SFOC
Solutions for Our Climate

Report

Choosing a Green Steel Pathway

Implications for South Korea, Japan, and Australia

Choosing a Green Steel Pathway

Implications for South Korea, Japan, and Australia

Publication Date	**September 2026**

Authors	**Ayantu Teshome Mossisa** | Solutions for Our Climate **Yeongmin Kweon** | Solutions for Our Climate
Contributors	**Lilly Qiu** | Transition Asia **Alastair Jackson** | Transition Asia **Akira Kanno** | Transition Asia
Design	**sometype**

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

Executive Summary

This report assesses the competitiveness of domestic green steel production in South Korea and Japan relative to imported Australian green iron by 2035. Using a Levelized Cost of Steel (LCOS) framework, the analysis compares production costs and emissions performance across domestic and import pathways to identify the conditions under which domestic green steel production can become both cost-competitive and emissions-eligible.

Key Findings

- **Hydrogen cost is a key determinant of the cost competitiveness of green steel production.** For domestic green steel production to compete with pathways using imported green iron, hydrogen production costs will need to fall to approximately \$2.21~\$2.38/kg H_2 in South Korea, and \$2.56~\$3.53/kg H_2 in Japan.

- **Increased use of renewable electricity is essential for domestic green steel production.** Under projected 2035 conditions, grid-based production in both South Korea and Japan remains above the ResponsibleSteel green steel threshold of 0.4 tCO_2/tcs. Therefore, hydrogen-based ironmaking should be accompanied by increased use of renewable electricity for domestic production to meet the emissions threshold for green steel classification.

- **Australia's early action is required to secure its position in green iron export market.** As domestic green steel production in East Asia becomes increasingly competitive under favorable policy and cost conditions, and as gas-based DRI pathways may not meet emerging green steel emissions standards, accelerating the deployment of green hydrogen-based iron production will be critical to securing long-term market opportunities as green iron supplier.

1. Introduction

The global steel industry is undergoing a structural transition of considerable economic and geopolitical consequences. Responsible for approximately 7–9% of global carbon dioxide emissions, the sector faces mounting pressure to decarbonize its production base while preserving industrial competitiveness.[1] Conventional steelmaking, dominated by blast furnace basic oxygen furnace (BF-BOF) routes reliant on metallurgical coal, is increasingly incompatible with national climate commitments and emerging carbon pricing frameworks.[2] Among the candidate low emission pathways, hydrogen based direct reduced iron (H_2-DRI) coupled with electric arc furnace steelmaking has attracted the most substantial policy and industrial attention, owing to its potential for deep emissions abatement.[3] In parallel, supply chain–oriented strategies, most notably the cross-border trade of low-emission iron inputs, are being explored to leverage geographic differences in resource endowments.[4] [5] In this context, the role of low-emission iron trade in advancing the decarbonization of steel sector has become an increasingly important area of research and policy discussion.

Green Iron Trade[6] and the East Asia Corridor

The economic rationale for green iron trade is grounded in regional disparities in renewable energy availability, hydrogen production costs, and iron ore endowments. These differences may reshape trade patterns, with Australia, the Middle East and North Africa (MENA), Brazil, and South Africa emerging as potential supply hubs, while major steel-producing economies such as South Korea, Japan, and Germany are expected to become key demand centers.

Among these potential trade relationships, the Australia-East Asia corridor has attracted particular attention.[7] Despite possessing globally competitive steel industries, both South Korea and Japan face structural constraints on deploying renewable energy at the scale

1 World Steel Association. (2024). *World Steel in Figures 2024*
2 OECD. (2025). *Hydrogen in steel: Addressing emissions and dealing with overcapacity*
3 UNIDO. (2025). *Iron and Steel: What is the State of Decarbonization Technologies?*
4 SteelWatch. (2025). *Why Green Iron Trade Will Catalyse Steel Industry Decarbonisation*
5 S. Bilici et al. (2024). *Global trade of green iron as a game changer for a near-zero global steel industry? - A scenario-based assessment of regionalized impacts*
6 Green iron trade refers to the production of low-emission direct reduced iron (DRI) or hot briquetted iron (HBI) using renewable electricity and green hydrogen in regions with favorable iron ore and renewable energy conditions, followed by the export of these semi-processed iron products to steel-producing countries for final conversion into steel, typically via electric arc furnaces.
7 OECD. (2025). *Green Iron Opportunities in Australia: A Case Study Within the OECD's Global Green Iron Project.*

required for cost-competitive green hydrogen production. By contrast, Australia combines abundant renewable energy resources with extensive iron ore reserves and well-established export supply chains, positioning it as one of the most promising near-term suppliers of green iron to East Asian markets.[8] This trajectory is further reinforced by active industrial investment, including South Korea's largest steelmaker, POSCO, which has strengthened its presence in Western Australia's Pilbara region through investments and partnerships aimed at future green iron production,[9] signaling growing commercial interest in an Australia-East Asia green iron corridor.

The Strategic Question for Import Dependent Economies

Within this emerging trade discourse, considerable research[10] has examined the strategic significance of green iron export potential. Comparatively little attention, however, has been paid to what sustained import dependence could mean for the long-term decarbonization pathways of importing economies. For South Korea and Japan, sourcing green iron from renewable-rich countries could be considered as a rational decarbonization strategy. Yet it also raises a broader strategic question: under what conditions could domestic green steel production become a viable and market-competitive alternative?

The answer is unlikely to remain constant over time because the relative attractiveness of domestic production and imports will evolve with changes in hydrogen and electricity prices, carbon pricing, renewable deployment, and technology costs. Accordingly, the relative merits of the two pathways are expected to evolve over time and across policy contexts rather than representing a binary choice.

Australia's near-term supply outlook adds further uncertainty. Although widely regarded as a promising supplier to East Asia, its green iron production remains underdeveloped. In addition, many proposed production pathways continue to rely on natural gas rather than green hydrogen, raising concerns regarding lifecycle emissions and the risk of fossil fuel lock-in.[11] Consequently, the availability of genuinely low-emission iron imports from Australia remains uncertain, reinforcing the need to examine the long-term role of domestic green steel production in expected importing economies.

8 WEF. (2025). *Unlocking Asia-Pacific as a First Mover: Australia's Green Iron Opportunity*
9 POSCO Port Hedland Iron Project - Global Energy Monitor
10 Agora Industry (2025). *The role of green iron trade in accelerating competitive steel transformation*
11 IEEFA. (2025). *South Australia: Long-term reliance on gas for iron and steelmaking faces significant risks*

Therefore, this study compares the costs of domestically producing green hydrogen-based steel with those of using imported green iron from Australia and identifies the pricing and policy thresholds at which domestic production becomes cost competitive. Through this comparative analysis, it aims to inform relevant policy decisions rather than advocate for either pathway. Accordingly, the findings provide insights for industrial decarbonization strategies in prospective importing economies such as South Korea and Japan, while also informing export market strategies for Australia as a prospective green iron supplier.

