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Report

Driving Hydrogen-Based Steelmaking in South Korea:

Focus on Green Hydrogen Sourcing

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Solutions for Our Climate (SFOC) is an independent nonprofit organization that works to accelerate global greenhouse gas emissions reduction and energy transition. SFOC leverages research, litigation, community organizing, and strategic communications to deliver practical climate solutions and build movements for change.

Table of Contents

1. Introduction

In 2020, South Korea pledged to achieve carbon neutrality by 2050, aligning itself with international efforts to tackle the climate crisis and aiming to build a low-carbon economy and sustainable society. Along this journey, the steel industry remains a significant challenge, emitting approximately 100 million tonnes of CO_2e annually, which accounts for 14-18% of the nation's total greenhouse gas (GHG) emissions. To decarbonize this major emitter, the South Korean government announced 'Steel Industry Development Strategy for Transition to Low-Carbon Steelmaking' in 2023, aiming to cut steel-sector emissions by 85% from 2018 levels by 2050 through the adoption of hydrogen-based direct reduced iron (H_2-DRI) technology. For H_2-DRI to effectively drive the industry toward carbon neutrality, the use of green hydrogen in the process is essential. However, plans to support green hydrogen production for industrial use remain a missing link in the country's hydrogen policy. This study assesses the economic feasibility of green hydrogen-driven DRI within the existing hydrogen policy framework and proposes measures to enhance the economic viability of low-carbon steelmaking.

Unlock the Economic Potential of Hydrogen-Based Steelmaking

Leading economies are proactively accelerating the shift to renewable energy and green hydrogen in order to strengthen domestic industries and boost the competitiveness of low-carbon products. Alongside these efforts, countries are adopting carbon tariffs on emission-intensive and trade-exposed products, such as steel. For example, the European Union (EU) and the United Kingdom (UK) plan to enforce Carbon Border Adjustment Mechanisms (CBAMs) in 2026 and 2027, respectively. Likewise, the United States is deliberating the Foreign Pollution Fee Act (FPFA), which would impose tariffs on products based on their carbon emissions. In 2023, South Korea's trade-to-GDP ratio amounted to an impressive 88%,[1] the highest among all G20 nations. Notably, steel products, which rank seventh among the country's top traded goods, serve as essential base materials for major export products such as automobiles (2nd), ships and offshore structures (4th), and automotive parts (6th).[2] Hence, a structural transition of the steel

1 World Bank Group. (2025). Trade (% of GDP).

2 e-Nara Indicators. *Top Ten Import-Export Items*.

industry toward low-carbon steelmaking is imperative—not only for achieving carbon neutrality in the steel sector, but also for strengthening the country's competitiveness in global trade.

The recent expansion of tariffs imposed by the U.S on steel imports is promoting reciprocal measures from other countries and straining global trade in steel products. However, the surge in trade barriers is not the only challenge. Domestically, steel demand has steadily declined over the past decade, weighed down by a contraction in domestic construction and the prolonged downturn of steel-consuming industries.[3] Adding to these pressures, the influx of low-cost Chinese steel products is expected to rise steadily due to the downturn in China's construction industry. Amid these challenging domestic and global market conditions, major Korean steelmakers including POSCO, Hyundai Steel, and SeAH Steel are pursuing strategies to expand their overseas production by ramping up investment in low-carbon, integrated mills in countries with strong economic growth prospects, rising steel demand, and more affordable energy costs, such as India, Indonesia, and the U.S.[4] However, primary steelmaking creates powerful forward and backward linkages and underpins extensive industrial networks,[5] serving as a cornerstone of South Korea's export-driven, manufacturing-based economy.[6] If South Korean steelmakers prioritize expanding low-carbon steelmaking processes such as H_2-DRI and electric arc furnace (EAF) technologies primarily at overseas sites, it could risk both eroding domestic capacity to produce high-value, low-carbon steel and delaying the broader transition of the nation's manufacturing towards greener processes, ultimately undermining industrial competitiveness. On the other hand, the domestic expansion of hydrogen-based steelmaking can accelerate the realization of hydrogen economy, strengthen energy security, create jobs through new infrastructure development, and ultimately contribute to regional economic growth. Therefore, the government should take a leading role in advancing low-carbon steelmaking by supporting green hydrogen production and the construction of H_2-DRI facilities, thereby encouraging private sector investment.

3 e-Nara Indicators. *Trends in the Steel Industry; Ferro Times* (Nov. 18, 2024). [Outlook] 2025 Steel Market Posed to Start Slow but Finish Strong … If the Triple Headwinds of Weak Demand, Falling Exports & Rising Imports Are Overcome.

4 Gwon, T.S. (Apr. 9, 2025). [After the Desk's Closed] Hyundai Motor's US Plant Proves a Divine Move. *Etoday*.

5 In 2014, primary steel products ranked second in direct and indirect backward linkage effects and second to none in industrial network effects, out of 82 industries.

6 Youn, W.J. (2018). Analysis of Domestic Inter-Industry Linkage Effects and Implications. *Korea Institute for Industrial Economics & Trade.*

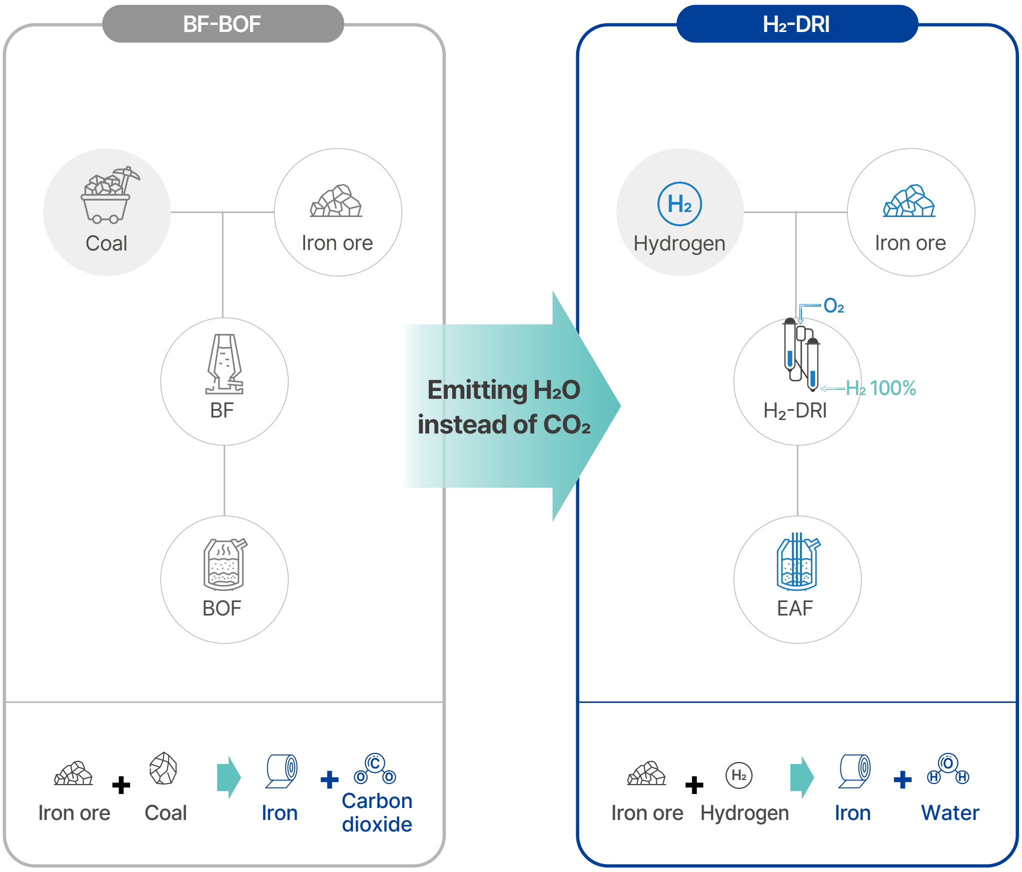
Green H_2-DRI: Emitting Water, Not Carbon

This study examines the economic feasibility of green H_2-DRI steelmaking, a low-carbon process capable of eliminating both direct and indirect emissions. There are two conventional methods of steel production; one is the blast furnace-basic oxygen furnace (BF-BOF) process, and the other is the electric arc furnace (EAF) process. As of 2023, roughly 70% of crude steel in South Korea was produced via BF-BOF, with the remaining 30% through EAFs.[7] In the BF-BOF process, the ironmaking stage—where iron ore and coke (derived from coal) are used to produce liquid iron (pig iron)—is particularly carbon-intensive, emitting approximately 2.3 tCO_2e per tonne of crude steel (tcs). In contrast to the blast furnace process, which relies on iron ore as its primary feedstock, the EAF process can operate using recycled steel scrap. Since EAFs consume electricity to melt the scrap into molten steel, the process is associated with indirect emissions, averaging about 0.4 tCO_2e per tcs.[8] While the EAF process has lower carbon emissions than the BF-BOF process, iron ore is still considered necessary as feedstock to produce high-quality steel with superior strength, corrosion resistance, and thermal durability. Therefore, in order to produce high-quality carbon-free steel, it is necessary to adopt H_2-DRI steelmaking process that makes reduced iron from hydrogen instead of coal, and expand the EAF process using direct reduced iron. Direct and indirect emissions are close to zero in H_2-DRI steelmaking, when green hydrogen and renewable electricity are used.

