better suited to hydrogen production due to limited competitiveness domestically.

Due to the recent challenges for hydrogen development, ArcelorMittal and Thyssenkrupp have announced delays to their DRI transition plans and intend to revise their decarbonisation strategies. German Chancellor Olaf Scholz has also advocated for introducing political pragmatism into the push for a green steel industry, addressing both the timeline for transitioning from gas to hydrogen and the choice of hydrogen sources, potentially paving the way for the use of blue hydrogen.

As the hydrogen landscape becomes more pragmatic, choosing the right “colour” of hydrogen becomes crucial to maximising its impact on decarbonisation. Although green hydrogen production costs have not declined as fast as forecasts suggested, it remains the most effective long-term solution for addressing the decarbonisation of primary steelmaking.

This report aims to critically assess the role of blue hydrogen in decarbonising steel, with a specific focus on its use within the direct reduced iron (DRI) pathway. Although there are initiatives to incorporate hydrogen into blast furnace-basic oxygen furnace (BF-BOF) technology, such as Nippon Steel’s COURSE50 project, IEEFA does not regard any coal-based steelmaking technology as a viable decarbonisation solution.

Blue hydrogen and DRI

Hydrogen-based direct reduced iron (H_2-DRI) is a promising alternative to fossil fuels in ironmaking. The technique uses hydrogen gas to reduce iron ore to iron, which is then used to make steel. While nearly all upcoming DRI-electric arc furnace (EAF) projects plan to initially operate on gas, a few with advantageous conditions – such as Stegra in Sweden and Blastr Green Steel in Finland – have opted to start with green hydrogen from day one using Midrex H_2 technology.

Meanwhile, some steelmakers are also considering blue hydrogen as an alternative feedstock for DRI production. POSCO has reportedly announced a 1 trillion won (US$730.4 million) investment in blue hydrogen for DRI production. This project, in collaboration with ADNOC, will be located at POSCO’s liquefied natural gas (LNG) terminal in Gwangyang, where the company operates one of the largest steel plants in the world. POSCO has previously stated that, by 2035, the project is projected to produce 1.26 million tonnes of blue hydrogen annually, intended for use in power generation and steel production at nearby facilities.

Published in July 2024, Germany’s hydrogen import strategy includes blue hydrogen to meet high anticipated demand in the coming years. The steel sector will be one of the primary end-users of imported hydrogen, with many major German steelmakers transitioning to the DRI-EAF route. According to the strategy document, the country requires as much as 130 terawatt-hours (TWh) of hydrogen by 2030, and up to 500TWh by 2045. While the country cannot supply that hydrogen demand domestically, it is eyeing imports to answer 50%-70% of its needs in the short term.

German steelmakers have secured multi-billion-euro grants to transition from blast furnaces to hydrogen-based DRI-EAF by the end of this decade. Steelmakers are anticipated to become one of the primary end-users of green hydrogen in this shift, creating nearly 0.85 million tonnes of demand by 2030.

The Christian Democratic Union (CDU), widely regarded as the party most likely to lead Germany's next government, may place greater emphasis on both the import and domestic production of blue hydrogen, turquoise hydrogen (via methane pyrolysis) and pink hydrogen (produced through nuclear-powered electrolysis). In its energy policy position paper, the CDU states, "If hurdles continue to be put in place for the import or pragmatic domestic production of blue or turquoise hydrogen, the rapid ramp-up of the hydrogen economy and thus the project of making Germany climate-neutral as an industrial country will fail… there must be openness to all colours."

Thyssenkrupp has issued a tender for the supply of 143,000 tonnes of hydrogen to fuel its planned DRI facilities in Duisburg, with potential contributions from blue hydrogen suppliers. Similarly, Salzgitter has announced a tender for hydrogen procurement to support its SALCOS project. The tender includes low-emission hydrogen that complies with EU regulations, achieving a lifecycle emissions reduction of at least 70% compared to the fossil benchmark of 94g of carbon dioxide-equivalent (CO_2e) per megajoule (MJ).

Released in June 2023, Japan's hydrogen strategy projects a demand of about 20 million tonnes of hydrogen across all industries by 2050, with around 7 million tonnes allocated for the steel sector. However, it does not specify the "colour" or production method of the hydrogen. The strategy defines "green" hydrogen with a carbon intensity threshold of 3.4 $kgCO_2e/kgH_2$, without mentioning the timeline for putting it into force, allowing for some flexibility in the production sources.

