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Report

Government Financing for H_2-DRI Commercialization

Comparative Risk-Sharing Cases and Implications for Korea

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Comparative Risk-Sharing Cases and Implications for Korea

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Design **sometype**

Solutions for Our Climate(SFOC) is an independent policy research and advocacy group that aims to make emissions trajectories across Asia compatible with the Paris Agreement 1.5°C warming target.

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* Exchange rate basis: 1 USD = 1,400 KRW = 0.9 EUR = 9 SEK.

1. Introduction

1) Hydrogen-Based Direct Reduced Iron (H_2-DRI): A Strategic Pathway for Decarbonizing Korea's Steel Industry

Steel decarbonization is no longer solely a matter of technological development. The focus of global competition is shifting toward establishing a commercially viable system that includes production facilities, energy supply, financing, and regulations. The European Union is leading the low-carbon steel market through the introduction of the Carbon Border Adjustment Mechanism (CBAM) and the formation of a green steel market. Japan and the United States also regard steel decarbonization as central to industrial competitiveness and supply-chain resilience and are expanding policy and financial support to enable the commercialization of low-carbon production methods. In this context, global competition is no longer centered on low-carbon technology development, but on the speed and execution of commercialization.

Korea is particularly exposed to these changes, with over 70% of steel production relying on blast furnace-based processes. Based on 2024 provisional emissions data, the steel sector accounts for approximately 15% of national greenhouse gas emissions,[1] while 13.5% of domestic steel exports are destined for the European Union. Although certain emissions reductions can be achieved through process improvements such as increased scrap use or mixed production using blast furnaces and electric arc furnaces (EAF), their mitigation potential remains limited under tightening international carbon regulations and Korea's 2050 carbon neutrality target. A transition to hydrogen-based direct reduced iron (H_2-DRI) therefore represents the most fundamental pathway to reducing emissions across the entire steel production process. The timing of this transition will be a decisive factor in shaping the future competitiveness of the steel industry.

Major global steelmakers have already begun constructing large-scale commercial facilities to deploy H_2-DRI technologies, which can replace blast furnace-based ironmaking. H_2-DRI uses hydrogen instead of coal as a reducing agent to reduce iron ore, emitting water rather than large amounts of carbon dioxide. When supplied with green hydrogen produced using renewable electricity, H_2-DRI can eliminate most direct emissions from the steel production process, positioning it as a core technology for steel decarbonization.

1 Ministry of Environment Greenhouse Gas Information Center (2025)

2) Characteristics of Korea's H_2-DRI (HyREX) Technology and Commercialization Challenges

Korean steelmakers are responding to this global trend by developing their own H_2-DRI technology, known as HyREX. While most H_2-DRI projects adopt shaft furnace-based reduction technologies, HyREX utilizes a fluidized bed reduction furnace. As a result, HyREX does not require a separate pelletizing process and has a lower reliance on high-grade iron ore.

However, the technological transition to H_2-DRI cannot be achieved through process modification alone. Unlike the blast furnace process, in which coal functions as both a reducing agent and a heat source, H_2-DRI is designed as an integrated system that combines hydrogen-based reduction with electricity-intensive downstream processing. Accordingly, large-scale supplies of green hydrogen and clean electricity are required, making commercialization a complex industrial transition that extends far beyond simple equipment replacement.

Commercializing H_2-DRI therefore requires stable access to economically viable green hydrogen, large-scale clean power infrastructure, substantial upfront capital investment supported by long-term financing structures, and mechanisms to share technical and market risks during facility conversion. Even with strong technological potential, the absence of these conditions makes it difficult to advance to commercial-scale facilities. Under such circumstances, the technological advantages of Korea's H_2-DRI cannot translate into actual market competitiveness.

Unlike major steelmakers that have already begun converting existing facilities or constructing commercial-scale shaft furnace-based H_2-DRI plants, Korea's H_2-DRI remains at the technology demonstration stage. This gap reflects not a limitation in technological capability, but a delay in aligning policy preparation with commercialization. Advancing H_2-DRI therefore requires the parallel preparation of large-scale facility investment, infrastructure development, and a financial and policy environment capable of absorbing early-stage market uncertainty.

3) Research Direction: The Funding Gap in H_2-DRI Commercialization

This study examines Korea's readiness for H_2-DRI commercialization, focusing on the current state of domestic policy, fiscal, and financial frameworks supporting the country's transition from demonstration to commercial deployment. While Korea has provided limited support for the research, development, and demonstration stages of H_2-DRI, the policy and financial architecture required for the commercial-scale facility construction and conversion phase—where large-scale capital investment is unavoidable—remains largely absent. In particular, there is no clearly defined framework for mobilizing financial support mechanisms or transition finance capable of sharing early-stage investment risks associated with commercial-scale H_2-DRI facilities. As a result, even when demonstration projects reach commercialization decision points, the institutional foundation necessary to translate technological progress into actual facility investment remains insufficient.

Against this backdrop, this report reviews the current status of domestic support for H_2-DRI and conducts a comparative analysis of financial and policy support frameworks implemented by major steel-producing countries' governments that have pursued steel process conversion based on the construction of new commercial facilities and the phased closure of existing ones. Based on this analysis, the report assesses the financial burdens and risk factors Korea is likely to face during the commercial facility construction phase and highlights the need for a coherent, national-level support system to address these challenges.