7 KOSIS. (2024). *Steel Production*.

8 Suer, J., Ahrenhold, F. & Traverso, M. (2022). Carbon Footprint and Energy Transformation Analysis of Steel Produced via a Direct Reduction Plant with an Integrated Electric Melting Unit. *Journal of Sustainable Metallurgy*, 1532–1545.

[Figure 1] Comparison of the BF-BOF and H_2-DRI Steelmaking Processes Source: POSCO



South Korea is currently developing an innovative H_2-DRI technology based on fluidized reduction furance technology, which enables the use of low-grade iron ore and thereby improves raw material accessibility. It plans to secure technology for an annual production capacity of 300,000 tonnes by 2030, and to begin scaling up to a commercial-level capacity of 2.5 million tonnes starting in 2031. With the transition from the BF-BOF to H_2-DRI steelmaking process, the primary fuel source will also shift from coal to hydrogen.

2. Methodology and Data

This study analyzes the economic viability of H_2-DRI steelmaking using a marginal abatement cost curve (MACC) framework. The marginal abatement cost refers to the cost of eliminating one additional tonne of carbon emissions beyond current levels,[9] and this analytical approach is often used to evaluate the economic efficiency of emissions reduction technologies or policies. Within the MACC framework, this study first set carbon reduction targets, estimated both the costs and emissions reductions associated with the relevant low-carbon steelmaking technologies, figured out the MACC, and used it to identify the most cost-effective pathways for decarbonizing steel production under emissions constraints. The carbon reduction targets were set based on POSCO's carbon neutrality roadmap, as the company has the largest blast furnace operations in South Korea; 10% reduction from the baseline year by 2030, 50% by 2040, and carbon neutrality by 2050. For low-carbon steelmaking processes other than H_2-DRI, this study incorporates the government's technology development initiatives and the industry's plans for adopting emissions reduction technologies.[10]

Assumptions for Steel Production Cost Estimation

In this study, steel production costs are evaluated by factoring in both current production costs, as well as additional costs associated with adopting low-carbon technologies, such as capital expenditures (CAPEX), fixed operating expenses (OPEX), feedstock, and fuel costs. Prices of iron ore, scrap, and other raw materials are drawn from the National Policy Monitoring System's statistics, while CAPEX and OPEX figures for low-carbon technologies are sourced from the Mission Possible Partnership (MPP). Electricity costs for steel production are projected to rise by an average of 4% annually over the next decade—mirroring the historical trends of industrial electricity price observed over the past decade—and are presumed to level off thereafter without further increases.

The factor that is expected to have the greatest impact on steel production costs when the hydrogen-based DRI steelmaking process is introduced is the price of green hydrogen, which will be used as a reducing agent for iron ore. Published literature is

9 World Bank. (2023). What You Need to Know About Abatement Costs and Decarbonization.

10 See the Appendix at the end of this report for detailed information on the low-carbon steelmaking processes considered in this study.

referenced for the cost of hydrogen from overseas, while domestic green hydrogen production costs are modeled on renewable energy potentials. Even though numerous studies have explored the cost of hydrogen sourced from outside of South Korea, their assumptions vary significantly, resulting in widely divergent findings. Notably, studies projecting relatively low costs for hydrogen from overseas often overlook critical factors, such as assumptions about renewable energy inputs, liquefaction costs, or economic losses from boil-off gas during storage and transport **[Table 1]**. The Korean government's forecast for green hydrogen costs from major green hydrogen production countries (Saudi Arabia, the United Arab Emirates, and Australia) in the 'First Master Plan for Hydrogen Economy Implementation' is very low, at about USD 2.5 per kg in 2030 and about USD 1.7 per kg in 2050 **[Figure 2]**. This suggests that, given the low estimation of 'other costs' at merely a few dozen cents, critical factors for cost estimation, such as liquefaction, storage, and transportation costs may not have been thoroughly reflected.

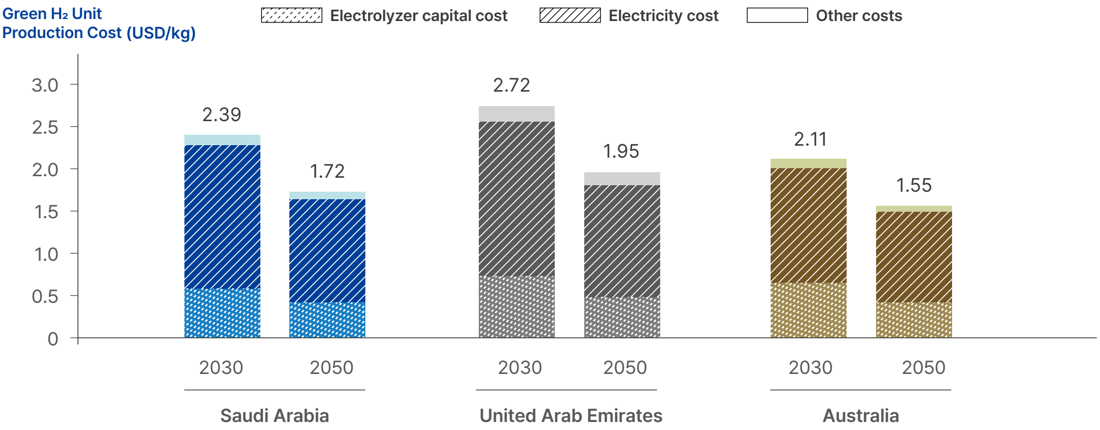
[Table 1] Comparison of Green H_2 Import Cost Projections[11]

Source: Adapted from Choi *et al*. (2024)

	Choi *et al.* (2024)	Lee *et al.* (2022)	IRENA (2020, 2022)	Hwang *et al.* (2022)	Ishimoto *et al.* (2020)	Makepeace *et al.* (2024)
Base year	2023-2050	2018	2030	2030	2015	2030
Levelized cost of hydrogen (USD/kgH_2)	30.21 – 18.3	8.36	7.5	5.5	7.54	12.2-18.4
Assumption of renewable energy use	O	×	O	O	O	×
Boil-off of liquefied hydrogen (Thermodynamic phenomenon)	O	×	×	×	×	×
Liquid hydrogen transport cost	O	O	O	O	O	×
Hydrogen liquefaction cost (process design-based)	O	×	×	×	×	×

11 Lee, H., Han, J. & Roh, K. (2024). Revisiting the cost analysis of importing liquefied green hydrogen. *International Journal of Hydrogen Energy*.

[Figure 2] Green H_2 Production Costs in Major Countries Projected by the *1st Master Plan for Hydrogen Economy Implementation*



The costs also vary depending on the form in which hydrogen is imported. For example, hydrogen can be transported either as ammonia or in liquefied form. Shipping hydrogen as ammonia incurs lower maritime transport and carrier conversion costs than liquefied hydrogen. However, the cracking process required to reconvert ammonia back into hydrogen not only adds substantial costs but also results in energy loss. Considering the energy losses during this conversion, it is more advantageous to use ammonia directly when feasible.[12] That said, for hydrogen to be used in H_2-DRI, it is more reasonable to assume delivery in liquefied form. In addition, Australia is considered in this study as supplying country given its relatively short shipping distance. Taking all these factors into account, this study references the findings of Choi et al. (2024), which incorporate all key elements of assumptions required to estimate the costs of green hydrogen imports.