2. Methodology & Data

This study used a levelized cost of steel (LCOS) model developed by Transition Asia to compare the costs and emissions performance of domestic green steel production and imported green iron pathways.

System Boundaries & Evaluation Pathways

This analysis compares the delivered cost and lifecycle emissions across three distinct regional pathways, capturing the transition from iron ore to crude steel. The boundaries are strictly defined to ensure comparability across the pathways. Each region's technology configuration reflects a promising deployment pathway for the region. The pathways differ in both feedstock and reduction technology, and the cost comparison should be read as a comparison of realistic regional options rather than of a single technology across locations.

- **South Korea (SK) Domestic Production**
  SK imports low-grade hematite iron ore fines (57.8% Fe) from Australia and processes them through Fluidized Bed (FB) reduction, followed by an electric smelter furnace (ESF) and a basic oxygen furnace (BOF).[12]

- **Japan (JP) Domestic Production**
  JP imports DR-grade magnetite pellets (67.0% Fe) from Brazil and processes them through a vertical shaft furnance (SF) reduction plant, feeding an Electric Arc Furnace (EAF) with a 15% scrap blend.[13]

- **Import from Australia (AUS to SK/JP)**
  Domestic low-grade iron ore fines undergo beneficiation and pelletization in Australia before being reduced with green hydrogen in a SF. The resulting DRI is melted in an ESF, and the pig iron is shipped to SK or JP for use in domestic BOF facilities.[14] The LCOS estimates

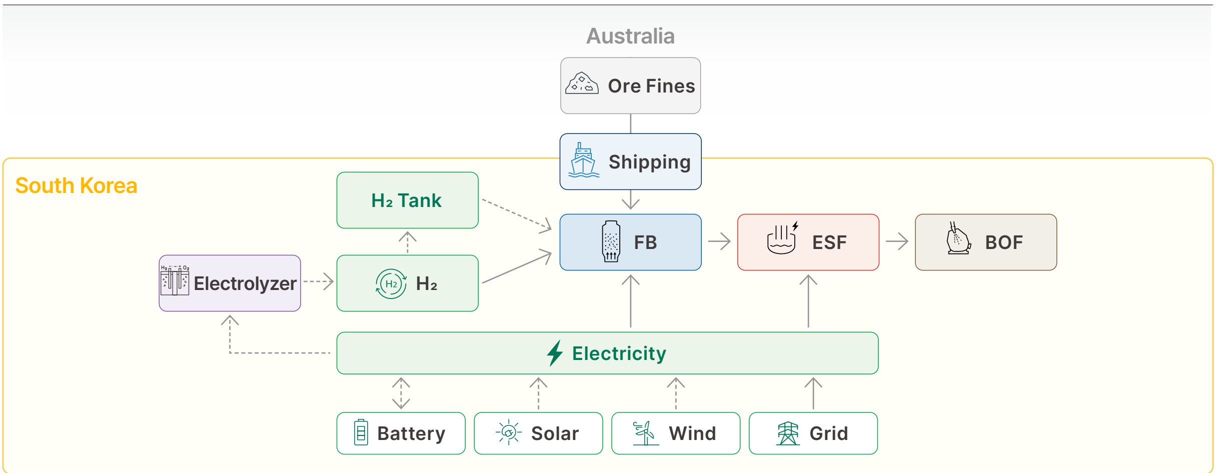
12 This route (similar to POSCO's HyREX technology under development), can directly process low-grade fines without pelletization. However, low-grade ore requires a higher hydrogen-to-ore ratio to maintain fluidization and prevent stiction. ESF is also needed to remove gangue from the resulting DRI before the hot metal is fed into BOF facilities.

13 This route the most commercially proven configuration reflects Japan's access to high-grade ore and established scrap supply chains. High-grade pellets limit slag formation and associated energy consumption, while the scrap blend supports greater use of secondary steel.

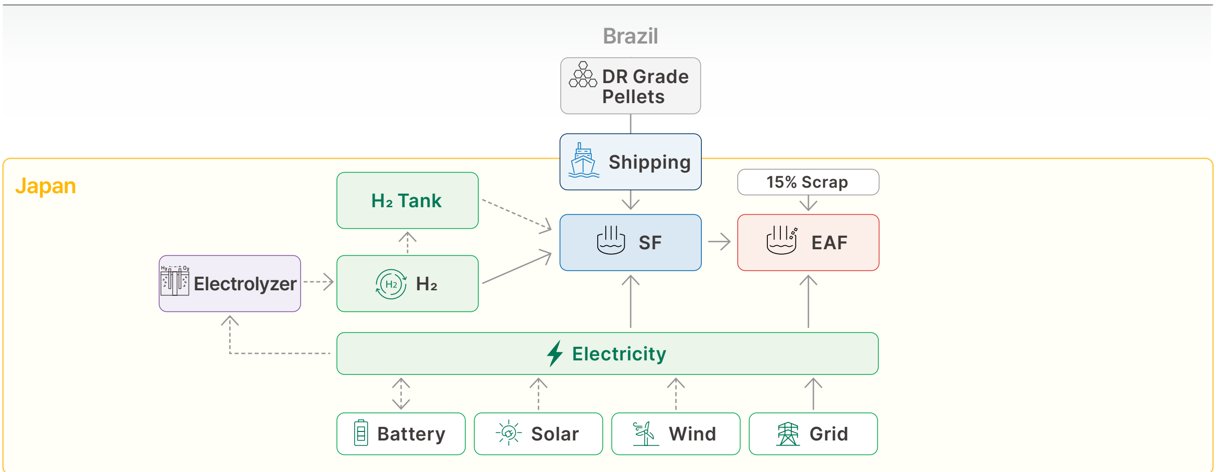
14 This pathway combines Australia's iron ore and renewable energy sources while liming the need for major modifications to downstream steelmaking facilities in importing countries. The Australian case primarily focuses on the SF-ESF production route, given the advanced stage of shaft furnace technology and its widespread use as a benchmark in prominent green steel modeling studies.

were also developed for the FB pathway to evaluate how technology selection may affect production costs and the competitiveness of Australian green iron under alternative deployment scenarios.