Direct reduction (DR) technology provider Tenova is providing Japan's first hydrogen-based Experimental Direct Reduction Plant (EDRP) for Nippon Steel, supported by Japan's New Energy and Industrial Technology Development Organization (NEDO). This pilot plant, located at Nippon Steel's R&D centre, uses Energiron technology, co-developed with Danieli, to enable hydrogen reduction of low-grade iron ore. The plant will feature CO_2-capture technology and can operate with various gases, indicating that the hydrogen supply may be fossil-based rather than renewable.

In Australia – which is the world's largest iron ore producer – BlueScope, BHP and Rio Tinto have announced their collaboration on the first pilot plant for a DRI-electric smelting furnace (ESF), named NeoSmelt, with an annual capacity of 40,000 tonnes of molten iron. Woodside Energy has joined the consortium to supply gas initially, with plans to provide low-emissions hydrogen instead of green hydrogen once operational.

Assessing the emissions footprint of blue hydrogen

Producing hydrogen from gas is highly energy-intensive and generates significant CO_2 emissions. The total emissions from the blue hydrogen pathway depend on various factors, and studies often overlook or inadequately address key assumptions, leading to potential inaccuracies in their conclusions.

The effectiveness of **CCS** in capturing CO_2 is often overestimated. Carbon capture technology has been around for nearly five decades but has a track record of significant underperformance, and projects have consistently fallen short of achieving their targeted carbon capture rates. There are three blue hydrogen projects currently operating in the US, all capturing CO_2 from steam methane reforming (SMR) plants. However, IEEFA research has shown that their capture rates fall well below the 95% often claimed by CCS proponents.

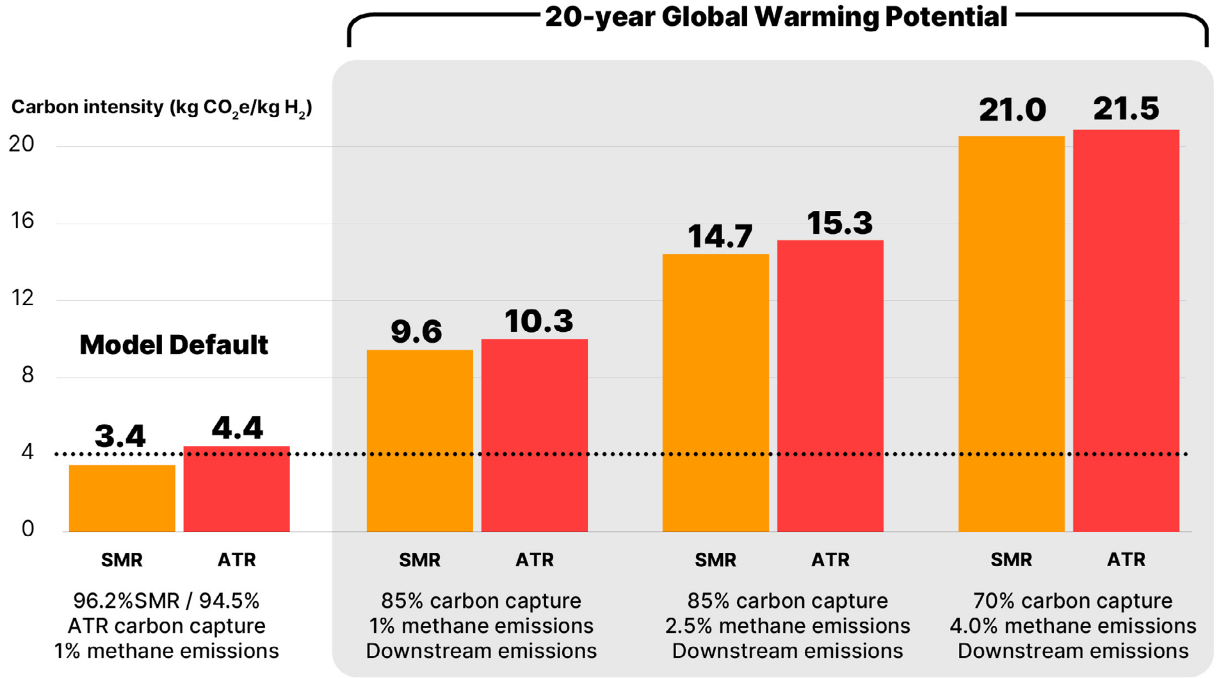
Moreover, **methane** is the largest component of gas and its emissions pose a significant challenge for gas-based technologies, including blue hydrogen. Methane emissions are frequently underestimated in terms of their:

- **Global warming potential (GWP) over the longer term.** Methane is a highly potent greenhouse gas with a much stronger warming effect than CO_2. Over a 20-year timeframe (GWP20), methane's global warming potential is 84-87 times that of CO_2, while over 100 years (GWP100), it is 28-36 times greater. Basing key assumptions on the GWP100 timeframe can underestimate methane's true impact on global warming.
- **Leakage rates.** Methane emissions reported by oil and gas companies have been significantly underestimated. Recent advancements in satellite monitoring technology and the increased availability of public data have revealed a much larger gap between reported and actual emissions.