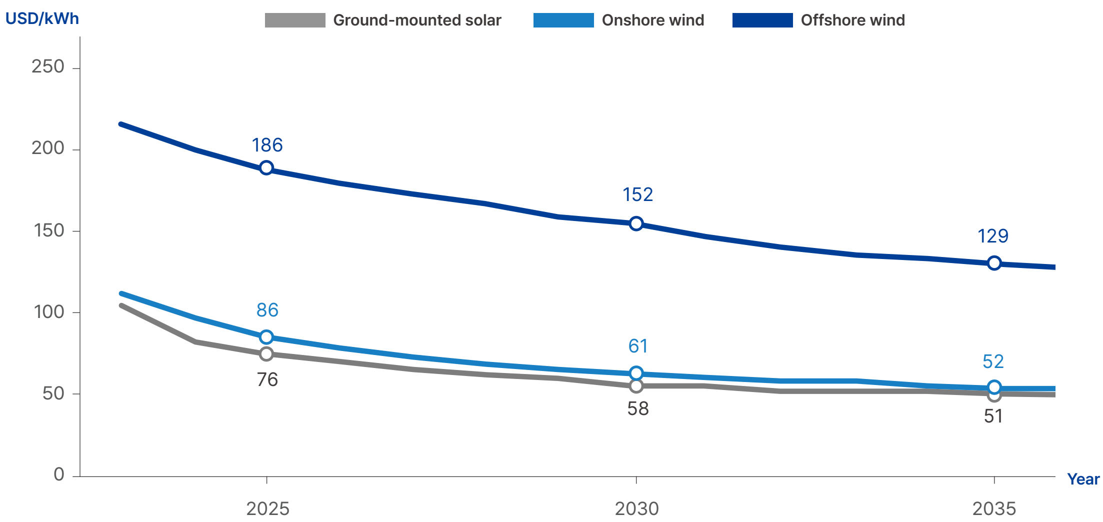
This study assumes that prices of domestically produced hydrogen will decline over the long term to a certain floor, as a result of gradually decreasing renewable power generation costs, advances in electrolysis technology, and economies of scale. For assumptions regarding the power mix, which is another key factor affecting green hydrogen production costs, South Korea's *11th Power Supply Master Plan* is referenced through 2038. From 2038 to 2050, the government's *2050 Carbon Neutrality Scenario B*[13] is referenced for power mix projetions, which envisions gradually growing shares of solar and offshore wind power, while maintaining constant nuclear output. Forecasts for renewable energy generation costs are sourced from BloombergNEF (BNEF) **[Figure 3]**, while estimates for electrolyzer efficiency, capital investment, and operating costs are taken from the International Energy Agency (IEA, 2019).[14]

12 Hwang, H., Lee, Y., Kwon, N., Kim, S., Yoo, Y. & Lee, H. (2022). Economic Feasibility Analysis of an Overseas Green Hydrogen Supply Chain. *Journal of Hydrogen and New Energy*.

13 Presidential Commission on 2050 Carbon Neutrality and Green Growth. (2021). *2050 Carbon Neutrality Scenarios.*

14 IEA. (2019). *The Future of Hydrogen.*

[Figure 3] **Global Levelized Cost of Electricity (LCOE) Projections by Renewable Energy Source**[15]



Additionally, to enable a comparison between conventional coal-based BF-BOF steelmaking and low-carbon alternatives, this study assumes a constant total annual steel production volume, with each facility's 2025 production volume set to its average over the most recent three years.

Lastly, this study excludes Carbon Capture, Utilization, and Storage (CCUS) technologies from its cost analysis reflecting widespread skepticism regarding their viability in steelmaking, despite the CCUS-based emissions reduction plans outlined by both POSCO and Hyundai Steel in their carbon neutrality roadmaps. This exclusion is consistent with the current state of the sector, as most CCUS trials in steelmaking have been unsuccessful[16], and no commercial-scale CCUS facilities are currently in operation anywhere in the world.[17]

15 BNEF. (2023). *LCOE data viewer 2023 1H*.
16 IEEFA. (2024). *Carbon capture for steel?*
17 IEEFA. (2024). *Steel CCUS update: Carbon capture technology looks ever less convincing.*

3. Economic Viability of H_2-DRI Under Three Different Scenarios

This study constructs three scenarios with varying proportions of domestically produced and imported hydrogen to evaluate the economic viability of H_2-DRI steelmaking. Each scenario represents a distinct strategic pathway; alignment with the government's current hydrogen policy, expansion of domestic hydrogen production, and achieving full hydrogen self-sufficiency as the most ambitious scenario.

Scenario 1 Import-Oriented Hydrogen Supply Aligned with Current Policy (Domestic Share: 50% → 18%)

The first scenario considered in this study references South Korea's *First Master Plan for Hydrogen Economy Implementation*[18] as the policy baseline. Announced by the government in 2021, it is the most recent officially published government roadmap regarding hydrogen. Representing a continuation of current policy, Scenario 1 assumes that green hydrogen for H_2-DRI steelmaking will be procured in the same proportions outlined in the national plan—about 50% imported by 2030, rising to roughly 82% by 2050.[19] This import-heavy mix raises two key concerns; there could be weaker supply security compared to domestic production, also there could be higher Scope 3 emissions from long-distance transport and storage, which could undermine the climate benefits of hydrogen-based steelmaking.

Scenario 2 Greater Domestic Hydrogen Share Than in Current Policy (Domestic Share: 50%)

The second scenario assumes a higher share of domestically produced green hydrogen, diverging from the downward trajectory projected in current policy. While Scenario 1 sees the domestic share fall from around 50% in 2030 to 18% by 2050, Scenario 2 maintains it at approximately 50%—supported by sustained efforts to scale up domestic production and utilization of green hydrogen. This scenario is designed to assess the economic implications of sustaining a higher proportion of domestically sourced green hydrogen, compared to the current policy.

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18 *The First Master Plan for Hydrogen Economic Implementation* (2021) sets out South Korea's strategic roadmap to develop a hydrogen economy by promoting production, infrastructure, and utilization across various sectors.

19 In 2030, of the total supply of 3.9 million tonnes, approximately 50.2% (1.96 million tonnes) is projected to be imported from abroad, soaring to about 82.1% (22.9 million tonnes of the total 27.9 million tonnes) by 2050.

Producing green hydrogen domestically offers substantial savings on the costs of long-distance shipping and storage. Greater reliance on domestic hydrogen also enhances supply security by shielding it from external supply chain uncertainties. These benefits support the nation's energy security as well as the long-term sustainability of its domestic steel industry. Moreover, by minimizing greenhouse gas emissions from international shipping, a higher share of domestic green hydrogen can play a critical role in mid- to long-term strategies for achieving carbon neutrality.

Scenario 3 Self-Sufficient Hydrogen Supply (Domestic Share: 100%)

The last scenario assumes full self-sufficiency in green hydrogen procurement for low-carbon steelmaking from 2030. Representing an even greater reliance on domestic hydrogen production than Scenario 2, this model envisions the rapid infrastructure deployment for green hydrogen production, underpinned by aggressive government and private-sector investment and technology development—including early buildout of renewable-powered electrolysis facilities, decarbonization of the power sector, and significant scaling up of green hydrogen production. Scenario 3 projects that these efforts will drive domestic hydrogen production costs down to competitive levels.

A fully domestic supply offers two significant advantages; it minimizes additional costs and greenhouse gas emissions associated with long-distance shipping and storage, and it frees the supply chain from uncertainties tied to imports. A highly reliable hydrogen supply is critical for hydrogen-intensive industries, such as steel, to maintain competitiveness. In parallel, strong hydrogen supply security strengthens national energy independence and overall energy security. Ultimately, this self-sufficient pathway supports a broader strategy to drive the sustainable transformation of South Korea's steel sector.