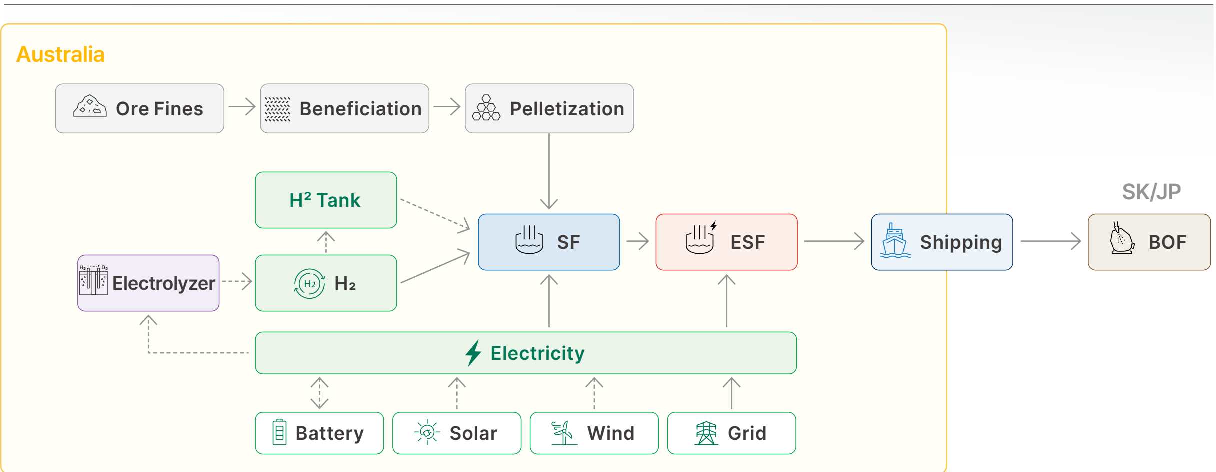
[Figure 1] System boundary for SK Domestic case: FB-H_2DRI-Smelter-BOF



[Figure 2] System boundary for JP Domestic case: SF-H_2DRI-EAF



[Figure 3] System boundary for AUS Import case: SF-H_2DRI-Smelter-BOF



Cost Modelling Inputs & Energy Options

To estimate the Levelized Cost of Steel, the model aggregates capital expenditure (CAPEX), fixed operations & maintenance (O&M), and variable operating expenditure (OPEX) across the defined system boundary. Unless otherwise stated, all costs are expressed in 2025 USD.

To reflect different grid decarbonization strategies, the model evaluates two distinct energy configurations:

- **Hydrogen supply**: Hydrogen procurement at an assumed constant wholesale price versus onsite production using alkaline electrolyzers with dedicated storage.
- **Electricity supply**: 100% Grid electricity versus onsite renewables (Solar PV and onshore wind, combined with 6-hour lithium-ion battery storage) supplemented by grid electricity. For the onsite renewables option, an hourly optimization model sizes and dispatches the renewable, electrolyzer, battery and hydrogen-storage assets capped by a 0.4 tCO_2/tcs limitations.

Key cost parameters, such as renewable installation costs, grid electricity prices, shipping rates, and raw material prices, are regionalized to reflect local market conditions in South Korea, Japan, and Australia (see Appendix for detailed assumptions).

Emissions Accounting for Iron and Steelmaking (excluding green hydrogen production)

The model employs a comprehensive Scope 1–3 emissions accounting framework aligned with ResponsibleSteel guidelines.[15] This includes:

- **Scope 1**: Direct emissions generated within the plant boundary. This primarily includes CO_2 emissions from electrode oxidation in the EAF/ESF and any natural gas-based combustion during pelletization and BOF operations.
- **Scope 2**: Indirect emissions from purchased electricity, calculated using projected 2035 grid emission intensities for each region.
- **Scope 3**: Upstream and value-chain emissions for the input materials and shipping.

15 Responsible Steel Standard (https://www.responsiblesteel.org/resource-hub/standards-certification-and-assurance)

[Table 1] Emissions accounting for iron and steelmaking

Scope	Item	SK	JP	AUS-JP/SK
Scope 3	Fines	FB	-	Beneficiation
	Pellets	-	SF	-
	Scrap	-	EAF	-
	Burnt Lime	BOF and ESF	EAF	BOF and ESF
	Refractories and Alloys	BOF	EAF	BOF
	Electrode	ESF	EAF	ESF
	Oxygen	BOF	EAF	BOF
	Cooling Water	All	All	All
	Shipping	Fines	Pellets	PI
Scope 2	Electricity	All	All	All
Scope 1	Natural Gas	BOF	-	Pelletization and BOF
	Electrode consumption	ESF	EAF	ESF

Emissions Accounting for Green Hydrogen Production

The emissions associated with hydrogen vary based on sourcing options:

- **External Sourcing**: Hydrogen procured from the wholesale market is assumed to be certified green hydrogen with an emissions intensity of 0 $kgCO_2e/kg\ H_2$ at the plant gate.

- **Onsite Production**: For hydrogen produced using onsite electrolyzers, emissions from electricity consumption are accounted for under Scope 2 based on the electricity source. Scope 2 emissions are assumed to be zero when electrolysis is powered entirely by dedicated onsite renewables.

Scenarios and Sensitivity Parameters

Given the uncertainty surrounding clean technology deployment through 2035, the model employs a scenario-based approach (Low, Base, High) specifically targeting CAPEX and grid electricity parameters. These scenarios assess regional competitiveness under different rates of technological advancement and grid decarbonization.

Renewable energy CAPEX projections for South Korea and Japan are based on estimates from Lawrence Berkeley National Lab (LBNL), while Australian CAPEX projections, including those for renewable energy and electrolyzers, rely on CSIRO GenCost report. For electrolyzer costs in Japan and South Korea, this scenario uses baseline estimates derived from their respective national hydrogen roadmaps. (see Appendix for detailed assumptions).

Grid electricity prices and emission intensities reflect stated current policies.

Sensitivity analyses are also conducted for two key parameters:

- **Hydrogen Price for external sourcing**: Ranging from $2.00 to $12.00 per kg.
- **Carbon Price**: Evaluating the impact of various carbon tax and emissions trading system pricing levels on the final delivered cost.