The role of downstream **hydrogen emissions** in extending the warming effects of methane has not been adequately considered. One study shows that, in the worst-case scenario for blue hydrogen (10% hydrogen leakage and 3% methane leakage), the initial climate impact could be worse than the CO_2 emissions from equivalent fossil fuel technologies. This scenario could result in up to 40% more warming over the first decade and require approximately 50 years before the benefits of transitioning to blue hydrogen are realised.

An IEEFA assessment of the US Department of Energy (DOE)'s greenhouses gases lifecycle analysis model (GREET) indicates that emissions for blue hydrogen may be significantly underestimated. By updating methane emissions from 100-year GWP to 20-year GWP, using more realistic estimates for upstream methane leakage and actual carbon capture rates in gas-based hydrogen production, and factoring in downstream hydrogen leakage, the total estimated emissions for blue hydrogen would be much higher (Figure 1).

Figure 1: Blue hydrogen carbon intensity based on DOE's GREET model



Source: IEEFA, based on DOE's GREET model. Note: SMR = steam methane reforming; ATR = autothermal reforming; GWP = global warming potential.

Does domestic or imported blue hydrogen fit within regulatory frameworks?

The DOE's clean hydrogen production standard has set a target of ≤4.0 $kgCO_2e/kgH_2$ for well-to-gate (excluding transportation value chain) lifecycle greenhouse gas emissions. This target aligns with the upper limit of the four-tier incentives in the Inflation Reduction Act (IRA)'s 45V tax credits for clean hydrogen.

For Japan and South Korea, the well-to-gate emissions standards were set at 3.4 and 4 $kgCO_2e/kgH_2$, respectively. Similarly, most regulatory frameworks with threshold and tier systems mandate a carbon intensity below 4 $kgCO_2e/kgH_2$.

In the EU, the emissions savings threshold plays a crucial role, requiring that any genuinely low-carbon fuel must achieve at least a 70% reduction in emissions compared with the emissions intensity of a fossil fuel benchmark, set at 94 gCO_2e/MJ (or 3.38 $kgCO_2e/kgH_2$). By the end of this decade, EU industrial producers, including those in the steel sector, must obtain 42% of their hydrogen consumption from green hydrogen sources, with this share rising to 60% by 2035.

It is extremely challenging for blue hydrogen to meet these emissions intensity targets. In September 2024, Shell and Equinor halted their gigawatt-scale blue hydrogen projects in Norway due to a lack of demand. Both projects were planned to supply hydrogen to Germany. This decision reflects the difficulty in meeting the EU's stringent carbon emission regulations through the blue hydrogen pathway, as end-users are reluctant to commit to materials with high associated CO_2 emissions.

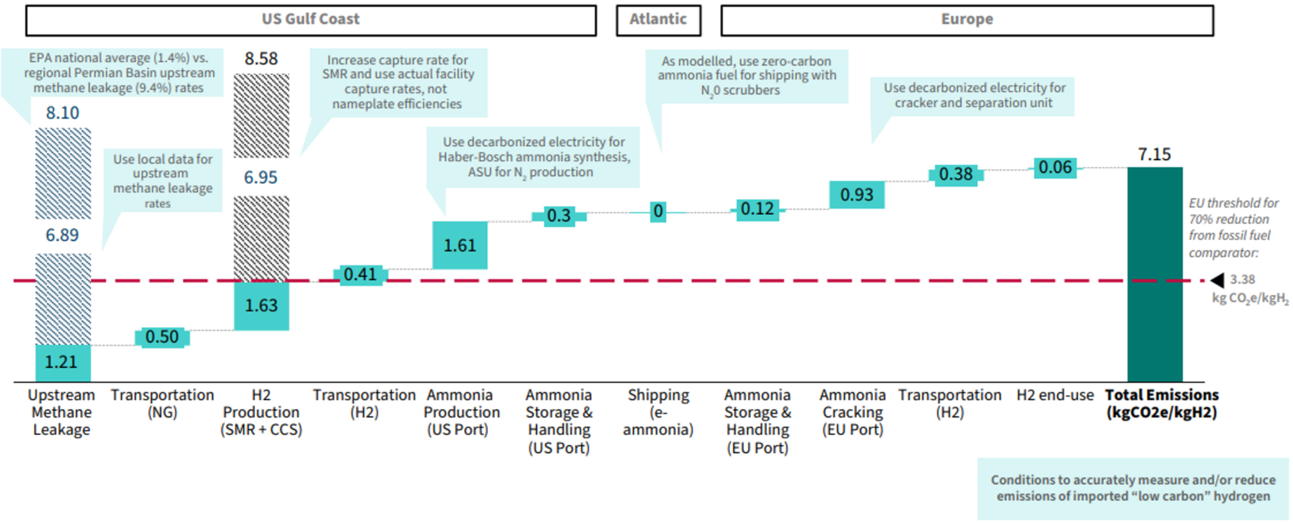
Stricter regulations will come into effect in the coming years, making it increasingly difficult for blue hydrogen to attract end-users including steelmakers, while green hydrogen developers continue to gain momentum.