[Table 2] Comparison of Scenarios by Hydrogen Procurement Mix

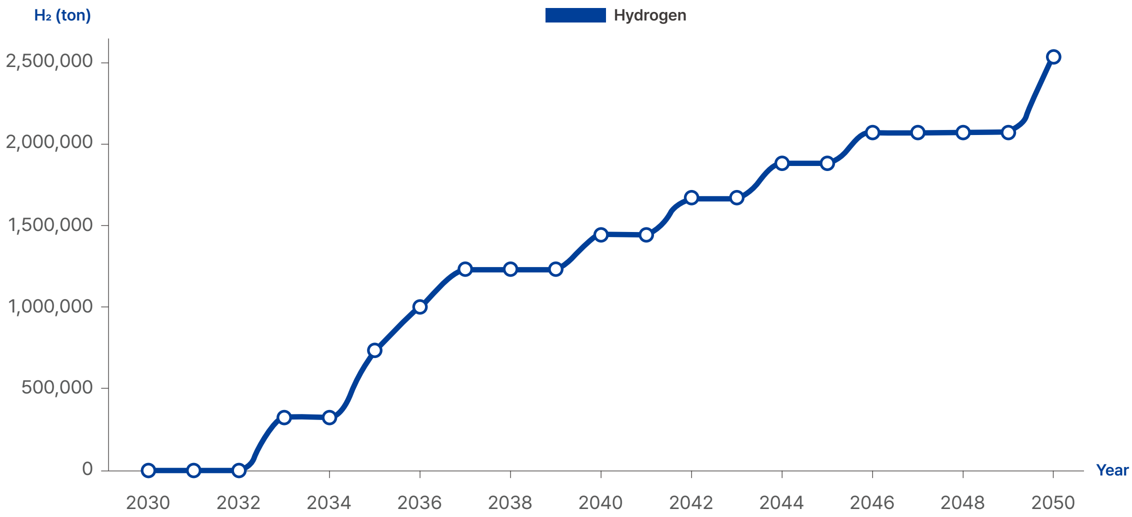
	Scenario 1	Scenario 2	Scenario 3
Share of domestic H_2	Gradual decline from 50% in 2030 to 18% by 2050	50% maintained from 2030 through 2050	100% self-sufficiency starting in 2030 ~
Share of H_2 imports	Very high	Moderate	None
Key assumption	Adherence to current government policy	Buildup of domestic H_2 production capacity	Substantial expansion of domestic H_2 production capacity
Supply security	Low	Moderate	High
GHG emissions	Relatively high	Moderate	Relatively low

4. Findings

Amid Skyrocketing Demand, Green Hydrogen Self-Sufficiency Lowers Long-Term Steel Production Costs

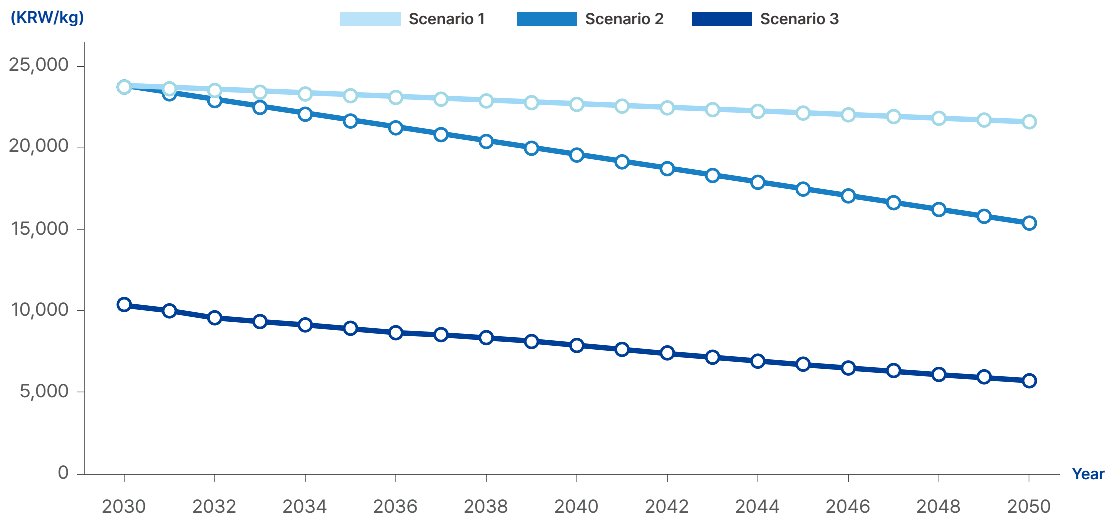
Based on the cost-effective transition pathway for the steel production derived from marginal abatement cost (MAC) analysis, projected hydrogen demand evolves as shown in **[Figure 4]**. Hydrogen demand first emerges in 2033, coinciding with the rollout of H_2-DRI facilities. In the early years, high hydrogen prices—relative to the fuel and feedstock costs of the conventional BF-BOF steelmaking—limit the uptake of H_2-DRI. However, H_2-DRI, with its unmatched emissions-reduction potential, gains ground over time as hydrogen becomes more affordable. Assuming that carbon neutrality targets are met against this backdrop, hydrogen demand is expected to rise to approximately 2.57 million tonnes by 2050. This surge in demand is a key determinant of changes in the cost structure of steelmaking on the pathway to net zero.

[Figure 4] Increasing Hydrogen Demand with the Expansion of H_2-DRI

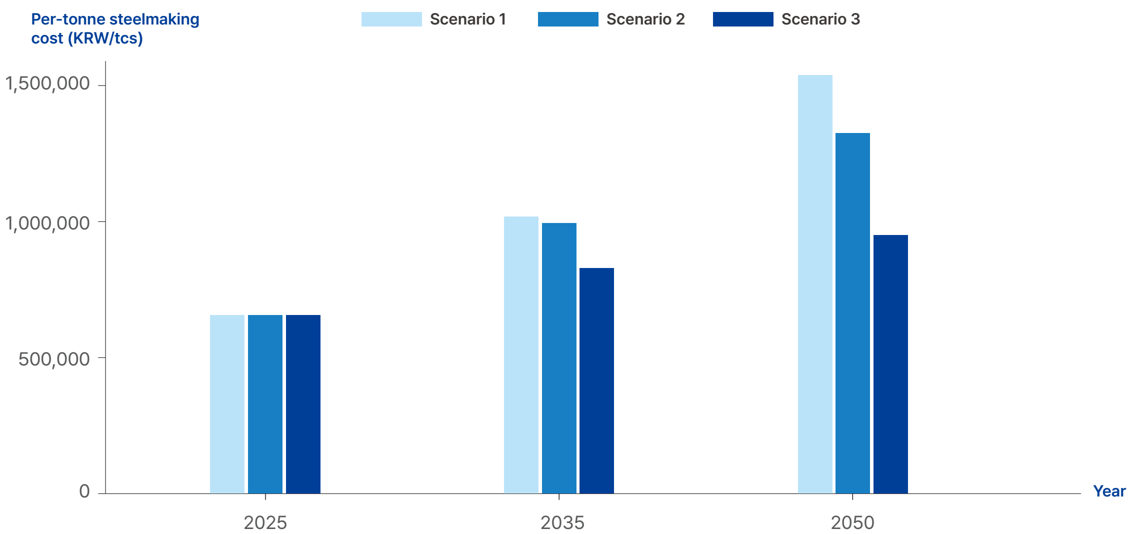


Green hydrogen and steel production costs under the three scenarios are illustrated in **[Figure 5]** and **[Figure 6]**, respectively.

[Figure 5] Green Hydrogen Cost Trends Across Scenarios



[Figure 6] Steelmaking Cost Comparisons Across Scenarios



All three scenarios start with high hydrogen prices, but technological advancements and economies of scale gradually drive prices down **[Figure 5]**. In both Scenarios 1 and 2, the hydrogen supply mix reaches a 50-50 balance between domestic and imported sources by 2030. Afterward, however, the scenarios diverge gradually over time; Scenario 1's reliance on imports steadily increases, exceeding 80% by 2050, whereas Scenario 2 maintains a consistent 50% domestic share through the same period. Greater import dependence drives overall prices upward, since this study assumes imported hydrogen is more expensive than domestic supply. Consequently, scenario 1 emerges as the most expensive option, with hydrogen prices remaining above KRW 20,000 (USD 14) per kg even in 2050. In contrast, Scenario 3—characterized by minimal reliance on imports thanks to early, rapid expansion of domestic hydrogen production—sees hydrogen prices drop from around KRW 10,000 (USD 7) per kg in 2030 to roughly KRW 5,700 (USD 4) per kg by 2050. As a result, the year 2050 is projected to see a price gap of up to KRW 16,000 (USD 12) per kg between the scenarios at the opposite ends of the import-dependence spectrum.

[Figure 6] illustrates projected changes in per-tonne steel production costs under the three hydrogen supply scenarios. At present, producing one tonne of steel via the conventional BF-BOF process costs about KRW 650,000 (USD 471). However, according to this study, production costs are expected to increase as the industry begins transitioning to H_2-DRI in 2033, a process that relies on more expensive inputs such as renewable electricity and green hydrogen. The origin of hydrogen—whether fully domestic or partially imported—determines the steepness of this cost trajectory. Naturally, the greater the dependence on imports, the more pronounced the cost escalation becomes. For instance, by 2035, the cost gap per tonne of steel between Scenario 3 (100% domestic hydrogen) and Scenario 1 (import reliance rising to over 80% by 2050, in line with current policy) is projected at roughly KRW 200,000 (USD 145), widening to approximately KRW 580,000 (USD 420) in 2050.