2. Current Status and Limitations of Korea's Government Support for H_2-DRI

1) Current Status of Government Support for H_2-DRI in Korea

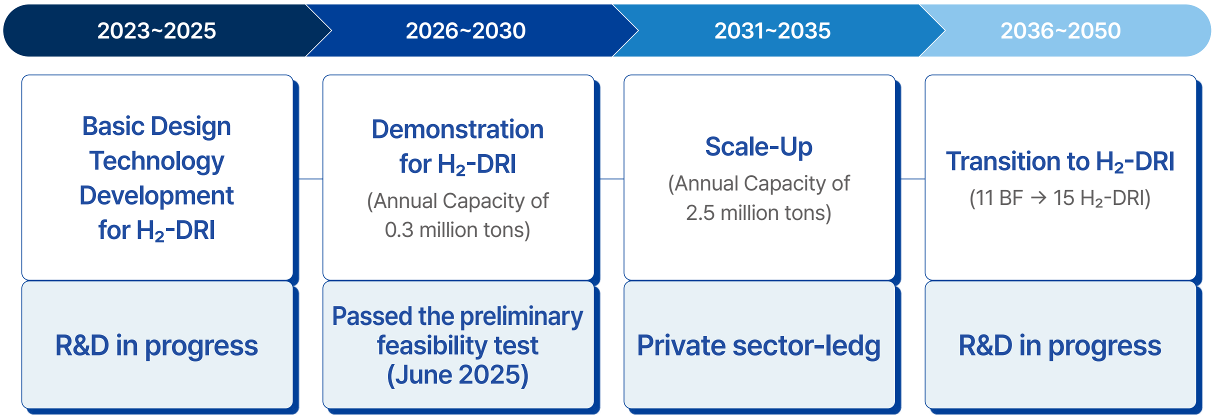
H_2-DRI is a capital-intensive industrial transition. It requires substantial upfront investment and entails sunk costs associated with the closure of existing blast furnaces. As a result, commercialization is difficult without government fiscal and financial intervention. Despite this, Korea currently lacks a support framework explicitly designed around the commercialization of H_2-DRI.

Since 2022, the government has taken steps to support technology demonstration through various policies and programs. However, these measures remain largely confined to the demonstration phase, and concrete support plans for full-scale commercial facility conversion have yet to be established. Between 2022 and 2025, the government allocated USD 149.8 million (KRW 209.7 billion) in R&D funding to the steel sector under the Carbon Neutrality Core Technology Development Project. Of this amount, only USD 19.2 million (KRW 26.9 billion) was directed toward core H_2-DRI technologies, limiting the scale of support.[2] Policy measures introduced thereafter—including the designation of H_2-DRI as a National Strategic Technology in January 2024 and its inclusion in the Fast Track Program in October 2024—provided tax incentives and procedural streamlining. However, these measures have had only a limited impact on addressing commercialization-related investment risks.

In June 2025, Korea's H_2-DRI demonstration project passed the preliminary feasibility study and entered the full-scale demonstration stage. The total confirmed project cost is USD 581.9 million (KRW 814.6 billion), comprising USD 220.6 million (KRW 308.8 billion) in government funding and USD 361.3 million (KRW 505.8 billion) in private investment. The project aims to build a demonstration plant with an annual capacity of 300,000 tons in Pohang between 2026 and 2030. While this facility is intended to verify the technical feasibility of Korea's H_2-DRI technology at demonstration scale, it does not constitute a commitment to commercial deployment or large-scale facility conversion.

2 Yeongmin Kweon(2024)

[Figure 1] H_2-DRI Transition Roadmap



Source: Plan for the Advancement of the Steel Industry (2025, Jointly Prepared by Relevant Ministries)

In November 2025, the Korean government announced the Steel Industry Advancement Plan, outlining its approach to maintaining industrial competitiveness while advancing the steel sector's low-carbon transition. According to the roadmap, the government envisions scaling up H_2-DRI annual production capacity to 2.5 million tons between 2031 and 2035, followed by the conversion of 11 existing blast furnaces into 15 H_2-DRI facilities between 2036 and 2050. However, for the post-2031 scale-up and commercialization phase, the plan explicitly characterizes implementation as "private sector–led," without specifying concrete government support measures. The plan acknowledges the need for public support to address financing challenges that the private sector cannot resolve independently and refers to the establishment of a legal basis for such support under the proposed K-Steel Act. At the same time, by formally designating the commercialization phase as private sector–led, the government stops short of committing to clearly defined responsibilities for sharing investment risks or providing concrete financial support. In the absence of concrete public support for the post-demonstration phase, firms are likely to adopt a cautious investment posture, delaying large-scale commitments until technological and cost uncertainties are reduced. Such delays in commercial facility construction would increase the risk of Korea falling behind in the global race to commercialize H_2-DRI.

2) The Beginning of Policy Change: The K-Steel Act and K-GX

H_2-DRI is an industrial transition task that requires technological development to proceed in parallel with transition planning and financial design for commercial-scale facility conversion. In 2025, following the successful completion of the preliminary feasibility study for H_2-DRI technology demonstration project and the announcement of the Steel Industry Advancement Plan, the Korean government began to establish policy foundations for low-carbon transition across institutional and financial frameworks. Key developments during this period included the enactment of the K-Steel Act and the initiation of policy discussions on transition finance under the K-GX framework (K-Green Transformation Promotion Strategy).

However, current policy discussions remain at an early stage. Concrete designs for fiscal and financial support, infrastructure preparation, and other elements essential for commercial facility conversion have not yet been presented. As a result, even if technology demonstration is completed by 2031, the domestic policy framework required to directly link demonstration outcomes to commercial facility conversion is unlikely to be sufficiently established, creating a high risk of delays in the transition. With international competition surrounding the commercialization of H_2-DRI already underway, securing the pace of transition for Korea's steel industry urgently requires preemptive and concrete designs for financial support and policy infrastructure premised on commercial deployment.