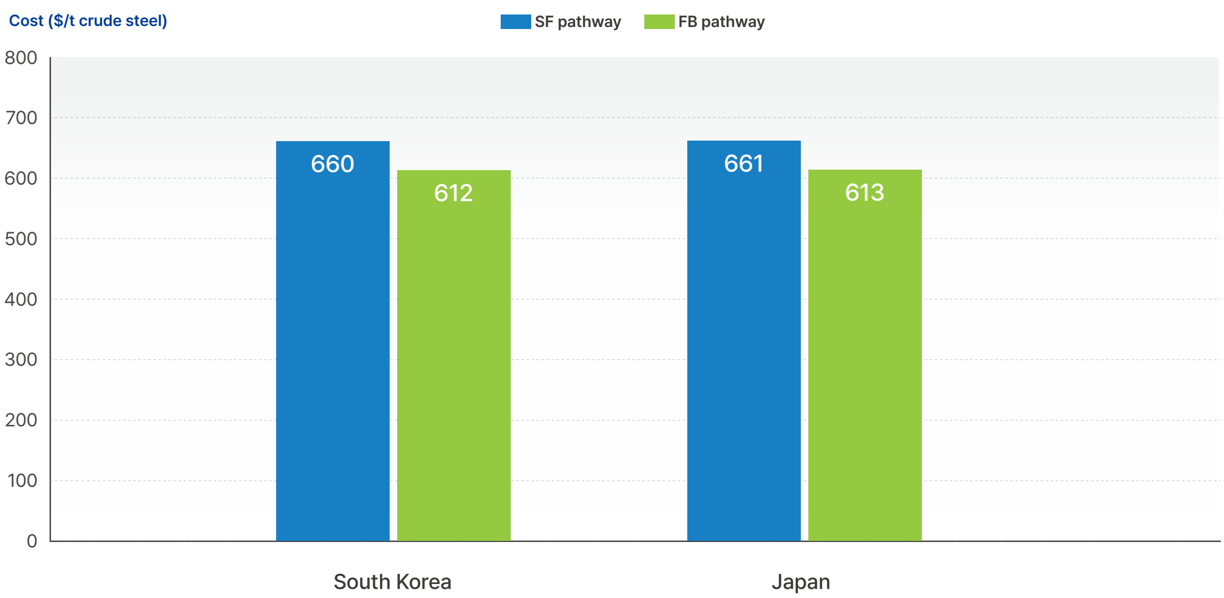
3. Results

Australian Green Iron as the Price Benchmark

Under the base scenario, the LCOS of steel produced using Australian green iron in 2035 is estimated at $660/tcs for the SF pathway and $612/tcs for the FB pathway when delivered to South Korea. The corresponding estimates for imports to Japan are $661/tcs and $613/tcs, respectively. These estimates incorporate projected reductions in renewable energy and electrolyzer costs and represent the total cost incurred by domestic steelmakers using imported Australian green iron.

In both markets, the FB pathway is $48/tcs cheaper than the SF pathway. This difference primarily reflects the ability of fluidized bed technology to process iron ore fines directly, avoiding the capital and energy costs associated with pelletization. However, fluidized bed reduction remains less commercially mature than shaft furnace technology and is therefore less readily deployable. Accordingly, the SF pathway is adopted as the primary reference case, while the FB results represent the lower bound of the import cost range.

[Figure 4] **Estimated Green Steel Production Costs Using Imported Australian Green Iron, 2035**



Together, the FB and SF pathways define the estimated cost range for Australian green iron imports in 2035. This range serves as the benchmark for evaluating the conditions under which domestic green steel production in South Korea and Japan can achieve comparable levels of competitiveness.

Grid Electricity and Emissions Eligibility

Before evaluating cost competitiveness across all pathways, this analysis first determines whether domestic production meets the emissions eligibility conditions used to classify steel as green. It applies the ResponsibleSteel threshold of green steel 0.4 tCO_2/tcs to domestic production using either grid electricity or off-grid renewable electricity in South Korea and Japan, with only eligible pathways included in the subsequent competitive analysis.[16]

[Table 2] Emissions intensities of Domestic productions in SK and JP

Year	South Korea		Japan	
	SK Grid	SK Off-Grid	JP Grid	JP Off-Grid
2025	2.38	0.40	1.64	0.40
2035	0.81	0.28	0.59	0.28

* Emissions intensities are expressed in tCO_2e/tcs

The results show that grid-based production exceeds the ResponsibleSteel threshold in both South Korea and Japan. In 2025, emissions intensity is estimated at 2.38 tCO_2e/tcs in South Korea and 1.64 tCO_2e/tcs in Japan, approximately six and four times the green steel emissions threshold, respectively. Although projected grid decarbonization reduces these values to 0.81 tCO_2e/tcs and 0.59 tCO_2e/tcs by 2035, both remain above the threshold. This is largely because grid-based electrolysis transfers the emissions intensity of electricity generation to hydrogen production and, consequently, to the H_2DRI production pathway.

By contrast, production based on off-grid renewable electricity meets the threshold in both countries by 2035 under the study assumptions. These results confirm that using renewable electricity with a lower emissions intensity than national grid electricity for hydrogen and

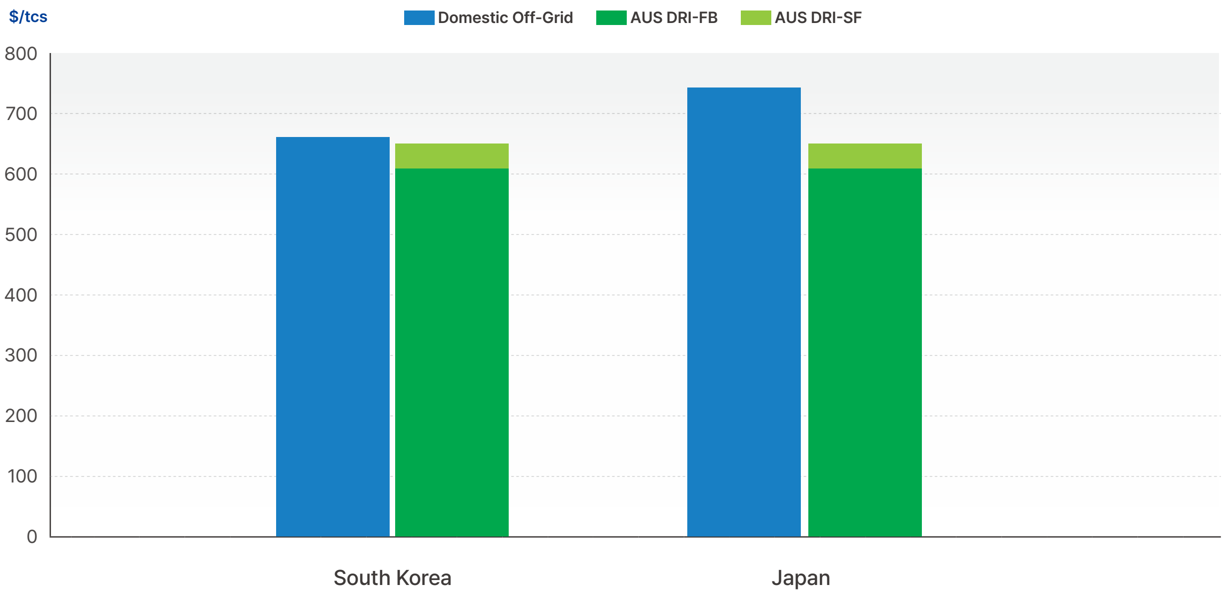
16 To facilitate the estimation of production costs and comparison across pathways, this study considers only off-grid renewable electricity among the various renewable energy procurement options. This analytical choice does not imply that off-grid generation is the only means of sourcing electricity for green steel production.

steel production is a key factor in meeting the green steel emissions threshold. Accordingly, grid-based pathways are excluded from the hydrogen price threshold analysis, even where they may achieve lower production costs. The subsequent cost comparison considers only domestic pathways powered by off-grid renewable electricity.