Drawing these findings together, this study suggests that if South Korea is to achieve its 2050 carbon neutrality target, the cost of producing one tonne of steel could range from approximately KRW 950,000 (USD 688, Scenario 3) to KRW 1.53 million (USD 1109, Scenario 1), depending on the mix of hydrogen supply. This substantial cost disparity underscores the critical role of hydrogen sourcing in shaping the economic viability of the steel industry after the commercialization of H_2-DRI technology. In particular, the proactive expansion of domestic hydrogen production—enabled by scaling up renewable energy and hydrogen production infrastructure—emerges as a strategic imperative for securing cost competitiveness. In contrast, a heavy reliance on hydrogen imports would not only drive up production costs but could also potentially undermine supply security.

5. Policy Recommendations to Accelerate the Adoption of H_2-DRI Steel

While this study assumes an optimistic outlook for the economics of renewable energy and advancements in green hydrogen technology, its projections for domestic green hydrogen costs exceed the cost targets laid out in the government's *Master Plan for Hydrogen Economy Implementation*—KRW 3,500 (USD 2.50) per kg by 2030 and KRW 2,500 (USD 1.80) per kg by 2050. In other words, our findings suggest that for these targets—which appear overly ambitious under current conditions—to be achieved, additional policy support is essential to gradually bring hydrogen prices down. Moreover, the government's current cost projections for imported hydrogen do not explicitly account for expenses associated with liquefaction, storage, and transportation [Figure 2]. [Table 3] below shows the green hydrogen production conditions assumed in Scenario 3 (100% domestically produced hydrogen) compared to the current level. This chapter presents policy recommendations to progressively whittle down domestic green hydrogen prices from current levels and to increase the economic viability of establishing H_2-DRI facilities in South Korea.

[Table 3] Green Hydrogen Production Conditions: Current vs. Scenario 3 (Full Self-Sufficiency)

Items	Current	2035	2040	2050
Efficiency of PEM electrolysis (%)	58.4%[20]	70%	71%	74%
Green Hydrogen LCOH (KRW/kgH_2)	17,977	8,941	7,909	5,767
Solar Photovoltaic LCOE ($/MWh)	111	100	91	72
Offshore Wind LCOE ($/MWh)	233	182	166	133

20 *Monthly H2 Economy*. (Oct. 14, 2024). Future of Green Hydrogen Contingent on Technological Innovation and Economic Feasibility.

Industrial Decarbonization Blueprint—A Critical Missing Link in the Current Hydrogen Strategy

In 2018, South Korea declared hydrogen economy as one of the nation's three strategic investment areas in its *Overall Strategic Investment Directions for Innovative Growth*. This was followed by the release of the Hydrogen Economy Roadmap in 2019 and the enactment of the Hydrogen Economy Promotion and Hydrogen Safety Management Act (in short the "Hydrogen Act") in 2020, to accelerate the transition to the hydrogen economy. The *First Master Plan for Hydrogen Economy Implementation* (hereinafter the "Master Plan")—the first of its kind published after the enactment of the Hydrogen Act—forecasts hydrogen demand across sectors. Yet, the Master Plan offers no specific hydrogen demand estimates for heavy industries. This omission is striking, considering the critical role hydrogen is expected to play in decarbonizing hard-to-electrify heavy industries, which face increasing pressure to cut down GHG emissions amid the climate crisis. The Master Plan has laid out three hydrogen utilization plans—1. power generation, 2. mobility (transport), and 3. industry—including demand forecasts, targets, and key milestones for each. However, the roadmap for industry is far less detailed than those for power generation and transport. This vagueness culminates in the absence of medium-term demand predictions and hydrogen utilization plans **[Table 4]**.

An estimated 4.05 million tonnes of green hydrogen would be required to produce roughly 45 million tonnes of crude steel—current production volume of 11 blast furnaces—by H_2-DRI by 2050. Moreover, a single commercial-scale H_2-DRI plant with an annual capacity of 2.5 million tonnes would require the government to allocate at least 225,000 tonnes of green hydrogen to the steel industry between 2030 and 2035 alone.[21] This need makes the absence of a dedicated hydrogen supply plan for the steel sector feel all the more pressing—a major policy gap that threatens to stall one of the most essential solutions for industrial decarbonization.

21 *The First Master Plan for Hydrogen Economy Implementation* indicates that 90 kilograms of hydrogen are required per tonne of H_2-DRI steel, which is considered as the maximum rate of hydrogen demand in this study.

[Table 4] Sectoral Hydrogen Utilization Roadmaps in the *First Master Plan for Hydrogen Economy Implementation*

	Year	Power	Mobility	Industry
H_2 Demand	**2030**	3.53 Mn tonnes	377,000 tonnes	**Absence of forecasts**
	2050	13.50 Mn tonnes	3.50 Mn tonnes	10.60 Mn tonnes
Targets	**2030**	Power generation: 48TWh	Fleet size: 880,000 vehicles	**None**
	2050	Power generation: 288TWh	Fleet size: 5.26 Mn vehicles	
Key Milestones	**2025**	-	Annual production of 100,000 vehicles	-
	2030	Coal-20% ammonia cofiring	• Durability comparable to ICE vehicles (800,000 km) • Driving range (1,000 km) secured • Commercialization of H_2 engine Urban Air Mobility (UAM)	-
	2030~	LNG turgine-50% hydrogen cofiring	Commercialization of H_2 trams, and liquefied H_2-powered ships	**[Petrochemicals]** Commercialization of direct raw material conversion **[Cement]** Fuel transition applied to aging facilities
	2050	100% ammonia and hydrogen combustion	-	**[Steel]** Transition of existing facilities to H_2-DRI steelmaking

Recommendation

Update the Hydrogen Utilization Roadmap for the Steel Sector in the *Second Master Plan for Hydrogen Economy Implementation*

Article 5 of the "Hydrogen Act" explicitly mandates that the Minister of Trade, Industry and Energy formulate the *Master Plan for Hydrogen Economy Implementation* to advance the hydrogen economy and allows for revisions to the Master Plan in response to changing socioeconomic conditions.

Since the release of the First Master Plan in 2021, South Korea has pursued the development of H_2-DRI as a national strategic initiative, driven by public-private collaboration. Moving forward, the Second Master Plan must be ironed out, with hydrogen demand projections for the H_2-DRI development and an aligned supply roadmap. Concluding its 2023-2025 foundational technology development phase, the H_2-DRI initiative is currently conducting a preliminary feasibility study to support a demonstration project between 2026-2030, targeting annual production capacity of 0.3 million tonnes. From 2031 onwards, plans call for scaling up to a commercial production capacity of 2.5 million tonnes per year, followed by a gradual transition from blast furnaces starting in 2036. On this basis, hydrogen demand is expected to reach approximately 27,000 tonnes by 2030, rise to around 225,000 tonnes between 2031 and 2035, and reach about 4.05 million tonnes annually from 2036 onward—assuming 45 million tonnes of crude steel produced via H_2-DRI. From a practical perspective, the transition will accelerate once hydrogen becomes economically viable after 2030. **To expedite the establishment of green hydrogen-driven steelmaking in South Korea, the Second Master Plan must incorporate an updated hydrogen utilization roadmap for the steel industry, as show in [Figure 7].**

[Figure 7] A Proposed Steel Industry H_2 Use Roadmap for the *2nd Master Plan*

	Current	2030	2035	2050
H_2 Demand		27,000 t	225,000 t	4.05 Mn t
Key Milestones		Develop demonstration technology for 300,000 tonnes	Scale up to 2.5 Mn tonnes	Full Transition to H_2-DRI

Lack of Policy Support for Domestic Green Hydrogen Production

Aligned with its national vision of maximizing energy self-sufficiency, South Korea's current hydrogen policy adopts a production strategy, whereby domestic capital and technology are invested overseas to produce green hydrogen for subsequent import back into the country. While this reverse offshoring approach might appear economically feasible, relocating the hydrogen production base abroad is likely to incur additional costs for converting hydrogen into transportable forms (i.e., liquefaction) and for transportation itself. Furthermore, this strategy may also expose the supply chain to greater trade-related uncertainties—ultimately undermining national energy supply security.

It should also be noted that the green hydrogen production costs presented in the First Master Plan for major countries overlook the costs of liquefaction, storage, and transportation, resulting in understatement of the true costs incurred by the U-turn trade clean hydrogen procurement plan **[Figure 2]**. As previously noted, the combined cost of liquefaction, transportation, and re-gasification (15.54 USD/kg) could exceed half the total green hydrogen cost (30.21 USD/kg) **[Table 1]**. The same analysis suggests a projection that overseas green hydrogen prices may tumble to KRW 25,000 per kg (18.25 USD/kg), improving the economic viability of green hydrogen imports. However, even this favorable prediction remains costlier than domestically produced green hydrogen in 2023 (KRW 18,000/kg or USD 13/kg).[22] If the government follows through with its reimportation plan—sourcing the majority of green hydrogen required for industrial decarbonization from abroad—both the economic viability of H_2-DRI and national energy security may prove elusive.