The Special Act on Strengthening the Competitiveness of the Steel Industry and Transition to Carbon Neutrality, commonly referred to as the K-Steel Act, was proposed in August 2025, passed the National Assembly plenary session in November 2025, and is scheduled to enter into force in June 2026. As the first government-level legislation to define the steel industry's low-carbon transition within an independent legal framework, the Act formalizes the need for structural transformation and government support for low-carbon steel production and related technologies. Article 11, Paragraph 1 authorizes government support for the development of H_2-DRI technologies and the introduction of related facilities. In addition, Articles 15 and 16 provide a basis for supporting low-carbon steel production and investment plans developed through inter-company cooperation by identifying low-carbon steel collaboration models, thereby establishing an institutional framework to support private-sector-led transition.

At the same time, the K-Steel Act does not specify how the government will share the initial investment costs and associated risks that constitute the most significant burden in the conversion to H_2-DRI facilities. Substantive support measures are deferred to subordinate regulations and subsequent policy design. As a result, the enactment of the Act alone remains insufficient to provide the level of clarity required to meaningfully support investment decisions by firms preparing for commercial facility conversion.

In parallel, discussions on transition finance aimed at accelerating industrial transition have gained momentum. As a follow-up to the establishment of the 2035 Nationally Determined Contribution, the government has indicated that it plans to formulate and announce the K-GX framework within the first half of 2026. K-GX is intended to identify key transition tasks across sectors—including power, industry, transport, and buildings—and to provide integrated support through fiscal, financial, tax, and institutional measures. Within this framework, transition finance is positioned as a financial mechanism to support emissions-intensive industries with substantial mitigation potential through process conversion, such as steel, cement, and chemicals. Notably, the industrial sector strategy under K-GX explicitly includes H_2-DRI demonstration and commercialization, indicating that a state-led transition finance support plan for the steel sector is expected to be announced within the first half of 2026.[3]

Against this backdrop, government support plans for the steel industry must clearly define application criteria, the scale of support, and the manner in which such support will be applied to large-scale facility conversion projects such as H_2-DRI. Most importantly, policy design must explicitly address how substantial upfront investment costs and long-term technological and market risks associated with commercial facility conversion will be shared. Without a clearly articulated risk-sharing structure, the transition framework will remain incomplete, limiting its ability to mobilize private investment and effectively support the shift to commercial-scale deployment.

3 Presidential Committee on Carbon Neutrality and Green Growth(2025)

3) Limitations of Government Support: Structural Gap in the Commercialization Transition Phase

The core limitation of Korea's current approach lies in the absence of concrete fiscal and financial designs explicitly premised on commercial-scale transition. Against the backdrop of a rapidly changing global industrial environment, the urgency of restructuring the steel industry, and the Ministry of Trade, Industry and Resources(MoTIR)'s stated objective of replacing 11 blast furnaces with 15 H_2-DRI facilities, the existing policy framework alone cannot ensure the pace of transition required. Korea is now at a critical policy juncture, as it prepares subordinate regulations under the K-Steel Act and develops concrete implementation plans for K-GX. If these processes proceed without fiscal and financial designs tailored to the post-demonstration, commercial transition phase, Korea's H_2-DRI pathway risks breaking between demonstration and commercial-scale deployment. This would constitute a case of policy failure, in which technological progress fails to translate into actual industrial transformation due to insufficient policy design.

[Table 1] Estimated Industrial Transition Costs by H_2-DRI Transition Scenarios

Transition Pathway		*Adoption Level by Period (%)			**Estimated Costs (USD billion)				GHG Reduction (2050 baseline)
		30	40	50	Facility CAPEX	Stranded assets	R&D	Total	
Korean H_2-DRI	High	–	10	100	26.8	6.0	1.0	**33.8**	95.1%
	Medium	–	5	72	19.3	4.3	1.0	24.6	68.5%
	Low	–	–	48	12.9	2.9	0.9	16.7	45.6%

* Assumes replacement of 11 blast furnaces with 15 H_2-DRI facilities (KRW 2.5 trillion per 2.5 million tons facility), Adoption levels (30/40/50%) indicate the share of blast furnace capacity converted by period.

** Costs are converted into USD using assumed exchange rate of 1 USD = 1,400 KRW.

Source: Ministry of Trade, Industry and Resource(MoTIR), Preliminary Feasibility Study Request for the Korean H_2-DRI Demonstration Technology Development Project (September 2024)

According to the preliminary feasibility study request submitted by the MoTIR, the total cost required to achieve the government's target of converting 11 blast furnaces into 15 H_2-DRI facilities by 2050 is estimated at USD 33.8 billion (KRW 47.3 trillion). Of this amount, USD 26.8 billion (KRW 37.5 trillion) is attributable solely to capital expenditure for new facility construction. When sunk costs associated with dismantling existing blast furnaces and additional research and development expenditures are taken into account, the overall transition costs increase further. While commercial conversion to Korea's H_2-DRI entails substantial upfront investment and significant technological and market uncertainty, its benefits extend beyond individual firms, generating broader spillover effects across the industry and the national economy. In this context, leaving commercialization entirely to private-sector initiative is likely to delay the transition timeline and increase the overall social costs of industrial restructuring. Government support at this stage should therefore be understood not as market distortion, but as a necessary mechanism for maximizing social benefits.

Empirical analyses of steel industry transition pathways reinforce this assessment. Socio-economic impact studies indicate that, even under the same 2050 carbon neutrality target, scenarios involving early closure of blast furnaces and accelerated transition to H_2-DRI generate cumulative production-inducing effects more than 2.4 times greater than scenarios without such early action.[4] In other words, an early and coordinated push toward H_2-DRI can accelerate industrial restructuring beyond the deployment of individual facilities, delivering broader socio-economic benefits to local communities and strengthening national competitiveness.

