Green Steel Economics

South Korea Factsheet

Introduction

The global steel industry accounted for over 7% of global greenhouse gas (GHG) emissions and over 11% of global CO_2 emissions. South Korea ranks 7th in terms of crude steel production. The Hydrogen Direct Reduced Iron (H_2-DRI) process utilizing green hydrogen made with renewable/ no-carbon electricity promises significant emission reductions and a transition to greener steel production in the sector. The adoption of green H_2-DRI-EAF steelmaking involves financial considerations varying by country, influenced by hydrogen costs and carbon pricing mechanisms. This study assesses the costs of green H_2-DRI-EAF steelmaking compared to traditional Blast Furnace-Basic Oxygen Furnace (BF-BOF) and Natural Gas Direct Reduced Iron-Electric Arc Furnace (NG-DRI-EAF) routes across seven major steel-producing countries, including South Korea.

Green Steel Premium across H_2 Prices and the Impact of Carbon Prices in South Korea

In South Korea, the analysis for steel production costs reveals varying costs across different carbon pricing scenarios and H_2 prices. With no carbon price, the green H_2-DRI-EAF method starts at $621 per ton of steel at $1/kg H_2, slightly above the BF-BOF cost of $605. South Korea is the only country among the seven countries studied where even at $1/kg H_2, the LCOS for green H_2-DRI-EAF remains above that of the BF-BOF route. This is partly because of high price of renewable electricity in South Korea. However, as carbon pricing is introduced, the competitiveness of green H_2-DRI-EAF increases. At a carbon price of $15 per ton of CO_2, the cost for green H_2-DRI-EAF drops to $596 per ton at $1/kg H_2, already offering savings over BF-BOF. This trend strengthens with higher carbon prices: at $30 and $50 per ton of CO_2, the costs for green H_2-DRI-EAF reduce further to $571 and $537 per ton at $1/kg H_2 price, underscoring substantial cost reduction compared to the BF-BOF process. With carbon prices at $50 per ton of CO_2, green H_2-DRI-EAF reaches cost-parity with BF-BOF at slightly above $2/kg H_2.

South Korea's largest steel company, POSCO, is developing its own green H_2-DRI steelmaking process, branded as HyREX. Instead of a shaft furnace used in conventional DRI technology, HyREX utilizes a fluidized reduction method, where high-temperature reduction gases are evenly dispersed through a distributor plate at the bottom of the reactor, causing powdered iron ore to float and mix, facilitating the reduction reaction. The HyREX technology allows the use of BF-grade iron ore without the need for prior processing into higher-grade pellets, which is a common requirement in H_2-DRI technology using a shaft furnace. Additionally, the system is being designed to optimize heat supply, essential for maintaining the reduction reaction, by allowing temperature control across multiple reactors, enhancing the efficiency of the process. POSCO plans for industrial scale construction of a HyREX plant in 2030s (POSCO, 2024).

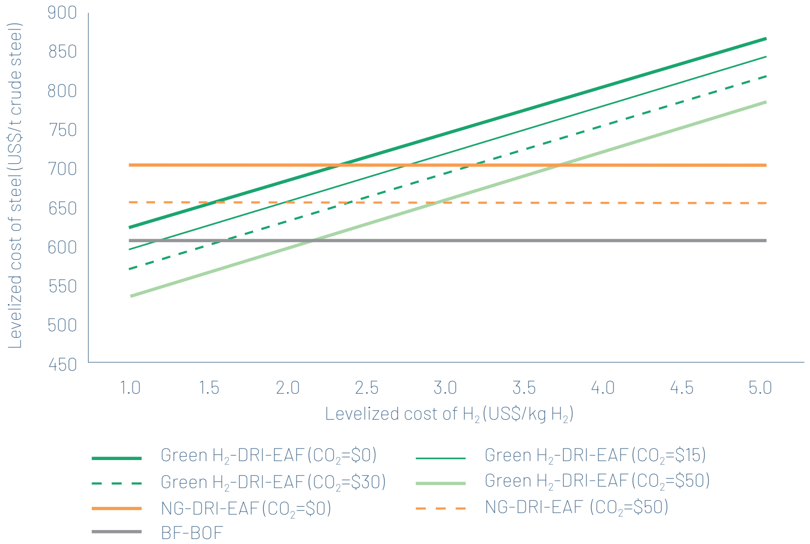


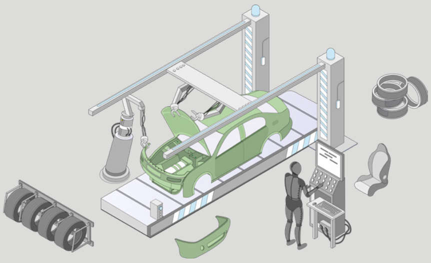
*Figure 1. Levelized Cost of Steel ($/t crude steel) with varied levelized costs of H_2 at different carbon prices in **South Korea** (Source: this study)*

Notes: Assumed 5% steel scrap is assumed to be used in both BF-BOF and DRI route.