The situation becomes even more complex when hydrogen is sourced from exports, as projects must also contend with the inefficiencies of hydrogen transportation.

A recent report from Green Hydrogen Catapult and the Green Hydrogen Organisation highlighted that importing blue hydrogen into the EU from sources like the US Gulf Coast fails to meet the carbon reduction thresholds set by regulators (3.38 $kgCO_2e/kgH_2$). The report also assessed hydrogen import options for Japan (for example, from Australia and the US) finding that all scenarios exceeded the limit of 28.33 gCO_2e/MJ.

The report considered not only emissions directly associated with blue hydrogen production, such as methane leakage and actual carbon capture rates, but also the inefficiencies involved in converting hydrogen into carriers like ammonia and reconverting it back to gaseous form. Figure 2 illustrates the emissions intensity of landed blue hydrogen in Europe, based on optimistic assumptions of 1.4% methane leakage and 85% carbon capture efficiency.

Figure 2: Calculated emissions intensity of landed blue hydrogen in Europe, $kgCO_2e/kgH_2$



Source: Green Hydrogen Catapult and Green Hydrogen Organisation.

Recent studies also indicate that long-distance transportation of liquefied hydrogen could be prohibitively expensive. For example, shipping hydrogen from Australia to South Korea in 2023 could cost as much as US$30/$kgH_2$. At European Hydrogen Week in Brussels 2024, Mohammad Abdelqader El-Ramahi, chief green hydrogen officer at Masdar, said “the transforming [into H_2], converting [into NH_3] and reconverting [into H_2] by cracking would be a business killer as simple as that because the cost would be astronomical.”

Blue hydrogen economics and emissions profile in steel production

Emissions

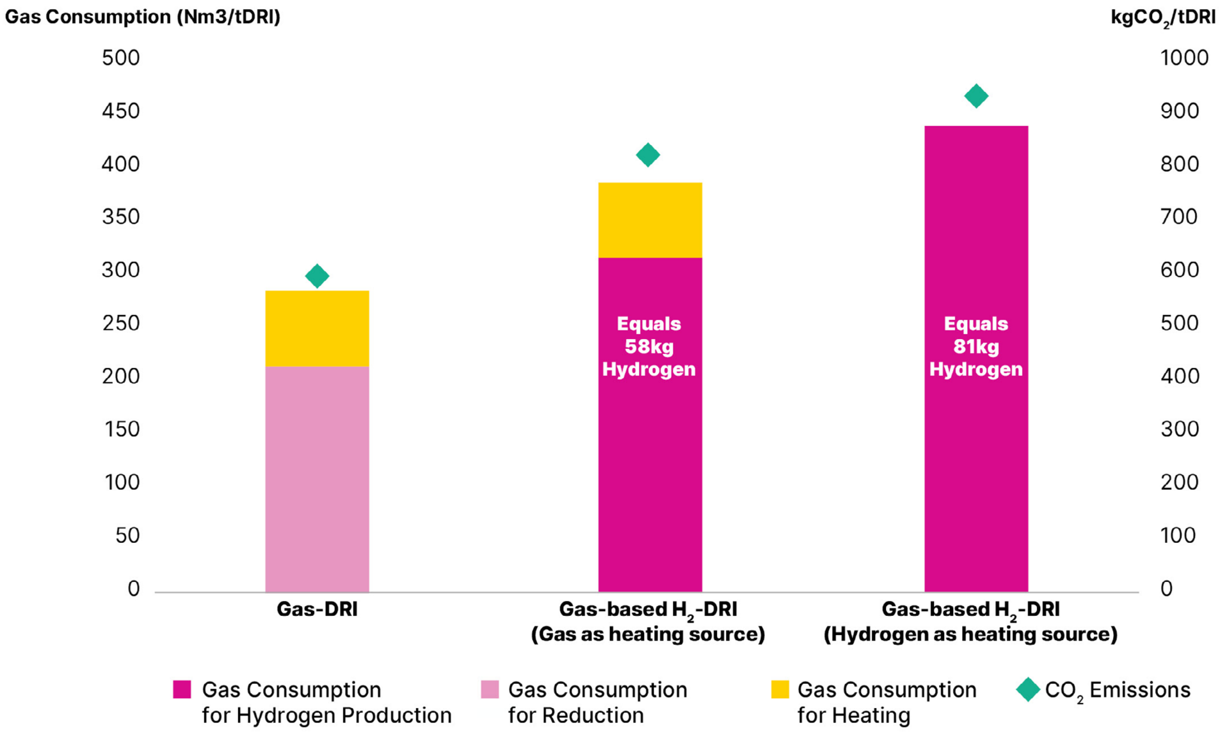
Hydrogen plays a critical role in ironmaking by replacing fossil fuels in DR technology. This process, which currently relies on gas (or syngas derived from coal gasification), can potentially lower emissions by using pure hydrogen as a reducing agent during the reduction of iron ore. Hydrogen’s ability to reduce emissions depends heavily on its production method. Only hydrogen produced through renewable-powered electrolysis (i.e. green hydrogen) can achieve near-zero emissions.