Despite this, Korea currently lacks a comprehensive support system for the post-demonstration commercialization phase. Concrete institutional mechanisms to support large-scale facility investment, market formation, and infrastructure development remain largely absent. By contrast, major steel-producing countries have positioned the construction of commercial-scale H_2-DRI facilities as the central pillar of their industrial transition strategies. Through combinations of large-scale subsidies, policy finance, and tax incentives, these countries have established frameworks in which the state explicitly shares early-stage risks with the private sector. This divergence in policy approaches is widening the gap between Korea and leading countries in terms of commercial deployment and early market formation for H_2-DRI.

The following chapter examines the specific policy and financial support mechanisms adopted by major steel-producing countries to enable the construction and operation of commercial-scale H_2-DRI facilities.

4 Yeongmin Kweon(2026)

3. Analysis of Financial Support Cases by Countries Promoting H_2-DRI Commercialization

1) Support Cases for Commercial-Scale H_2-DRI Facilities by Major Steel-Producing Countries

This report examines the policy frameworks and support mechanisms of countries that are actively pursuing the closure of existing blast furnace processes alongside the construction of commercial-scale H_2-DRI facilities. While countries without concrete plans for commercial-scale facility conversion may provide insights into technological feasibility or policy intent, they provide limited empirical evidence on how public and private actors share the substantial upfront investment costs and transition risks associated with commercialization. Accordingly, this analysis focuses on Germany and Sweden, which have already entered the commercialization phase by making investment decisions for commercial-scale facilities and initiating industrial restructuring, including blast furnace decommissioning. The analysis examines how governments in these countries share transition risks with the private sector through fiscal, financial, and institutional mechanisms.

Germany and Sweden treat the commercialization of H_2-DRI as a national industrial transition centered on the conversion of blast furnace-based processes to low-carbon production systems. To support this transition, both countries have established comprehensive policy packages that combine direct subsidies, long-term loans and guarantees, and tax incentives. Notably, they have institutionalized risk-sharing frameworks in which national governments—together with the European Union—absorb a substantial portion of the initial investment costs and transition risks associated with commercial-scale facility construction.

As EU member states, Germany and Sweden implement direct subsidies for commercial H_2-DRI facilities in accordance with the Climate, Energy and Environmental Aid Guidelines (CEEAG). Under the CEEAG framework, investments in decarbonization facilities that require large upfront capital and involve significant uncertainty—such as H_2-DRI—are recognized as cases where public intervention is justified due to the limitations of private-sector-only implementation. At the same time, to prevent excessive market distortion, subsidies are strictly limited to covering the funding gap associated with low-carbon process conversion and are subject to ex-post verification and claw-back mechanisms in cases of overcompensation.[5]

In parallel, the European Union deploys common EU-level funds to alleviate the financial burden on member states. The Innovation Fund, financed by revenues from the Emissions Trading System (ETS), provides direct subsidies for the commercial deployment of low-carbon industrial processes, including H_2-DRI. The Just Transition Fund supports equipment conversion costs in regions undergoing structural adjustment, such as those affected by blast furnace closures. Together with national subsidies, these EU-level instruments function to distribute the initial risks of commercial-scale facility conversion. At the same time, the EU is expanding institutional frameworks that allow member states to apply tax-based support measures for industrial decarbonization investments, including accelerated depreciation and targeted tax credits.

(1) Germany: A Large-Scale Direct Subsidy-Centered Transition to Commercial-Scale H_2-DRI

Germany is the world's seventh-largest steel producer, with crude steel output reaching 37.2 million tons in 2024. The country stands out for its proactive approach to transitioning away from blast furnace-based processes by supporting the conversion to commercial-scale H_2-DRI facilities.

Germany's commercial-scale H_2-DRI projects are characterized by a financing structure that combines large-scale direct subsidies from both the federal and state governments with policy-based financing instruments, primarily long-term loans. The German government frames steel decarbonization as a national industrial transition that reorganizes the country's industrial base, and it provides direct subsidies covering up to half of total investment costs in accordance with the EU State Aid Guidelines. Through this approach, the government positions itself as a risk-sharing partner, jointly bearing responsibility for both commercial feasibility and the transition pathway alongside the private sector.

Notably, Germany's commercial-scale conversion projects do not rely on fully renewable hydrogen-based processes from the outset. Instead, all three major projects—Salzgitter, ThyssenKrupp Steel, and Stahl Holding Saar—begin operation using natural gas-based direct reduction while being designed as hydrogen-ready facilities, with a clear pathway toward full hydrogen conversion over time. This reflects a strategic choice: rather than postponing facility conversion until hydrogen supply infrastructure is fully established, Germany prioritizes early

5 European Commission(2022)

conversion of production facilities and subsequently integrates renewable hydrogen as supply conditions mature.

The German government formally established hydrogen-based direct reduction as the central pathway for achieving carbon neutrality in the steel sector through its 2020 Steel Action Concept. Consistent with this framework, each commercial conversion project includes plans to phase out at least one existing blast furnace.

Salzgitter (SALCOS Project, 1.9 million tons/year H_2-DRI facility + 1 EAF)

In April 2023, Salzgitter secured total subsidies of USD 1.11 billion (EUR 1 billion), including USD 780 million (EUR 700 million) from the federal government and USD 330 million (EUR 300 million) from the state of Lower Saxony.[6] These subsidies cover 43% of the Phase 1 investment cost of USD 2.56 billion (EUR 2.3 billion). The remaining financing includes USD 560 million (EUR 500 million) secured through policy-based green loans backed by export credit guarantees.[7] Phase 1, scheduled for completion in 2027, includes the construction of a 1.9 million tons-per-year H_2-DRI facility, an EAF, and the phase-out of one blast furnace (BF A). The SALCOS project represents a comprehensive steel mill conversion strategy rather than a single plant project and is one of Europe's flagship initiatives for transitioning integrated steelmaking processes toward H_2-DRI and EAF-based production. Salzgitter has presented a phased roadmap that includes additional facility deployment and the gradual phase out of remaining blast furnaces by 2030 (Phase 2), culminating in full conversion of the steelworks by 2033 (Phase 3).