To produce more green hydrogen domestically at lower cost in the future, it is essential to improve electrolysis efficiency, scale up electrolyzer capacity, and set up targeted production support designed specifically for those hard-to-electrify heavy industries. Yet, South Korea's current hydrogen policy offers no hydrogen production support plan dedicated to industrial use. As shown in **[Table 5]**, many countries have already adopted a range of mechanisms—including subsidies, tax credits, and contracts for difference (CfDs)—to build green hydrogen supply chains for industrial applications. Some have gone further, introducing targeted support measures specifically for the steel sector's transition to H_2-DRI. Moreover, global steelmakers are actively leveraging these policies by integrating green hydrogen demonstration projects with H_2-DRI development.

22 Eom, M.J. & Lee, G.N. (2024). Economic Analysis on 3.3 MW-class Green Hydrogen Production System in Jeju, South Korea. *Korean Society for New and Renewable Energy.*

Such integrated efforts can not only help secure reliable sources of hydrogen supply but also strengthen the economic case for industrial hydrogen production.

However, in South Korea, demonstration projects currently integrated to the country's H_2-DRI development initiative are absent **[Table 6]**. The forthcoming pilot H_2-DRI project—scheduled for the 2026-2030 timeframe with a target annual production capacity of 300,000 tonnes—will require roughly 27,000 tonnes of hydrogen. Yet, the policy blind spot renders sourcing gray hydrogen via natural gas reforming far more feasible than procuring green hydrogen. Moreover, if the lack of policy incentives persists, depending on long-term procurement agreements is likely to become a more realistic option for the steel industry than directly investing in hydrogen production facilities. According to the industry, a hydrogen price of around USD 1-2 per kg is essential for the commercial viability of H_2-DRI.[23]

23 *ZDNET Korea*. (Apr. 16, 2025). POSCO Steps from Hydrogen to Become a "Fast Follower."

[Table 5] Hydrogen Production Support Policies for Low-Carbon Steelmaking in Major Economies

Source: hyperlinks in country names

Support Policy	Country	Details
Subsidies	Belgium	EUR 6 Mn (USD 7 Mn) in support for developing green hydrogen-based green steel projects
	Estonia	EUR 49.1 Mn (USD 58 Mn) for subsidies to promote the adoption of green hydrogen in such sectors as chemicals and transport. The maximum support per project amounts to EUR 20 Mn (USD 24 Mn).
	Germany	Through a conditional payment mechanism, ThyssenKrupp Steel Europe is set to receive EUR 1.5 Bn (USD 17 Bn) to cover additional costs for procuring green hydrogen for its H_2-DRI facility during the first ten years of operation.
	Spain	EUR 460 Mn (USD 541 Mn) has been allocated to ArcelorMittal España's green hydrogen-based H_2-DRI project, along with an additional EUR 400 Mn (USD 471 Mn) to secure 345 MW of electrolyzer capacity.
	India	INR 4.6 Bn (USD 55 Mn) has been assigned in support for low-carbon steelmaking projects utilizing green hydrogen.
Contract for Difference (CfD)	Japan	A CfD scheme is to be introduced, covering the price gap between renewable- and fossil-based hydrogen.
	Germany	EUR 5 Bn (USD 6 Bn) has been committed to a 15-year CfD scheme aimed at using hydrogen and electrification in cement, chemicals, and steelmaking industries.
	UK	Through its Hydrogen Production Business Model (HPBM), the UK has pledged up to GBP 2 Bn (USD 28 Bn) to facilitate long-term green hydrogen procurement contracts and establishing at least 250 MW of electrolysis capacity.
Tax Incentives	US	A tax credit of USD 3/kg for green hydrogen production is provided under the Inflation Reduction Act (IRA).

[Table 6] Major Steelmakers' H_2-DRI Projects Integrated with Green Hydrogen Projects

Country	Steelmaker	Project	Details
Germany	Salzgitter	SALCOS	Salzgitter AG partners with wind power companies such as Avacon and Linde, as well as with electrolysis companies such as Sunfire and Green Industrial Hydrogen (GrInHy) for H_2-DRI technology • By 2025: 100 MW electrolysis capacity and production of 2.1 Mn tonnes of H_2-DRI • By 2030: 400 MW electrolysis capacity and additional production of 2 Mn tonnes of H_2-DRI
Sweden	SAAB	HYBRIT	The Swedish steelmaker collaborates with Vattenfall (Swedish state-owned power company) on carbon-free hydrogen production and storage. • By 2026: Commercialization of carbon-free steelmaking technology • By 2039: Annual production of 1.35 Mn tonnes of carbon-free steel
India / Oman	Jindal Steel Group	Vulcan Green Steel	Vulcan Green Steel, a subsidiary of India's Jindal Steel Group, plans to establish a green hydrogen-ready steel plant in Duqm, Oman, where green hydrogen and renewable electricity will be generated onsite through its own 7-9 GW renewable energy capacity. • 2027: Operations will commence with 100% natural gas-based reduction, with a planned full shift to 100% green hydrogen-based reduction.
South Korea (No Integrated Green Hydrogen & H_2-DRI Projects)	POSCO	HyREX	A preliminary feasibility study is underway for a demonstration project targeting an annual production of 300,000 tonnes from 2026 to 2030. • The estimated demand for approx. 27 kilotonnes of hydrogen for the demonstration is likely to be sourced with gray hydrogen produced via natural gas reforming. Scale-up to a commercial scale of 2.5 Mn tonnes/year will begin in 2031, followed by the gradual retirement of blast furnaces starting in 2036.

Recommendation

Integrating Green Hydrogen Demonstration Projects with H_2-DRI Development

The availability of large-scale supplies of green hydrogen will prove make-or-break in ensuring the adoption of H_2-DRI facilities and competitiveness in producing low-carbon, high value-added steel products. Even if H_2-DRI commercial technology is successfully demonstrated, a lack of access to green hydrogen is likely to force the industry to rely on fossil fuel-based alternatives such as gray or blue hydrogen, limiting steel sector's contribution to reach carbon neutrality. To advance both H_2-DRI technology and carbon-free fuel supply, introducing **a CfD mechanism for long-term green hydrogen procurement** is essential. Such a scheme would ensure fixed pricing for green hydrogen. In addition, **integrating green hydrogen production projects with the 300,000-tonne H_2-DRI demonstration project** scheduled to launch in Pohang in 2026 would strengthen both hydrogen production capacity and the economic viability of H_2-DRI steelmaking.

The Pohang Shinkwang Wind Farm—located in Buk-gu, Pohang, and in commercial operation with an installed capacity of 19.2 MW and an estimated annual generation potential of 50,458 MWh—stands as the sole wind power facility currently operating in Pohang. The aforementioned 300 kilotonnes-per-year (ktpa) H_2-DRI demonstration project is anticipated to require approximately 27,000 tonnes of hydrogen—which would in turn require about 1.6 TWh of renewable electricity, assuming an electrolyzer efficiency of 60%. As explained in **[Table 6]**, leading overseas steelmakers are partnering with renewable energy producers and electrolysis companies, integrating their H_2-DRI initiatives with green hydrogen demonstration projects. South Korea is also producing wind-powered green hydrogen alongside additional demonstration projects in Jeju Island. Drawing on insights from the Jeju case, it is worth exploring the potential to source part of the required 27,000 tonnes of green hydrogen for the H_2-DRI demonstration project through *a green hydrogen demonstration initiative at the Pohang Shinkwang Wind Farm*. The Korean government could offer direct subsidies, tax credits, or implement a CfD mechanism to ensure long-term price stability for green hydrogen.

Renewable Energy Policy is the Economic Constrains of Green Hydrogen

Renewable electricity stands out as the single largest cost factor in green hydrogen production—accounting for roughly 28% of production costs for a 1-MW electrolyzer[24] —offering the greatest potential for cost savings at the same time. To secure renewable power for H_2-DRI in an economically viable manner, it is essential to lower the levelized cost of electricity (LCOE) from renewable sources by raising renewable energy generation targets, streamlining permitting and development expenses, and reforming electricity market regulations.