> “ **In DR ironmaking, replacing gas with hydrogen produced from gas (grey hydrogen) does not lead to a reduction in gas consumption or carbon emissions.**

In DR ironmaking, replacing gas with hydrogen produced from gas (grey hydrogen) does not lead to a reduction in gas consumption or carbon emissions. The gas required for hydrogen production and the associated emissions from the grey hydrogen process are higher compared with traditional gas-based DR. Additionally, for blue hydrogen, the process introduces extra energy demands for capturing and transporting the CO_2 emitted, further diminishing hydrogen’s efficiency and environmental benefits.

The carbon intensity of gas-based hydrogen production through SMR technology is approximately 11.46 $kgCO_2e/kgH_2$. Based on figures from Midrex (the leading provider of DR technology and Primetals), for each tonne of DRI, about 58.4kg to 81.3kg of hydrogen is required, depending on whether heating of the reducing gas is included or not. Figure 3 shows the gas consumption and the related emissions in different scenarios of switching from gas to gas-based hydrogen. This equates to 817 kgCO$_2$/tDRI when grey hydrogen is used for iron ore reduction and gas for heating, and 931 kgCO$_2$/tDRI when hydrogen is used for both reduction and heating. In comparison, gas-based DRI direct emissions from using gas are 584 kgCO$_2$/tDRI, underscoring the substantial challenges associated with transitioning to any fossil-based hydrogen. The critical question is, how much can emissions realistically be reduced from this fossil-based hydrogen process, and at what cost?

Figure 3: Gas consumption and related CO$_2$ emissions in DRI production (switching from gas to gas-based hydrogen)