ThyssenKrupp Steel (H_2-DRI facility with an annual capacity of 2.5 million tons + 2 EAFs)

In July 2023, ThyssenKrupp Steel received approval for a total of USD 2.22 billion (EUR 2 billion) in direct subsidies, including USD 1.44 billion (EUR 1.3 billion) from the federal government and USD 780 million (EUR 700 million) from the state of North Rhine-Westphalia.[8] Of this amount, approximately USD 610 million (EUR 550 million) is allocated to facility investment costs, while USD 1.61 billion (EUR 1.45 billion) is designated to support renewable hydrogen operating costs over a ten-year period. Although the total project cost has not been publicly disclosed, official announcements indicate that ThyssenKrupp Steel will additionally invest less than USD 1.11 billion (EUR 1 billion) in its own capital. The project is expected to be completed by the end of 2026, with phased operations commencing in 2027.

6 Salzgitter AG(2024)

7 For the construction of the direct reduced iron (DRI) plant, Italy's export credit agency SACE provides guarantees totaling €300 million, while for the electric arc furnace (EAF) facilities, Austria's export credit agency OeKB provides guarantees of €200 million.

8 thyssenkrupp Steel(2023)

Stahl Holding Saar (2 million tons per year H_2-DRI facility + 2 EAFs)

In December 2023, Stahl Holding Saar received approval for USD 2.89 billion (EUR 2.6 billion) in state subsidies from the German government. In addition, the company secured USD 1.89 billion (EUR 1.7 billion) through a consortium of international financial institutions and corporate investment, bringing the total conversion investment to USD 4.78 billion (EUR 4.3 billion).[9] The project is scheduled for completion in 2027.

These policy orientations are concretely reflected in individual steelmakers' commercial-scale H_2-DRI transition projects. Through the SALCOS project, Salzgitter has announced plans to phase out three blast furnaces by 2033. ThyssenKrupp Steel plans to close one blast furnace upon the completion of its 2.5 million tons H_2-DRI facility. Stahl Holding Saar is accelerating a major industrial transition by announcing plans to fully replace its two existing blast furnaces with a 2-million-ton H_2-DRI facility.

In summary, Germany defines the transition to commercial-scale H_2-DRI as a large-scale industrial transformation in which the state directly shares costs. By centering its strategy on direct subsidies, Germany seeks to guide private-sector investment decisions and accelerate the commercialization of low-carbon steel production.

(2) Sweden: A Phased Commercialization Strategy Centered on State Guarantees and Public Finance

Sweden, with crude steel production of approximately 4 million tons in 2024, is relatively small in scale but was the first country to present H_2-DRI as a standard model for national industrial transition. The Swedish government's support approach is characterized by a phased structure, that differentiates financial and fiscal instruments according to technology maturity and the stage of commercialization.

To advance the transition to H_2-DRI, Sweden combines EU-level joint funding, including the Innovation Fund, with national policy instruments such as the Industrial Leap Program, an industrial decarbonization support scheme operated by the Swedish Energy Agency. Through this policy mix, steel decarbonization is managed as a joint industrial transition task supported by both the Swedish government and the European Union.

9 SHS – Stahl-Holding-Saar(2024)

A defining feature of Sweden's approach is its stage-specific risk-sharing structure, in which the nature and weighting of support instruments evolve over the course of the transition. In the early phase, EU joint funds and the Industrial Leap Program are used to provide subsidy-centered support for the demonstration of core H_2-DRI technologies and processes, with the public sector directly absorbing technical uncertainty and early-stage investment risks. As projects enter the commercial transition phase, the emphasis shifts away from direct subsidies. Instead, support is reoriented toward a finance-centered structure that combines policy finance and state guarantees, enabling the government to share financing risks associated with large-scale facility investment and to crowd in private capital.

HYBRIT Initiative (New 1.3 million tons/year H_2-DRI facility + electrolyzer)

The HYBRIT Initiative is a joint project involving Swedish steel producer SSAB, iron ore supplier LKAB, and power company Vattenfall. It serves as a core pillar of Sweden's national steel decarbonization strategy by enabling the transition of iron reduction processes. In April 2022, the HYBRIT project secured approval for USD 159 million (EUR 143 million) from the EU Innovation Fund to support the construction of a commercial-scale H_2-DRI plant with an annual capacity of 1.3 million tons, together with a 500 MW-class electrolyzer.[10] In December 2023, the Swedish Energy Agency approved an additional USD 344 million (SEK 3.1 billion) in state aid through the Industrial Leap Program.[11] Although formally classified as a demonstration facility due to its scale, the HYBRIT plant effectively functions as a semi-commercial conversion project, replacing a substantial share of SSAB's European production. In 2023, during the implementation of the HYBRIT project, Sweden successfully shut down one blast furnace at Oxelösund steelworks and replaced it with an EAF-based mini-mill.