Inadequate Renewable Energy Generation Targets

H_2-DRI steelmaking—as its name suggests—requires vast volumes of hydrogen, and for the process to be truly green the hydrogen must be made from renewable electricity. To introduce two H_2-DRI plants by 2035, each with a scale of about 2.5 million tonnes per annum, roughly 25 TWh of renewable power per year is required, which is approximately 14% of South Korea's renewable energy generation target for the same year. There are several hurdles to producing the necessary renewable power. Foremost, no national target specifically allocates renewable electricity for green hydrogen production via electrolysis. Moreover, in 2023, the country generated only 49,401 GWh of renewable energy, a mere 8.4% of total power generation.[25] This is starkly overshadowed by China, which generated a staggering 2,673,556 GWh—54 times more than South Korea—living up to its reputation as the world's leader in renewable energy generation.[26] The *11th Power Supply Master Plan* aims to raise renewable shares to 18.8% (120.9 TWh) by 2030, 26% (179.9 TWh) by 2035, and 29.2 % (205.7 TWh) by 2038. However, analyses call for far more ambitious renewable energy generation targets to achieve the nation's carbon neutrality goals: 47% by 2030 and 65% by 2035.[27] Furthermore, the 2030 renewable target presented by the *2050 Carbon Neutral Strategy of the Republic of Korea: Towards a Sustainable and Green Society*, released by the government in 2021, was initially 30%, but has since been downgraded to 18.8%. This reduction may not only discourage renewable

24 IRENA. (2020). *Green Hydrogen Cost Reduction: Scaling Up Electrolysers to Meet the 1.5C Climate Goal.*

25 Of the "new and renewable energy" sources as defined by the South Korean government, "new energy"—which includes hydrogen, fuel cells, and coal gasification/liquefaction energy that uses existing fuels via new methods or chemical reactions)—is excluded because it does not meet international standards for renewable energy.

26 IRENA. (2024). *Renewable Energy Statistics 2024.*

27 Behrendt, J., Borrero, M., George, M., Bertram, C., Rader, A., Churlyaev, D., Kreis, A., Lou, J., Hultman, N. & Cui, R. (2025). Evaluating a High Ambition Pathway for Decarbonization in the Republic of Korea. *Center for Global Sustainability, College Park.*

energy developers and investors from expanding business but also lower the priority of much-needed policies and regulatory reforms.

Challenges in Permitting and Development Costs

Global levelized costs of energy (LCOE) from renewable sources[28] have steadily declined, but South Korea's rates remain high. In 2023, the LCOE for renewable energy was USD 111 per MWh for solar photovoltaic (PV), USD 120/MWh for onshore wind, and USD 233 per MWh for offshore wind. These figures far exceed the median LCOE in lower-cost countries, where solar PV ranges from USD 34 to 49 per MWh, onshore wind from USD 33 to 46 per MWh, and offshore wind from USD 63 to 89 per MWh.[29] These gaps stem from a combination of persistent challenges, such as low national renewable energy targets, high permitting and development expenses, limited land availability, and restrictive electricity market regulations. As a consequence, renewable power remains expensive and so does producing green hydrogen domestically.

In the case of solar photovoltaic (PV), in South Korea, one major regulatory obstacle to solar PV expansion is the government's setback-distance requirement. This regulation limits how closely solar installations can be built near specific areas.[30] This regulation alone was responsible for cutting new solar PV deployment by as much as 30% in 2022.[31] Typically, similar setback rules apply exclusively to facilities that pose hazards, such as waste treatment plants and livestock farms. In 2023, the government announced, through its *setback requirement improvement plan*, that solar PV installations pose no particular hazards. Nevertheless, this acknowledgement has remained with no subsequent legislative action to date.[32]

South Korea has already included government-led offshore wind deployment in its ambitions to expand renewable energy. This plan targets 78 GW of renewable capacity—including solar and wind—by 2030, increasing to 121.9 GW by 2038. However, this roadmap is being held back by an inefficient permitting process for offshore wind projects. The inefficiencies are reflected in the scant current offshore wind capacity

28 LCOE is the average cost incurred to produce 1 kWh of electricity over the lifetime of a power plant.

29 Korea Energy Economics Institute. (2024). *Trends in Levelized Cost of Electricity (LCOE) from Renewable Sources in 2023.*

30 In light of this requirement, local governments enact ordinances prohibiting the installation of solar power facilities within a radius ranging from a 100 to 1,000 meters of roads, residential areas, and other designated zones.

31 Korea Energy Economics Institute. (2023). *Assessment of Setback Regulation Policies on Solar Photovoltaic Deployment.*

32 SFOC. (Sept. 25, 2024). [Press Release] "Relaxation of Solar Setback Regulation Has Been Easier Said Than Done by MOTIE for 7 Years … Climate Groups File Constitutional Challenge, Accusing *MOTIE of Being a Climate Crisis Onlooker*."

in commercial operation of only 224.6 MW. Furthermore, of the combined capacity of 31.5 GW across the 97 licensed projects, only 0.8 GW—or 2.5%—has passed the final procedural hurdle of obtaining a permit for the occupancy or use of public waters. For the seven projects that cleared this bureaucratic hurdle, the average approval time—from application submission to permit issuance—totaled 484 days, nearly five times the statutory 98-day limit.[33]

Challenges Facing the Renewable Energy PPA Market

Today in South Korea, a renewable power consumer with demand exceeding 1 MW has three options: a third-party power purchase agreement (PPA), a direct PPA, or self-generation.[34] Yet, these options are crippled by the current power market structure. Korea Electric Power Corporation (KEPCO)—which monopolizes generation, transmission, distribution, and sales—likely perceives increased PPA demand as customer attrition and has little incentive to support its growth. Companies signing PPAs face extra transmission and distribution fees in addition to surcharges levied by KEPCO. The core of the problem is the lack of transparency around how these fees are calculated. Last year, these discriminatory network charges prompted the filing of a complaint under the Fair Trade Act.[35]

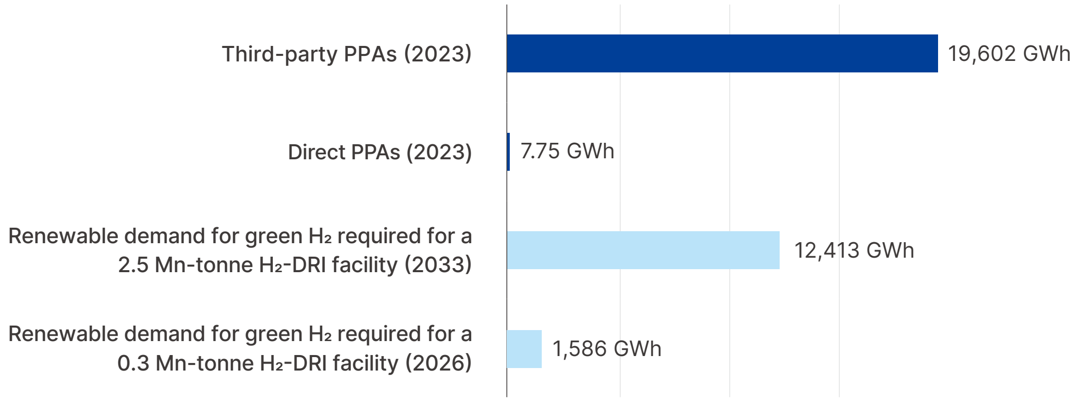
This power market structure, which limits the growth of PPAs, threatens the viability of H_2-DRI steelmaking, which depends on large, stable supplies of renewable electricity to produce green hydrogen. To put this into perspective, a single 2.5 million-tonne H_2-DRI facility requires about 12.4 TWh of renewable electricity annually—roughly 63% of South Korea's total PPA volume in 2023 (19.6 TWh) **[Figure 8]**. Therefore, to enable large-scale deployment of renewable energy-driven hydrogen steelmaking, South Korea must reform its renewable energy framework to meet this demand, with an eye toward large-scale facility deployment. It must also ensure that PPA network usage fees and ancillary charges are transparent and equitable. These are critical issues that directly impact the effectiveness of industrial decarbonization.

33 Kim, E. & Jo, E. (2025). Against the Current I—Public Waters Occupancy or Use Permit Processing Delays and Policy Recommendations. *Solutions for Our Climate*.

34 Excluded from this list are the green premium (because it adds little to renewable energy and carries a risk of greenwashing) and renewable energy certificates (RECs), which face quantity limitations when not subject to the Renewable Portfolio Standard (RPS) system.

35 SFOC. (May 27, 2024). [Press Release] "Pinpoint Power-Sector Litigation Series No. 3: Industry Trembling Before Opaque Network Usage Fees … KEPCO's PPA Fee Structure Reviewed by the FTC."