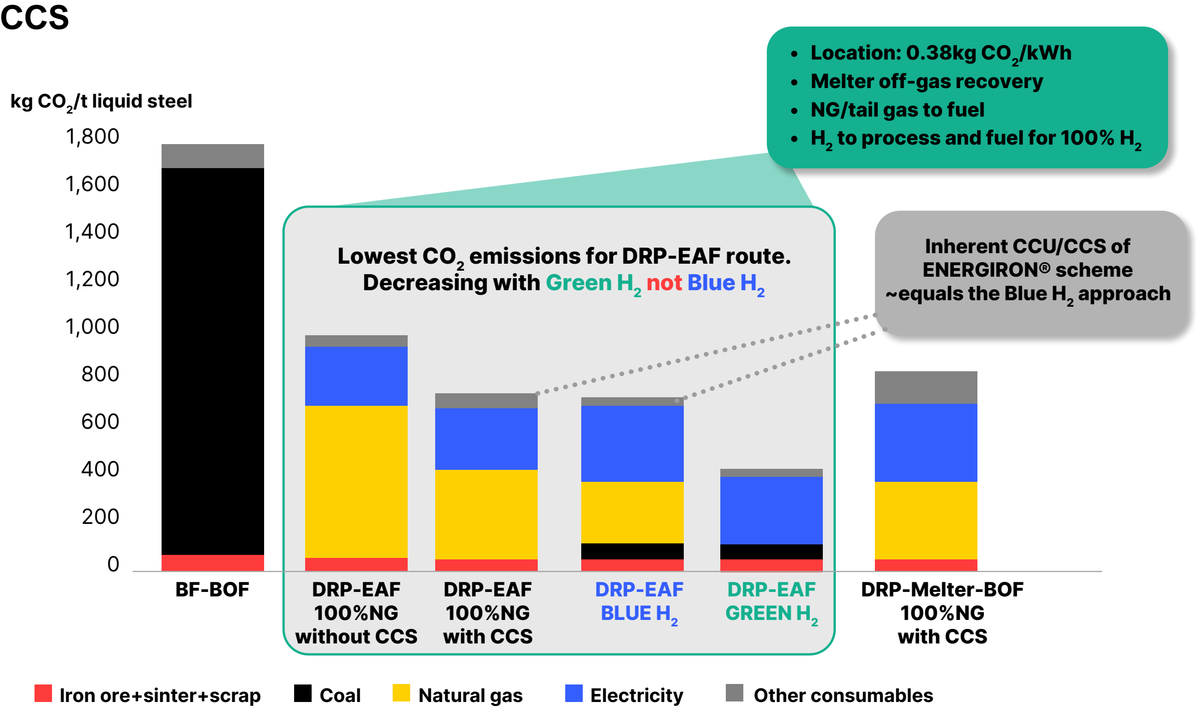


Sources: Primetals, Midrex, IEEFA calculations.
Assumptions: Gas emissions: 0.056 tCO$_2$/Gj; Gas consumption for SMR: 3.85 kg/kgH$_2$; Grey hydrogen emissions: 11.46 kgCO$_2$/kgH$_2$. The total gas consumption for the DRI process is 282 normal cubic metres (Nm^3), of which nearly 25% is needed for heating the gases in the reformer. To completely replace gas with gas-based hydrogen, a total of 436 Nm^3 of gas would be required, equivalent to 81 kg or 904 Nm^3 of hydrogen.

Transitioning to fossil-based hydrogen not only worsens carbon emissions but also depends on unproven CCS technology for emissions mitigation. CCS has yet to provide a reliable solution for either the steel industry or the hydrogen sector.

Tenova indicates that using blue hydrogen or deploying CCS achieves only about a 25% reduction in total emissions within the DRI-EAF pathway when considering emissions across the entire steel value chain. This analysis also emphasised that "whenever there is the possibility of ENERGIRON® technology, with inherent selective CO$_2$ elimination for CCU/CCS … the direct use of NG [natural gas] followed by Green-H$_2$ will be the efficient and economical approach versus Blue H$_2$ in terms of CO$_2$ emissions."

Figure 4: Expected CO_2 emissions for different DRI routes with and without CCU/CCS



Source: Tenova.
Note: CO_2 capture from flue gases is excluded from this calculation due to its low concentration, inefficiency, and high energy demand. CCU = carbon capture and utilisation; CCS = carbon capture and storage; DRP = direct reduction plant; NG = natural gas.

The performance of the Al Reyadah carbon capture, utilisation and storage (CCUS) facility, with a nominal capturing capacity of 0.8 million tonnes per annum (Mtpa), supports these figures. Emsteel has utilised Energiron DR plants and has been capturing CO_2 emissions through this facility since 2016. From 2020 to 2023, this facility captured and sequestered 19.3% to 26.6% of total emissions (Scopes 1 and 2).

Cost

Currently, the production cost of blue hydrogen is lower than that of green hydrogen. This is primarily because the green hydrogen economy is still in its infancy, whereas gas-based hydrogen technologies have dominated production for decades, resulting in lower costs. However, the primary objective of using hydrogen in the steel sector is to reduce carbon emissions, necessitating its comparison with other mature technologies in the industry.

Proponents of blue hydrogen argue that it is cheaper and that achieving cost parity with green hydrogen will take many years. However, a recent study indicates that the higher residual emissions of blue hydrogen could undermine its price competitiveness well before green hydrogen reaches cost parity. This study, which includes an interactive model, suggests that blue hydrogen would only be cost-competitive under very low gas prices (≤EUR15 per megawatt-hour), with over 90% of CO_2 captured and with minimal methane emissions (<1%) – criteria that are unlikely to be achievable in real-world conditions.