Cost Competitiveness Under the Base Scenario

Given the estimated hydrogen prices derived above, the base scenario LCOS results reveal how close each country is to domestic competitiveness under projected conditions by 2035 relative to the imported price.

[Figure 5] **LCOS for Domestic Production and Import Pathway 2035**



By 2035, South Korea's domestic production using dedicated renewable electricity is projected to reach $668/tcs, which is slightly above both AUS FB at $612/tcs and AUS SF at $660/tcs. The narrow gap relative to SF reflects the cost advantages of the domestic HyREX pathway, together with projected reductions in renewable energy and hydrogen production costs. The trajectory suggests that under base scenario conditions, South Korea's domestic green steel production comes close to genuine market competitiveness within the mid-2030s horizon, even though it remains slightly more expensive than both Australian pathways.

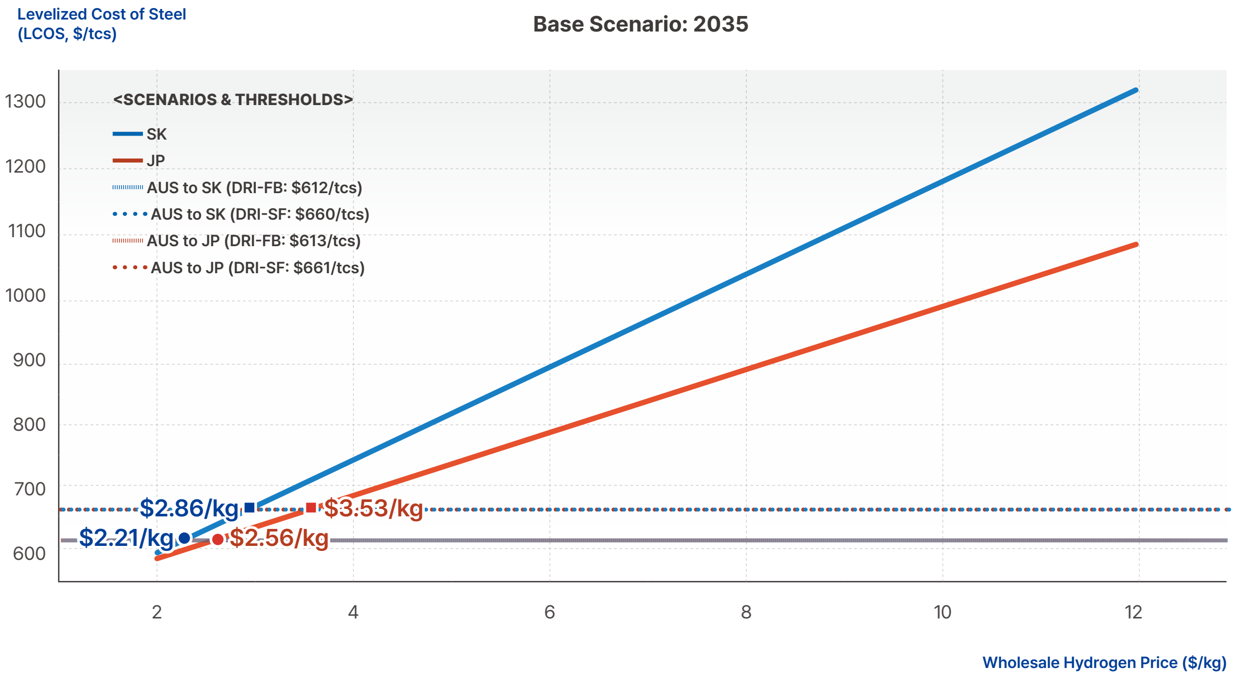
Japan's position by 2035 is more structurally constrained compared to South Korea. Domestic off grid production cost projected to be $746/tcs, remaining meaningfully more expensive than both AUS FB at $613/tcs and AUS SF at $661/tcs.

This divergence has direct implications for policy sequencing. South Korea's narrow cost gap to the Australian benchmark suggests that domestic production could become competitive with targeted support and further cost reductions. Japan faces a larger cost disadvantage, strengthening the case for imported green iron in the medium term unless accompanied by a technology pathway shift or more aggressive policy intervention on renewables and hydrogen costs.

Hydrogen Price Thresholds for Domestic Production

The hydrogen cost levels at which domestic off-grid production in South Korea and Japan reaches cost parity with imported Australian green iron produced via the SF pathway are shown below. These thresholds define the hydrogen cost targets that domestic decarbonization strategies must achieve for green steel production to become cost-competitive without sustained reliance on imports by 2035.

[Figure 6] Hydrogen Price Estimates under Cost competitive LCOS for 2035

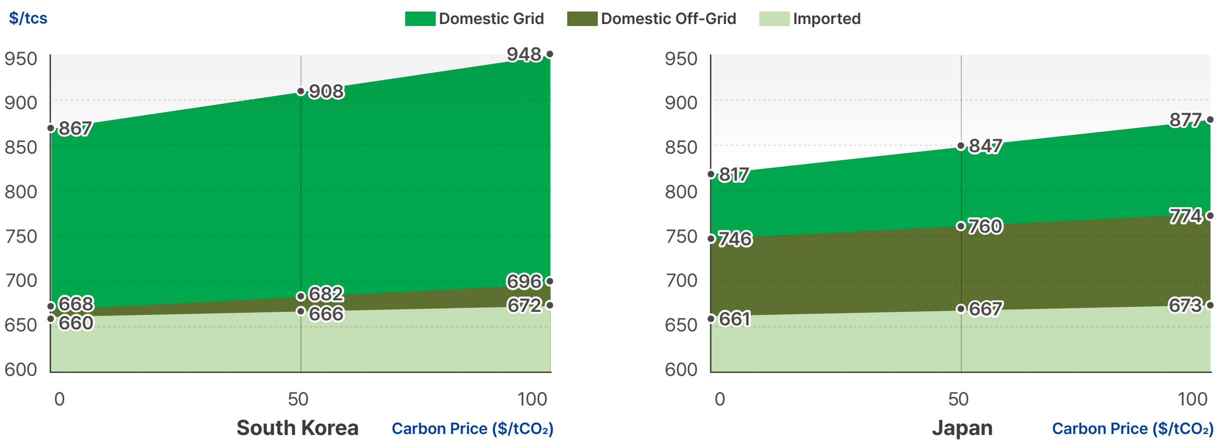


The results show that domestic production in Korea reaches cost parity with the Australian benchmarks at hydrogen prices of $2.21-2.86/kg. Achieving this range would require hydrogen costs consistent with the model's low- to base-cost scenarios, supported by sustained reductions in renewable energy and electrolyzer costs. For Japan, hydrogen cost of $2.56-3.53/kg is required to reach cost parity with Australian DRI. Japan's SF route requires high-grade DR-grade pellets at $163/t and a hydrogen input of 55 kg H_2/tDRI under standard operating conditions, with additional electricity demand for pelletization increasing overall energy cost sensitivity. Overall, the findings indicate that both South Korea and Japan could narrow the cost gap between domestic production and imported Australian green iron by 2035 if hydrogen costs decline sufficiently.