[Figure 8] PPA Volume vs. Renewable Power Demand for Producing Green H_2 Required for H_2-DRI in South Korea[36]



36 Korea Power Exchange (KPX)

Recommendation

Renewable Energy for Electrolysis: Setting Generation Targets and a Dedicated Tariff System

To ensure the economic viability of green hydrogen and meet carbon neutrality goals, South Korea must expand and stabilize its renewable electricity supply. To this end, the government should establish **national targets for renewable power generation specifically dedicated to electrolysis** and clearly incorporate these targets into both the *Power Supply Master Plan and the Second Master Plan for Hydrogen Economy Implementation*. The government also needs to enact complementary legislation—such as a Korean version of the Inflation Reduction Act (IRA)—to provide additional tax incentives and subsidies for green hydrogen production and renewable energy projects for electrolysis. This would spur broader investments from power producers and steelmakers in green hydrogen production. At the same time, further efforts are needed to reduce renewable energy costs and accelerate the penetration of renewables—such as eliminating setback distance regulations for solar photovoltaic (PV) and streamlining the permitting process for offshore wind ventures. Clear disclosure of grid-usage fees for participants in power purchase agreements (PPAs) must also be mandated to activate the PPA market. Collectively, these reforms will bolster renewable energy development and PPA adoption.

Another critical factor is cost of renewable electricity purchase. If green hydrogen producers are required to purchase renewable energy certificates (RECs) when procuring renewable electricity, green hydrogen prices could remain high between KRW 8,000 and 10,000 (USD 5.80 and 7.20) per kg even through 2040. **Introducing a dedicated electricity tariff system for electrolysis with discounted rates for PPAs** could push green hydrogen costs down more quickly. According to the Korea Energy Economics Institute, a 90% discount on renewable PPA rates could reduce hydrogen production costs to around KRW 1,638 (USD 1.20) per kg—close to the KRW 1,356 (USD 0.98) per kg threshold[37] needed for hydrogen-based steelmaking to compete economically with conventional blast furnace-based steelmaking.[38]

37 Kim, J., Kim S. & Park, J. (2020). A study on the strategies for early settlement of market driven hydrogen economy in Korea (1/3). *Korea Energy Economics Institute.*

38 Kang, B. (2022). Scenario analysis of iron and steel production process for carbon neutrality. *Korea Energy Economics Institute*.

6. Conclusion

This study has assessed the economic viability of green H_2-DRI steelmaking under South Korea's hydrogen policies and proposed measures to help establish low-carbon steelmaking processes. While the government currently plans to rely heavily on imports to meet domestic clean hydrogen demand, the plan is fraught with overlooked components. First, the government's current policy underestimates the prices of hydrogen sourced from overseas, failing to accurately account for ancillary costs such as liquefaction and transportation expenses. Moreover, there are no specific hydrogen volume projections indicated for H_2-DRI—which demands a reliable supply of substantial volumes of green hydrogen—nor is there a clear strategy to ensure stable domestic production and supply.

If green hydrogen is procured from abroad, the production cost per tonne of H_2-DRI is projected to be about KRW 220,000 (USD 159) higher than when using domestically produced hydrogen in 2033, rising to KRW 590,000 (USD 428) by 2050. Even under optimistic assumptions on declining domestic green hydrogen costs, **transitioning to H_2-DRI will still incur an incremental cost of roughly KRW 300,000 (USD 217) per tonne of steel, compared with conventional BF-BOF steelmaking**. However, these additional costs could be partially or fully offset by declines in PPA prices driven by expanded renewable energy, policy support for renewable power production and purchase dedicated to electrolysis, and growth in low-carbon steel markets.

The key insights drawn from this study are as follows:

- **First**, while demand for green hydrogen will sharply rise from 2033 from the introduction of H_2-DRI facilities, the government currently lacks precise forecasts for industrial hydrogen demand. It only prioritizes importing hydrogen without meaningful policy support for domestic green hydrogen production, which can delay the introduction of H_2-DRI facilities.
- **Second**, actual costs of importing hydrogen are likely to greatly surpass current government projections. Early establishment of domestic production through supportive policies—such as a CfD mechanism for long-term green hydrogen procurement agreements and dedicated electricity tariffs for renewable-based electrolysis—is a strategic choice. This approach not only represents a cost-effective path to carbon neutrality but also fortifies energy security.

- **Third**, even though H_2-DRI translates into incremental costs, its economic viability can improve in the medium to long term, with cost reductions from expanded domestic renewable energy and green hydrogen production, and their streamlined permitting processes. Increasing market demand for low-carbon steel products can further improve the economic viability of H_2-DRI steelmaking.

Strong policy support in green hydrogen and renewable energy production are critical for South Korea to meet its carbon neutrality targets, enhance energy security, and ensure industrial competitiveness. Hyundai Steel recently announced an investment of approximately KRW 8.5 trillion (USD 6.2 billion) to build a new steel plant in the US. This decision reflects not only a response to US steel tariffs but also the attractive policy environment created by federal incentives for low-carbon fuels, including those in the US Inflation Reduction Act. Looking ahead, the competitiveness of core industries like steel will increasingly depend on their ability to produce low-carbon, high value-added products. Without robust incentives for the production of low-carbon fuels such as green hydrogen and renewable energy, South Korea's industrial base would risk remaining reliant on fossil fuels and eventually losing competitiveness in the global marketplace.

7. Appendix

Cost-Effective Transition Towards Carbon-Neutral Steelmaking

To select steelmaking processes for transition analysis, this study considered the South Korean government's low-carbon steel production development initiatives and the domestic steel industry's plans to adopt emissions mitigation technologies, both as of February 2025 **[Table 7]**. This approach places clear emphasis on the technological pivots aimed at reducing carbon emissions, reflecting the latest technological trends and strategies within South Korean steel industry. To analyze the cost of converting coal-based facilities—the heart of the industry's carbon emissions—this study identified the 11 blast furnaces (BFs) and two FINEX plants currently in operation as candidates for transition. The existing electric arc furnaces (EAFs) were excluded from transition cost analysis because they are considered low-carbon technology due to their low carbon intensity relative to BF-BOFs.

Carbon neutrality calls for swift transition in the BF-BOF route, which accounts for roughly 70% of the country's crude steel output and is the steel industry's primary source of emissions. Accordingly, this study assumed the gradual decommissioning of these facilities without further relining or capacity expansion, with a maximum operational life capped at 20 years post-last relining. A range of carbon reduction technologies is being discussed for possible application to the conventional BF-BOF process, but the emissions cutting potential across those technological options differs only marginally. This led us to refer to Best Available Technology (BAT) data presented by the Mission Possible Partnership (2022).[39]

It must be noted that three EAFs will sequentially be operated starting in 2026, utilizing scrap steel and hot briquetted iron (HBI) to produce high-quality steel with reduced emissions. These were included as viable low-carbon replacements for existing BF-BOF processes within the transition pathways. Lastly, H_2-DRI—widely considered the most promising alternative in emissions abatement potential—was assumed to be phased in from 2033 onward, accounting the announcements from POSCO, the leading industry in developing the technology.

39 Mission Possible Partnership. (2022). *Making Net-Zero Steel Possible: An Industry-Backed, 1.5°C-Aligned Transition Strategy.*

[Table 7] A List of Technologies Considered in Steelmaking Transition Analysis

Technology	Description	Time of Introduction
BF-BOF	A production method where iron ore is reduced and melted by use of coal (coke) in a blast furnace (BF) and then processed through a basic oxygen furnace (BOF). This route currently accounts for approximately 70% of steelmaking in South Korea.	In operation
BAT BF-BOF	A production method that uses alternative iron sources and hydrogen-enriched gases in the BF-BOF route and thereby reduces carbon emissions to some extent.	2029
EAF (HBI-Scarp)	A production method that charges an EAF with hot briquetted iron (HBI)—a reduced iron made by removing oxygen from iron ore—alongside steel scrap and thereby reduces carbon emissions.	2026
H_2-DRI-ESF	A production method whereby iron ore is directly reduced by hydrogen instead of coal, and the resulting direct reduced iron (DRI) is melted in an electric smelting furnace (ESF) to make steel.	2033 (2.50 Mn tonnes)

SFOC

Solutions for Our Climate (SFOC) is an independent nonprofit organization that works to accelerate global greenhouse gas emissions reduction and energy transition. SFOC leverages research, litigation, community organizing, and strategic communications to deliver practical climate solutions and build movements for change.