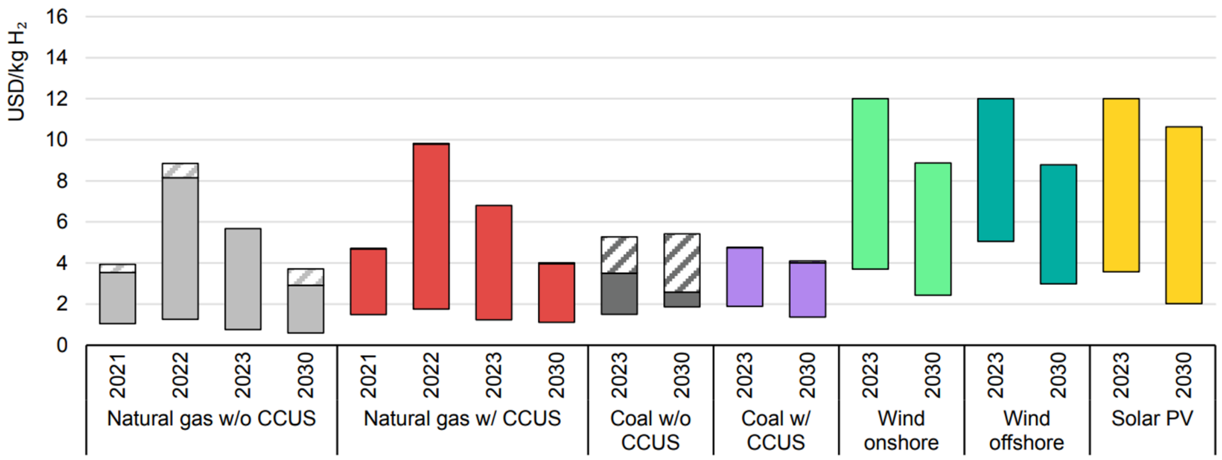
From a cost perspective, despite the challenges facing green hydrogen, developers strategically positioned in areas with access to affordable renewable energy will be able to produce green hydrogen at a lower cost than blue hydrogen by the end of this decade. Over time, the cost of electrolysers is expected to decrease significantly, while the cost of electricity – the main component and cost driver of green hydrogen production – is on a consistent long-term downward trend. These factors strongly favour green hydrogen as the more economical and sustainable option in the long run.

Although the cost reduction in electrolysers has not met earlier projections, capital expenditure for electrolysis is still expected to decrease by 50% by 2050 in key markets such as China, Europe and the US. Additionally, advancements in electrolysis technology are anticipated to boost efficiency to over 84%, compared to the current 66%-72%, further driving down the cost of green hydrogen and enhancing its competitiveness.

A recent BNEF analysis forecasts that on average the levelised cost of green hydrogen will decline by 34% by the end of this decade and an additional 40% by 2050, reaching \$1.6–\$5.09/kg across different markets. Green hydrogen could become cost-competitive with grey hydrogen in regions such as India and China by 2040.

The International Energy Agency (IEA)'s Global Hydrogen Review 2024 forecasts that in the Net Zero Emissions (NZE) scenario, certain regions with abundant renewable energy potential could produce green hydrogen at costs ranging from US\$2-4/kg, making it competitive with blue hydrogen. (Figure 5)

Figure 5: Hydrogen production cost by pathway, 2023, and in the Net Zero Emissions by 2050 Scenario, 2030



Source: IEA, Global Hydrogen Review 2024

Unlike electrolysis, carbon capture remains a highly expensive option, primarily due to its significant customisation requirements and the complexity of its design and engineering processes.

Carbon capture continues to face significant challenges in proving its effectiveness in reducing climate emissions, particularly in sectors like steel, where its role in decarbonisation remains minimal. Costs associated with CCUS projects are notably high, with escalating expenses posing a barrier to wider adoption. A recent IEEFA report showed that in the last two financial years, the CCS facility at the Gorgon LNG plant incurred a cost of US\$138 per tonne of CO_2 captured, which is four to six times higher than IEA's median cost estimates for the sector. This highlights the financial and technical hurdles that must be addressed for CCUS to play a meaningful role in global emissions reduction efforts.

Like the gas-based DRI pathway, the blue hydrogen pathway is highly sensitive to gas prices. As gas prices rise, its cost-competitiveness diminishes significantly. Blue hydrogen also faces challenges from high gas price volatility and the significant costs associated with CO_2 capture.

Based on projects in the pipeline, almost 80% of blue hydrogen development is planned to be built in the US, driven by tax credits for both CCS and low-emission hydrogen production. In the US, the IRA's 45Q CCS tax credits have been increased to help offset capture costs, but they are still insufficient to make the technology financially viable.

The potential of CCUS technology to significantly reduce emissions from either DRI production or blue hydrogen pathways remains limited. When residual emissions and rising carbon prices are considered, it becomes evident that neither pathway offers a viable long-term solution for achieving full decarbonisation of the DRI-EAF process. A more sustainable approach lies in gradually transitioning from gas to green hydrogen. This phased shift ensures the process remains both efficient and effective in reducing carbon emissions while adapting to evolving energy and cost dynamics. In this configuration, blue hydrogen plays no role.