Effects of Carbon Pricing on Steel Production Costs

Carbon pricing affects the relative cost position of each pathway by imposing higher costs on more emissions intensive production routes. In this analysis, where carbon pricing is applied to full emissions, the cost of grid-based domestic production increases by the largest margin as the carbon price rises. By contrast, off-grid domestic production and Australian green iron import pathways experience comparatively modest cost increases across the carbon price range modeled (see **[Figure 7]**).

[Figure 7] Effect of Carbon Pricing on Domestic and Imported Pathways



This difference arises because Australian green iron imports have a significantly lower emissions intensity than grid-based domestic production in South Korea and Japan. As carbon pricing imposes a greater cost burden on grid-based domestic production, the cost gap relative to Australian imports widens, further weakening the competitiveness of grid-based pathways. In South Korea, the import-based LCOS increases from $660/tcs with no carbon price to $666/tcs at $50/tCO_2$ and $672/tcs at $100/tCO_2$. Japan experiences a similar increase, from $661/tcs to $667/tcs and $673/tcs, respectively. Even at a carbon price of $100/tCO_2$, the increase is limited to only $12/tcs, reflecting the low emissions intensity of the Australian import pathway. Off-grid renewable-based domestic production also experiences relatively modest cost increases due to its low emissions intensity. Its cost position relative to Australian green iron imports therefore remains largely unchanged.

Overall, carbon pricing increases the cost burden on emissions-intensive grid-based production, reinforcing the economic importance of securing low-emissions electricity for steel production. However, within the carbon price range modeled, it does not fundamentally reshape the cost gap between off-grid production and Australian green iron imports. This suggests that their relative cost competitiveness is influenced more strongly by key cost drivers, such as renewable energy and hydrogen prices, raw material costs, and technology configurations.

4. Policy Implications

The findings highlight that the competitiveness of domestic green steel production and the future development of the Australia-East Asia green iron trade corridor will be shaped by policy decisions made during the next decade. The following recommendations identify key policy priorities arising from the analysis.

Hydrogen Price Targets

Hydrogen pricing is a major determinant of the competitiveness of domestic green steel production. Relative to the Australian SF benchmark, domestic production reaches cost parity at approximately \$2.86/kg H_2 in South Korea and \$3.56/kg H_2 in Japan by 2035. When compared with the lower-cost but technologically less mature Australian FB pathway, the thresholds fall to \$2.21/kg and \$2.56/kg respectively.

These thresholds should not be interpreted in isolation. A higher parity threshold does not necessarily indicate that a country is closer to competitiveness, but the relevant consideration is the gap between the threshold and the cost at which hydrogen can actually be produced domestically. Under the base scenario, South Korea approaches parity with the Australian SF pathway, while Japan retains a substantially larger LCOS gap because of its higher renewable electricity, hydrogen production, and raw material costs.

Reaching these thresholds will likely require coordinated policy support. Relevant measures include production-linked support that lowers the effective cost of green hydrogen, capital support for early large-scale electrolyzer projects, and long-term offtake agreements that provide revenue certainty. Contract-for-difference mechanisms could also support investment by providing producers with long-term price certainty and reducing market risks. Such support should be predictable but time-bound, with payments linked to verified emissions performance, delivered hydrogen costs, and cost reductions. This would help mobilize early investment without creating permanent subsidies for projects that fail to improve their commercial or environmental performance.

Increase Access to Renewable Energy

Achieving emissions-eligible green steel production will require a significant expansion of access to dedicated renewable electricity for industrial hydrogen production. Given the limitations of grid-based electricity in South Korea and Japan in meeting green steel emissions requirements, policy efforts should focus on accelerating the deployment and procurement of renewable energy for industrial users.

One priority is for steelmakers to maximize on-site renewable energy generation using available land within their facilities. However, given the scale of electricity required for hydrogen-based steelmaking, on-site generation alone is unlikely to be sufficient. Steelmakers should therefore complement self-generation with direct investment in renewable energy projects and long-term power purchase agreements (PPAs) to secure additional renewable electricity supply.

On the other hand, government policy should focus on removing institutional barriers to renewable energy procurement by improving the PPA framework, strengthening grid connection conditions, and establishing the institutional basis for wider deployment of energy storage systems and water electrolysis. Where financial or tax support is needed by the steel makers, rather than simply subsidizing electricity costs, it should be targeted and conditional on verifiable emissions reductions.

Cost-Competitive Decarbonization Pathways by 2035

Technology choice materially shapes the LCOS each country can meet and therefore the feasibility of the domestic competitiveness target. The fluidized bed pathway modeled for South Korea avoids pelletization costs and enables the use of cheaper, low-grade hematite fines, resulting in a lower cost than the shaft furnace pathway. These advantages support policy efforts to accelerate the commercialization of domestic hydrogen based production capacity, although its competitiveness will ultimately depend on reductions in hydrogen and renewable energy costs and successful technology commercialization.

For Japan, domestic production cost still remains significantly higher than Australian imports within the analysis horizon. Imports could therefore provide a relatively cost-effective complementary pathway while Japan continues to develop its domestic production capacity. Carbon pricing further disadvantages emissions-intensive grid-based domestic production, while having a comparatively modest effect on the lower-emissions import pathway. Higher carbon prices therefore progressively improve the relative cost position of Australian green iron imports compared with grid-based domestic production.

Early Action for Export Market Security

Australia's position as a potential supplier of green iron to South Korea and Japan is not guaranteed by resource endowments and existing trade relationships alone. As this report demonstrates, domestic green steel production in East Asia could approach cost competitiveness under favorable hydrogen cost and policy conditions by 2035. Australia's opportunity to establish itself as the preferred supplier of green iron to East Asian markets is therefore time-bound.

This highlights the importance of accelerating the transition to green hydrogen-based direct reduction for Australia. While gas-based DRI is often presented as a transitional pathway, it is unlikely to satisfy the emissions requirements associated with emerging green steel standards and does not provide importing countries with a credible pathway for deep industrial decarbonization. Continued reliance on gas-based DRI may therefore delay the development of long-term market relationships for genuinely low-emission iron products.

The strategic risk is not that domestic production in South Korea and Japan will immediately replace imports, but that delays in commercializing green H_2-DRI could reduce Australia's window of opportunity to establish itself as the preferred supplier of green iron while importing countries continue to strengthen their own domestic production capabilities. Early investment in green hydrogen-based iron production is therefore essential for Australia to develop a new export value in green iron and secure a long-term position in the Australia-East Asia green iron trade corridor.