SSAB (Integrated steel mill construction with 2 EAFs)

The Luleå Steelworks conversion project, pursued at a total cost of USD 5 billion (EUR 4.5 billion), centers on establishing commercial-scale production facilities anchored by two large EAFs. The project aims to replace Sweden's last remaining blast furnace at the Luleå Steelworks with steelmaking processes utilizing hydrogen-based iron and scrap supplied through the HYBRIT project. In December 2024, the European Union and the Swedish government approved USD 161 million (SEK 1.45 billion) in direct grants. In addition, the Swedish government approved USD 349 million (SEK 3.14 billion) in support for post-process electrification equipment through the Industrial Leap Program. Alongside these subsidies,

10 European Commission(2022)
11 Swedish Energy Agency (2023)

SSAB secured USD 3 billion (EUR 2.7 billion) green loan package for facility conversion and integrated steel mill construction, with the Swedish government supporting this financing through its national credit guarantee system.[12]

Stegra (New 2.5 million tons/year H_2-DRI facility)

Stegra is advancing a commercial-scale H_2-DRI project to construct a new integrated steel mill in Boden, northern Sweden, with an annual capacity of 2.5 million tons of low-carbon steel. With a total project cost of USD 7.2 billion (EUR 6.5 billion), the project is regarded as one of Europe's most advanced commercialization cases. As Stegra does not operate blast furnace facilities, the project is designed from the outset as a fully integrated H_2-DRI steel mill. In 2023, Stegra received USD 278 million (EUR 250 million) from the EU Innovation Fund. In addition, in accordance with EU state aid guidelines, the European Commission approved a Swedish government state aid ceiling of up to USD 294 million (EUR 265 million).[13] As of September 2024, USD 111 million (EUR 100 million) had been disbursed, followed by an additional USD 41 million (EUR 37 million) in November 2025.

While direct subsidies account for only a limited share of total investment, a substantial portion of the project's financing is structured around a finance-centered model combining policy finance, state guarantees, and private capital. Stegra secured USD 2.67 billion (EUR 2.4 billion) in senior loans backed by state guarantees, USD 2 billion (EUR 1.8 billion) in private loans, and USD 2.3 billion (EUR 2.1 billion) in private equity investment.[14] The project is proceeding with a target completion date of 2026.

In summary, Sweden has institutionalized a differentiated risk-sharing structure tailored to each stage of the H_2-DRI transition. Public subsidies play a central role during the technology demonstration phase, while the commercial transition phase relies primarily on policy finance, state guarantees, and private capital, reflecting a deliberate shift from fiscal support to finance-centered risk sharing.

12 This green loan package includes a SEK 15 billion (KRW 2.1 trillion) syndicated loan guaranteed under the Swedish National Debt Office's 'Credit Guarantees for Green Investments', along with EUR 808 million (KRW 1.3 trillion) from Italy's export credit agency, SEK 1.15 billion (KRW 160 billion) from the Nordic Investment Bank (NIB), and EUR 430 million (KRW 700 billion) from the German export credit agency Euler Hermes.

13 Stegra (2024)

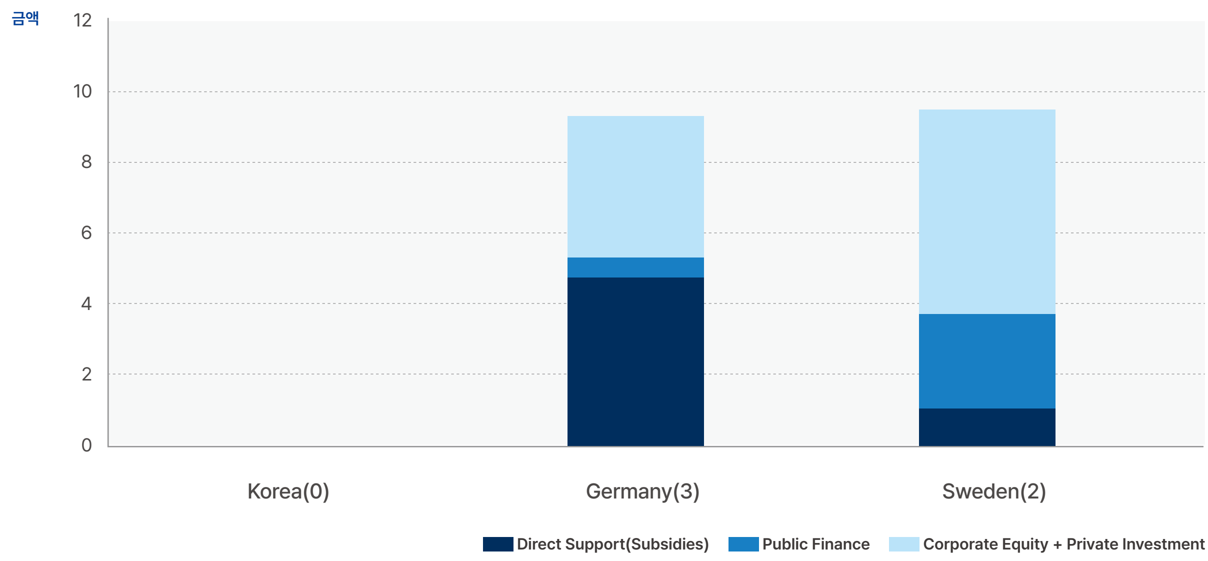
14 Stegra's project financing consists of a combination of senior loans and private capital: €1.2 billion in senior loans guaranteed under the Swedish National Debt Office's Green Investment Credit Guarantee, an additional €1.2 billion in senior loans covered by Germany's Euler Hermes export credit guarantees, €1.8 billion in purely private loans, and €2.1 billion in private equity investments involving participants such as the Microsoft Climate Innovation Fund and Siemens Financial Services.

2) Comparison of National Support for Commercial-Scale H_2-DRI Facilities and Implications

As observed in the preceding country cases, Germany and Sweden are advancing the transition to commercial-scale H_2-DRI facilities through financing structures that combine direct government subsidies, policy finance instruments such as loans and guarantees, and corporate equity or private investment. While the core components of support are broadly similar, the way in which these instruments are combined and weighted differs substantially across countries, reflecting differences in policy frameworks, fiscal capacity, and public financial systems.