Impact of Green Steel Premium on Car Prices

<1%

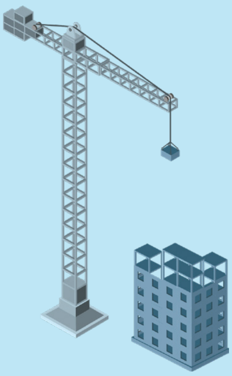
price increase on an average price of passenger car in South Korea



The automotive industry accounts for 12% of global steel demand. The additional cost attributed to using green H_2-DRI-EAF steel in passenger vehicles—known as the green premium—is aligned with studies that estimated automotive sector as a likely first mover for green steel procurement and demonstrates minimal impact on overall vehicle pricing. For example, in South Korea, when the price of H_2 is at $5/kg, the green premium for steel produced via green H_2-DRI-EAF, compared to the traditional BF-BOF methods, stands at approximately $263 per ton steel. Assuming on average 0.9 ton of steel used in a passenger car, this translates to an additional cost of about $237 per passenger car, which represents a less than 1% price increase on an average price of passenger car in South Korea ($22,000), maintaining affordability and market stability. Future projections suggest that with H_2 costs potentially reducing to below $1/kg, the green premium could effectively disappear, making green H_2-DRI-EAF steel economically comparable to conventionally produced steel. With the introduction of carbon price/credit, the green premium for H_2-DRI-EAF steel can substantially drop even further.

Impact of Green Steel Premium on Building Construction Cost

The construction industry (building and infrastructure) accounts for 52% of global steel demand. In the context of building construction in South Korea, the economic effect of adopting green steel produced by H_2-DRI-EAF route can be considered minimal when compared to conventional BF-BOF steelmaking route. Using the green H_2-DRI-EAF route, the additional cost of steel at a H_2 price of $5/kg is approximately $263 per ton of steel, translating into an added expense of about $658 for a 50 m^2 residential building unit (assuming 50 kg steel per m^2 used for low to mid-rise residential building). This represents a small fraction of the total cost of a residential building. In addition, with future reductions in H_2 cost or the introduction of carbon pricing, the green premium could diminish or even disappear, making green H_2-DRI-EAF an economically viable alternative for building construction in South Korea.



small added expense of about

$658

for a

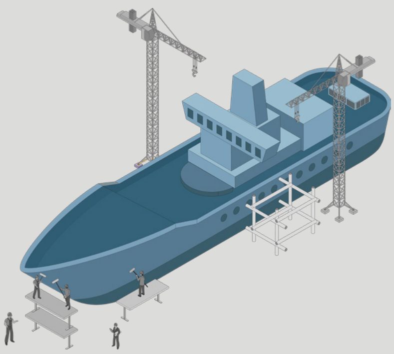
50 m^2

residential building unit

Impact of Green Steel Premium on Shipbuilding Cost

~11%

increase in the ship's price for South Korea



The top three shipbuilding nations, China, South Korea, and Japan, account for over 90% of global shipbuilding. Incorporating green H_2-DRI-EAF steel into shipbuilding shows a small cost increase for ship building. While there are many types of ships in the global market. This study focused on bulk carrier ships which are built in large numbers every year around the world. For example, to build an average 40,000 DWT (Deadweight tonnage) bulk ship, approximately 13,200 tons of steel are needed. If green H_2-DRI-EAF at $5/kg H_2 is used in South Korea to build this ship, the additional cost would be about $ 3.5 million per ship. Considering the average cost of a new 40,000 DWT bulk ship is over $30 million, this represents around 11% increase in the ship's price for South Korea.

The reason for this relatively higher green steel premium as a share of total cost for shipbuilding compared to cars and buildings is higher share of steel cost in the shipbuilding cost. Over 95% of a ship consists of steel. Anticipated reductions in H_2 costs in the future could nullify this green premium, aligning the costs of green H_2-DRI-EAF steel with those of traditional BF-BOF steelmaking. Moreover, the introduction of carbon pricing could further reduce the green premium costs, enhancing the financial attractiveness of adopting green H_2-DRI-EAF steel in the maritime sector.

Our Recommendations

Financing the transition to H_2-DRI steelmaking requires both public and private investments to mitigate financial risks. Our recommendations for stakeholders include:

Government:

- Enact tax rebates and other incentives for green H_2 production to make it more economically viable.
- Invest in R&D and infrastructure to drive down the costs of green hydrogen production.
- Implement public procurement policies that prioritize green steel in publicly funded projects to boost market demand.
- Provide enabling policy support to develop a renewable energy infrastructure needed for green H_2 production.

Steel Companies:

- Transition from traditional BF-BOF routes to green H_2-DRI by forming partnerships for a reliable hydrogen supply.
- Engage in industrial-scale pilot projects to demonstrate the feasibility and benefits of green H_2-DRI.
- Secure market demand through long-term supply agreements with major end-use sectors and share the costs of the green premium.

Automotive and Construction Companies:

- Integrate green steel into procurement strategies to stimulate demand and help cover the green premium.
- Enhance market positioning by promoting the climate, environmental, and health benefits of green steel.
- Cater to climate-conscious clients by engaging in green private procurement practices.

Shipbuilding and Shipping Companies:

- Utilize both public and private procurement strategies to boost the adoption of green steel in the industry.
- Establish robust supply chains with green H_2-DRI steel manufacturers to ensure a steady demand for green steel.
- Promote broader industry adoption through government policies and commercial agreements to reduce the green premium.

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Download the full report from https://transitionasia.org/green-steel-economics

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