Appendix

A.1 CAPEX and Energy Scenarios (2035)

[Table A1] Energy & Storage CAPEX scenarios

Technology	SK				JP				AUS			
	2025	Low	Base	High	2025	Low	Base	High	2025	Low	Base	High
Solar PV ($/kW)	1262	704	912	1137	1911	851	1075	1674	944	363	450	551
Onshore Wind ($/kW)	2615	808	1111	1200	2891	2105	2314	2376	1381	952	972	1014
Battery (6-hr, $/kWh)	270	127	183	216	270	127	183	216	270	127	183	216
Electrolyzer ($/kW)	1200	450	698	979	1361	364	792	1110	1470	688	855	1199
H_2 Storage ($/kg)	700	400	500	600	700	400	500	600	700	400	500	600

Solar PV and Onshore wind: CAPEX for solar PV and onshore wind in 2025 are derived from IRENA for SK, JP, and Australia. The CAPEX for solar PV and onshore wind for 2035 are derived from Lawrence Berkeley National Lab's (LBNL's) projection for SK[17] and JP[18]. Australia 2035 data reflect the cost reduction (2035 vs. 2025) in CSIRO GenCost[19].

Battery Storage: CAPEX of battery storage (6-hr) for 2025 and 2035 are derived from CSIRO GenCost and applied to all the regions.

Electrolyzer (Alkaline): To establish a baseline, current (2025) prices for alkaline electrolysis are estimated at $1,361/kW in JP and $1,733/kW in AUS based on S&P Global market data[20]. SK is estimated slightly lower at $1,200/kW. For 2035 projections:

- **AUS (All Scenarios)**: Costs are derived directly from the cost-reduction curves in the CSIRO GenCost report.
- **SK & JP (Base & High)**: The proportional cost-reduction trajectory from the CSIRO report is applied to the respective 2025 baselines for SK and JP to derive the Base and High scenario costs.

17 Lawrence Berlkeley National Lab. (2023). *A Clean Energy Korea by 2035*
18 Lawrence Berlkeley National Lab. (2023). *The 2035 Japan Report*
19 CSIRO.(2026) *GenCost: cost of building Australia's future electricity needs*
20 Platts.(2026) *Methodology and Specifications Guide Global Hydrogen & Ammonia*

- **SK & JP (Low)**: The Low scenario assumes the successful realization of aggressive domestic policy targets. For JP, this reflects the NEDO Green Innovation Fund estimate of $364/kW (56,510 JPY/kW)[21] required to achieve Japan's Net Zero goals. For SK, the $450/kW estimate reflects the required CAPEX to support the 3,500 KRW/kg-H2 target outlined in South Korea's Hydrogen Economy Roadmap.[22]

H_2 Storage (Compressed Gas): Standardized across all regions.

[Table A1.2] Grid price and emission scenarios

Grid	SK			JP			AUS		
	Low	Base	High	Low	Base	High	Low	Base	High
Price change (2035 vs. 2025)	-5%	0%	+4.4%	-7.5%	-5%	+2.6%	-5%	0%	5%
Price 2035 ($/kWh)	0.116	0.122	0.128	0.136	0.140	0.151	0.239	0.252	0.265
Emission Intensity ($kgCO_2e$/MWh)	55	113	305	36	109	141	2	24	68

Electricity Price: 2025 baseline prices are $0.252/kWh for AUS, $0.122/kWh for SK, and $0.147/kWh for JP. We use projected change relative to 2025 to derive 2035 grid price.

- **SK & JP Scenarios**: The Low, Base, and High scenarios correspond to the "Low RE and Storage", "Base", and "High RE and Storage" pathways, respectively, as modeled in the LBNL 2035 Reports.
- **AUS Scenarios**: Due to a lack of publicly available long-term grid price projections for the region, we assume a 0.5% annual decrease, a 0% change, and a 0.5% annual increase for the Low, Base, and High scenarios, respectively. Note that this variance has a minimal impact on the final LCOS, as the AUS pathway relies predominantly on captive onsite renewable generation.

Grid Emission Intensity

- **JP Scenarios**: The Low scenario utilizes the "Clean Energy" pathway in LBNL 2035 report, the Base scenario uses projection data from the Japan Renewable Energy Institute (REI), and the High scenario aligns with the stated targets in Japan's Strategic Energy Plan (also corresponding to the "Current Policy" pathway in LBNL 2035 report).

21 NEDO. *Hydrogen Production through Water Electrolysis Using Power from Renewables*
22 Government of the Republic of Korea. (2019). *Hydrogen Economy Map of Korea*

- **KR Scenarios**: The Low and High scenario aligns with the "Clean Energy" and "Current Policy" pathways in LBNL report. The Base scenario is linearly interpolated between these two bounds.
- **AUS Scenarios**: Emission intensities reflect the projected grid emission pathways for the National Electricity Market (NEM) as outlined by CSIRO.[23]

A.2 Levelized Cost of Steel (LCOS) Framework

The economic feasibility of green H_2DRI routes were evaluated using a bottom-up techno-economic assessment model developed by Transition Asia. The model is grounded in mass and energy balances for each process route, derived from standard engineering parameters. The resulting Levelized Cost of Steel (LCOS) represents the breakeven price required to recover all capital and operational expenditures (CAPEX and OPEX) over the plant's lifetime.

$$\mathrm{LCOS_{year}} = \frac{(\mathrm{CAPEX} \times \mathrm{CRF}) + \mathrm{OPEX_{Fixed}}}{\text{Capacity Factor}} + \mathrm{OPEX_{Variable}}$$

- **CRF (Capital Recovery Factor)**: Function of Weighted Average Cost of Capital (WACC) and project lifetime. WACC assumptions: SK (6.0%), JP (4.8%), AUS (5.2%).
- **Capacity Factor**: Assumed at 90% for the steel plant.

23 Open Electricity. *Scenarios*

A.3 Iron Ore, Hydrogen, Commodity & Logistics Inputs

[Table A3.1] Iron Ore and H_2 Input Parameters

Variable	JP	SK	AUS
Source	Brazil	Australia	
Ore Grade	67.0% Fe Magnetite DR-grade Pellets	57.8% Fe Hematite Fines	
Ore Input (t/tcs)	1.2504	1.8936	
Scrap Input (t/tcs)	0.162	0	0
Ore Price ($/t)	$163	$76	$63
H2 input (kg/tDRI)	55	63	60

※ **Note**: Ore input: calculated based on grade and DRI technology.
Ore pricing: Baseline prices are derived from Wood Mackenzie's 2035 projections.[24]

※ Hydrogen input: Hydrogen input scales with ore quality and DRI technology. Japan's SF pathway utilizing high-grade DR pellets requires a standard 55 kg/t-DRI. In AUS, processing lower-grade hematite (beneficiated to ~62% Fe prior to pelletization) in the SF increases the requirement to 60 kg/t-DRI. SK's FB pathway requires the highest hydrogen input (63 kg/t-DRI) as direct reduction of unpelletized, low-grade fines (from Australia, $13/t more expensive than Australia domestically) necessitates a high hydrogen-to-ore ratio to maintain proper fluidization.