Figure 2 compares the share of government support in commercial-scale H_2-DRI projects by country. The total length of each bar represents the overall investment scale of commercial conversion projects. Sweden's two SSAB EAFs are excluded from the figure, as they do not directly involve H_2-DRI facilities. Korea is marked as "None", as only a five-year budget for a 300,000-ton-per-year demonstration project has been confirmed, while no commercial-scale conversion project has been planned or approved for government support.

[Figure 2] Government Support for Commercial-scale H_2-DRI Projects by Country **Unit**: USD billion



∗The number shown next to each country indicates how many projects have reached semi-commercial scale or above.

The key characteristics of national support structures can be summarized as follows.

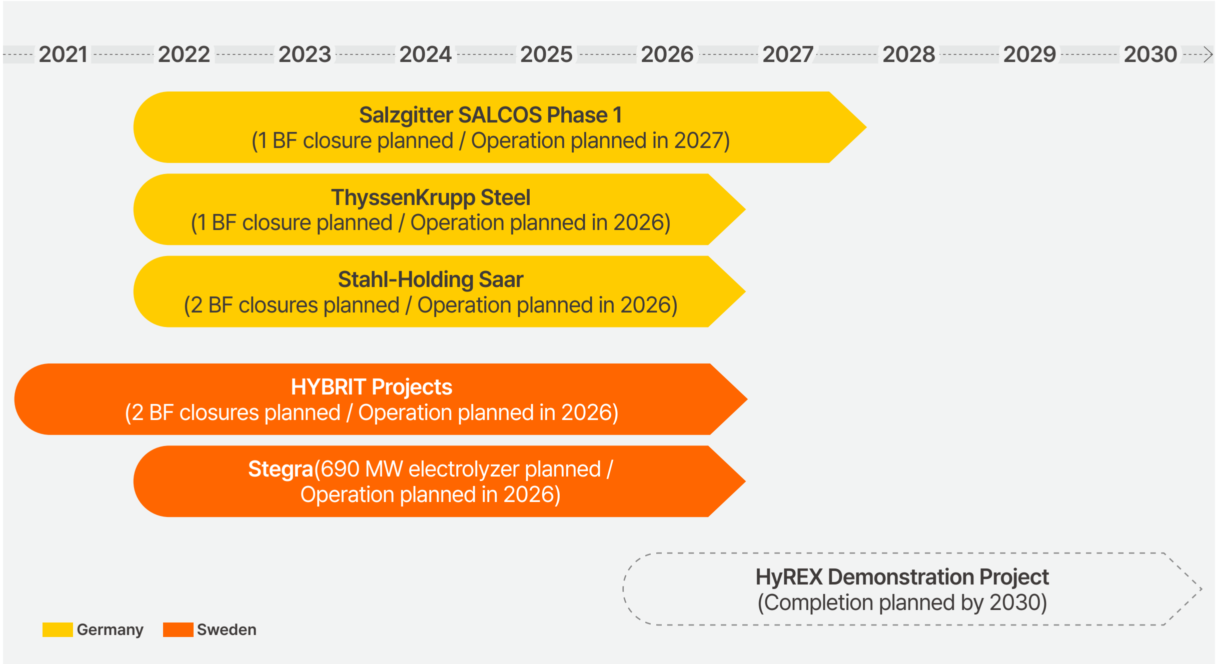
First, Germany adopts the most aggressive direct support model. Federal and state governments cover 40–60% of total project investment costs through direct subsidies. Under the EU State Aid Guidelines, Germany explicitly approves substantial public support for commercial-scale facilities. Importantly, subsidy eligibility is conditioned on the phase-out of existing blast furnace capacity, thereby directly linking public funding to both blast furnace closure and conversion to H_2-DRI process.

Second, Sweden relies on a different approach. While the absolute scale of direct subsidies is relatively limited, large-scale green loan packages backed by state guarantees from the Swedish National Debt Office constitute the core financing source for steel decarbonization investment. Rather than injecting public funds primarily through grants, Sweden leverages sovereign credit to provide long-term financing, significantly reducing firms' financing risks. This public financial structure enables companies to attract additional private loans and investment, thereby expanding the total capital available for large-scale facility conversion. Unlike Germany, Sweden does not condition public support on blast furnace closure. Instead, it pursues a strategy of constructing large-scale electrolysis capacity (exceeding 500 MW) alongside steel facility conversion, aiming to mitigate long-term hydrogen supply uncertainty in parallel with process transition.

Third, in contrast to these countries, Korea currently lacks any planning or institutional foundations for commercial-scale conversion. There are no project-level plans for H_2-DRI deployment, no blast furnace phase-out strategies, no designed financing structures, and no government support measures for commercialization. This is reflected in Figure 2 as "None," indicating not merely a delay, but the absence of a roadmap for scaling up from government-led demonstration projects to commercial deployment, implying a potentially significant competitive lag in the global steel transition.

Figure 3 summarizes key features of commercial conversion projects by steelmakers in each country and their anticipated commercialization timelines.

[Figure 3] **Commercialization Timelines for H_2-DRI Projects by Country**



Source: Steel company websites and press releases; the official project start year (e.g., investment decision) is used as the baseline.

As shown in **Figure 3**, both Germany and Sweden have announced concrete schedules to begin operating commercial-scale H_2-DRI and EAF facilities between 2026 and 2027. With the exception of Stegra—which is developing a H_2-DRI project supplied with green hydrogen and without blast furnaces—all projects incorporate explicit plans to shut down existing blast furnace or coke-based processes. These cases therefore represent comprehensive industrial transition roadmaps that extend from blast furnace closure to new facility construction and entry into commercial production, supported by secured public financing.