Blue hydrogen risks for investors and end-users

Any investment in fossil fuel-based hydrogen production risks trapping investors, as they may find themselves committed to a long-standing technology likely to become obsolete in the coming years due to advancements in the green hydrogen economy, falling electrolyser manufacturing costs, and decreasing electricity prices.

Unlike blue hydrogen, which requires significant upfront investment in production facilities, gas infrastructure and carbon capture, green hydrogen can be developed incrementally due to its modularity. This phased approach helps lower investment risks over time.

Furthermore, not all steelmakers have access to the gas resources required for blue hydrogen production, and transporting blue hydrogen is not an economically viable solution. In contrast, renewables-based hydrogen production offers greater flexibility, as it can be established in diverse locations, provided there is access to water and renewable energy sources. This adaptability makes it a more practical and sustainable option for many regions.

François Paquet, managing director of the Renewable Hydrogen Coalition, said in a recent interview, "You need to go large scale to make it (blue hydrogen) cost-competitive, but the investment risk is enormous… In less than half the lifetime of your asset, you will be undercut by cheaper renewable hydrogen – so the case for investing is very risky."

The strict threshold of low-emissions hydrogen has raised concerns for major oil companies like Equinor, who are uncertain about meeting these targets with their blue hydrogen projects Europe-wide. The company has discontinued its 10 gigawatt (GW) blue hydrogen export project to Germany in the early stages, citing insufficient demand and high costs. The company has stated that its customers are unwilling to sign long-term offtake agreements for blue hydrogen, as it poses a risk of being tied to high-emissions sources that may not comply with EU regulations.

Equinor has launched a blue hydrogen offtake process for its 1GW H2M Eemshaven project, prioritising potential buyers with an annual demand of at least 50 megawatts. The downsizing of project ambitions and the active search for offtakers highlight the significant challenges big companies face in making the blue hydrogen economy viable.

Shell has also put its 2.5GW Aukra blue hydrogen project on hold. The Aukra Hydrogen Hub, developed in partnership with Aker Horizons and CapeOmega, was initially intended to produce 1,200 tonnes of hydrogen per day by 2030 for export to Germany. Aker Horizons Asset Development Managing Director Knut Nyborg said: "Aker Horizons agrees with Equinor's assessment that the framework conditions [in a blue hydrogen export pipeline from Norway to

Germany] are not in place for large investments… We also share Shell's conclusions that major industrial players in Europe now seem to prefer green hydrogen over blue."

The early cancellation of these major projects underscores the significant risks involved, driven by misalignment with regulations and customer demands.

The Australasian Centre for Corporate Responsibility (ACCR) has sued Santos for misleading investors on blue hydrogen's carbon reduction potential by relying on CCS technology. ACCR mentioned that Santos had described blue hydrogen as "clean" and "zero-emissions" and had therefore "failed to disclose that blue hydrogen production will increase its Scope 1 and 2 emissions".

As oil and gas companies face challenges in establishing viable blue hydrogen supply chains and navigating the associated risks, it raises questions about why corporations like POSCO are investing in blue hydrogen capacity for use in their steel mills.

Moreover, as end-users of hydrogen, steelmakers are unlikely to commit to long-term contracts with developers, as emissions from blue hydrogen fail to meet the stringent thresholds required to qualify as a low-emissions feedstock for producing green steel.

The global demand for low-emissions steel has been steadily increasing. In the US alone, it is projected to reach 6.7Mt by 2030, driven primarily by the automotive sector, which accounts for nearly 50% of the demand. Globally, transportation remains a key driver of green steel adoption, with demand outpacing the current capacity of steelmakers to supply it. This surge is largely driven by companies striving to reduce their Scope 3 emissions by sourcing greener materials.

An increasing number of companies are moving away from materials that rely on fossil fuels in their value chains. In the steel sector, continuing to use fossil fuels poses significant risks, especially given the unrealistic expectations of CCUS as a means to eliminate emissions.

Last year IEEFA's report on CCUS technology made clear that CCUS will not play a significant role in steel sector decarbonisation. As we wrote then, "CCUS installations will not decarbonise steel production enough to satisfy the growing number of steel consumers demanding truly green steel. Car makers are already signing purchase agreements for green steel made using green hydrogen with virtually no emissions. Tighter definitions of what exactly constitutes 'green steel' can be expected in the near future. There is a significant risk that the low capture rates of CCUS will mean steel produced this way will not meet such definitions."

As we head into 2025, these issues seem even more relevant, indicating that green hydrogen – not blue – represents the future of green steelmaking.

About IEEFA

The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

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