[Table A3.2] Shipping & Logistics

Route	Distance[25] (miles)	Transit (Days)	Emission intensity (gCO_2e/t-mile)	Freight Cost ($/dmt)	Emission (tCO_2e/dmt)
AUS → SK	3,484	14.5	3.95	13.05	0.0138
AUS → JP	3,454	14.4	5.14	12.96	0.0177
Brazil → JP	11,145	42	5.14	24	0.0573

※ **Note**: SK/JP freight rates estimated based on SGX Jan 2026 KR C5 Route benchmark[26] (Capsize, 10 days, $9/dmt) and Brazil-JP freight rates estimated based on C3 Route (Capsize, 42 days, $24/dmt) benchmark. The shipping emission intensity (2035 WTW) of SK is an average of 2035 target emission factors of Pan Ocean and HMM, and that of JP is an average of MOL and K-Line. Port charges in AUS (Port Hedland) are estimated at $2.82/t (~4 A$/t[27]). A 1.5% material loss is assumed during transit. The transit days are calculated based on Port Hedland-Pohang and Port Hedland-Yawata for AUS-SK and AUS-JP respectively, used for rescaling the freight cost and emission.

24 Wood Mackenzie. (2024) *Global iron ore strategic planning outlook*
25 Sea-Distances.org. *sea-distances.org*
26 Singapore Exchange (SGX). *Dry Bulk Voyage Routes*
27 Pilbara Ports. (2026) *Schedule of Port Charges*

[Table A3.3] **Baseline Commodity Prices ($/Unit, 2025 Price)**

Item	JP	SK	AUS
Low-Grade Fines (/t)	-	76	63
DR-Grade Pellet (/t)	163	-	-
Scrap (/t)	308	324	-
Burnt Lime (/t)	35	35	35
Natural Gas (/MMBtu)	12.9	14.0	9.0
Oxygen (/Nm3)	0.14	0.14	0.10
Ferroalloys (/t)	1,511	1,500	-
Refractories (/t)	1,050	1,050	1,050
Electrode (/t)	2,500	2,500	2500
Water (/t)	0.68	0.68	0.68
Labor (/hr)	27.7	23.5	39.4

A.4 Technology & Operational Parameters

[Table A4.1] **Parameters of renewable and hydrogen technologies**

Technology	Lifetime (yr)	Efficiency	Fixed O&M (% of CAPEX)
Onshore Wind	30[29]	99%	2.0%[29]
Solar PV	30[29]	99%	2.0%[29]
Alkaline Electrolyzer	10[30]	70%[28]	3.0%[30]
Li-ion Battery (6-hr)	15[29]	90%[29]	2.0%[29]
H_2 Storage	35	90%	1.0%

28 U.S. Department of Energy. *Technical Targets for Liquid Alkaline Electrolysis*
29 IRENA (2025) *Renewable power generation costs in 2025.*
30 CSIRO.(2026) *GenCost: cost of building Australia's future electricity needs*

[Table A4.2] Parameters of iron and steelmaking technologies

Technology (Unit)	Lifetime (yr)	CAPEX ($)	Fixed O&M (% of CAPEX)	Electricity Consumption (kWh/Unit)	Labor (hr)
Pellet Plant (/t-Pellet)	25	208	4.0%	65	0.06
Beneficiation Plant (/t-Fines)	25	62	5.0%	60	0.02
DRI-SF (/t-DRI)	25	337	3.0%	685	0.15
DRI-FB (/t-DRI)	25	327	3.0%	715	0.30
EAF (/tcs)	25	294	3.0%	404	0.47
ESF (/tPI)	25	294	3.0%	548 for cold PI and 475 for hot PI	0.47
BOF (/tcs)	25	0 (Brownfield)	$3.7/tpa	0	0.47

A.5 Emission Intensity

[Table A5.1] Emission intensity

Item (Unit)	Emission Intensity (tCO_2e/Unit)
Water (/kg)	0.0003
Refractories (/t)	3.0000
Electrode (/t)	0.7800
Oxygen (/kNm^3)	0.4260
Burnt Lime (/t)	0.0050
Ferroalloys (/t)	2.1860
Scrap (/t)	0.0000
Ore Mining (/t)	0.0250
DR-grade Pellets (/t)	0.0520
Natural Gas (/MMBtu)	0.0297

※ **Note**: The DR-grade pellet's emission intensity is reported by Vale. Other emission intensities are sourced from Responsible Steel default values.

References

- World Steel Association. (2024). *World Steel in Figures 2024*
- OECD. (2025). *Hydrogen in steel: Addressing emissions and dealing with overcapacity*
- UNIDO. (2025). *Iron and Steel: What is the State of Decarbonization Technologies?*
- SteelWatch. (2025). *Why Green Iron Trade Will Catalyse Steel Industry Decarbonisation*
- S. Bilici, et al. (2024). *Global trade of green iron as a game changer for a near-zero global steel industry? - A scenario-based assessment of regionalized impacts*
- OECD. (2025). *Green Iron opportunities in Australia: A case study within the OECD's Global Green Iron project*
- World Economic Forum. (2025). *Unlocking Asia-Pacific as a First Mover: Australia's Green Iron Opportunity*
- Global Energy Monitor. *POSCO Port Hedland Iron Project - Global Energy Monitor*
- Agora Industry (2025). *The role of green iron trade in accelerating competitive steel transformation*.
- RMI. (2024). *Green Iron Corridors: Transforming Steel Supply Chains for a Sustainable Future*.
- IEEFA. (2025). *South Australia: Long-term reliance on gas for iron and steelmaking faces significant risks*
- ResponsibleSteel. *https://www.responsiblesteel.org/resource-hub/standards-certification-and-assurance*
- Lawrence Berlkeley National Lab. (2023). *A Clean Energy Korea by 2035*
- Lawrence Berlkeley National Lab. (2023). *The 2035 Japan Report*
- CSIRO. (2026). *GenCost: cost of building Australia's future electricity needs*
- Platts. (2026). *Methodology and Specifications Guide Global Hydrogen & Ammonia*
- NEDO. *Hydrogen Production through Water Electrolysis Using Power from Renewables | NEDO Green Innovation Fund Projects*
- Government of the Republic of Korea. (2019). *Hydrogen Economy Roadmap of Korea*.
- Open Electricity. *Scenarios*
- Wood Mackenzie. (2024). *Global Iron ore strategic planning outlook*
- Sea-Distances.org. *sea-distances.org*
- Singapore Exchange (SGX). *Dry Bulk Voyage Routes*
- Pilbara Ports. (2026). *Schedule of Port Charges*
- U.S. Department of Energy. *Technical Targets for Liquid Alkaline Electrolysis*
- IRENA (2025). *Renewable power generation costs in 2025*

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.