By contrast, Korea lacks project-specific conversion plans, investment structure design, and a government policy framework for commercial-scale deployment. Critical foundations for scaling up from the 300,000-ton-per-year demonstration phase (2026–2030)—including public–private risk-sharing mechanisms and integrated planning for hydrogen and power infrastructure—have yet to be established. This situation goes beyond a slow transition pathway. It risks locking a structural gap in which major steel-producing countries enter commercial production between 2026 and 2029, while Korea remains unable to reach the starting line for commercialization.

Given the steel industry's high capital intensity and process lock-in characteristics—where major facility conversions limit future process flexibility for extended periods—prolonged delays in commercializing H_2-DRI in Korea increase the risk of losing not only domestic deployment opportunities but also potential pathways for international expansion.

4. Conclusion

Major steel-producing countries have already presented concrete schedules to operate and convert commercial-scale H_2-DRI facilities before 2030 and have institutionalized structures through which governments actively share transition risks with steelmakers. In both Germany and Sweden, large-scale direct subsidies have been combined with policy-based financing during the commercial facility conversion phase, thereby catalyzing substantial private investment and strengthening the overall execution capacity of steel industry's decarbonization strategies.

In contrast, although Korea has set a national target to convert 11 blast furnaces into 15 H_2-DRI facilities by 2050, it currently lacks a concrete support system and implementation roadmap to underpin commercial-scale upscaling and near-term transition pathways. The Special Act on Strengthening the Competitiveness of the Steel Industry and Transition to Carbon Neutrality (K-Steel Act) represents an important first step toward establishing an institutional foundation. However, the critical task remaining in subordinate regulations and follow-up policies is to clearly define how, to what extent, and under what conditions the government will share risks with the private sector in the course of actual commercial facility conversion. It is essential to institutionalize a robust risk-sharing structure that explicitly addresses the allocation of substantial upfront investment costs and long-term technological and market risks.

The transition to H_2-DRI requires long-term investment of approximately USD 33.8 billion (KRW 47.3 trillion). This scale of investment exceeds the scope of individual corporate decision-making and constitutes a national industrial transition that fundamentally restructures production systems, supply chains, and energy demand across the steel industry. Relying solely on firm-level investment decisions and timelines risks delaying the transition and undermining national industrial competitiveness. From this perspective, government intervention is required not only as a source of financial support, but as a strategic planning and coordination mechanism to guide the direction, sequencing, and pace of industrial transition and to facilitate early market formation.

As major economies accelerate commercial facility deployment under strong government leadership—thereby shaping the initial competitive landscape of the global green steel market—Korea urgently requires institutional reforms to enhance both the speed and execution capacity of its own commercial transition. Specific directions for institutional improvement are proposed as follows.

1) K-Steel Act: Specification of Korean Low-Carbon Steel Transition Support Framework

Under the current legislation, the scope, instruments, or procedures of government support during the commercial-scale H_2-DRI conversion phase are not clearly defined. Core elements—including the balance between direct subsidies and policy finance, eligibility criteria, support priorities, implementation procedures, and governance arrangements—remain to be specified through subordinate regulations and follow-up policies. For the K-Steel Act to function as an effective institutional foundation for commercial transition, the government must promptly prepare detailed implementation frameworks tailored to the commercialization stage and formalize them through enforcement decrees, rules, and administrative guidelines. This is essential to secure predictability and transparency in government support and to enable firms to formulate credible mid- to long-term transition investment strategies.

2) K-GX: Activating Investment in H_2-DRI Conversion

Germany and Sweden have advanced commercialization by directly linking financial support to the deployment of new low-carbon facilities through sector-specific transition roadmaps and clearly articulated emissions reduction benchmarks. This has been possible because eligibility criteria, public–private risk allocation, and support levels linked to emissions reduction outcomes are explicitly defined. By contrast, Korea currently lacks core policy criteria for transition finance, including evaluation standards, eligibility requirements, and sector-specific transition pathways.

The K-GX implementation framework for the steel sector must therefore clearly specify the scope of support across stages—from technology demonstration to commercial facility conversion—and explicitly define the government's role in sharing technological and market uncertainties. Such clarity is critical not only for accelerating corporate investment decisions, but also for providing the institutional predictability required for domestic financial institutions to participate meaningfully in transition finance.

3) Streamlining National Resources for Steel Decarbonization

Commercial-scale H_2-DRI conversion requires significant capital investment and long-term, sustained financial support. International cases share three common features: (1) the establishment of dedicated transition funding pools, (2) prioritization of these resources for commercial facility conversion, and (3) integrated policy packages combining direct subsidies, policy finance, and tax incentives.

The European Union has institutionalized transition-dedicated funds—such as the Innovation Fund and Just Transition mechanisms—financed by emissions trading revenues and prioritized for projects that combine H_2-DRI with blast furnace closures. Germany has leveraged these mechanisms to cover 40–60% of total investment costs through direct subsidies, while Sweden has absorbed private-sector investment risks by mobilizing long-term loans backed by state guarantees through the Swedish National Debt Office.

By contrast, Korea lacks both a funding roadmap for commercial-scale facility conversion and a clearly articulated risk-sharing structure. Scaling up from a 300,000-ton-per-year demonstration facility to a 2.5-million-ton commercial plant entails substantial upfront capital requirements and prolonged recovery risks that private firms cannot reasonably absorb alone. Without a preemptive, medium- to long-term funding strategy covering direct subsidies, policy finance, and tax incentives, commercial conversion investment decisions are likely to stall.

Accordingly, the government must move beyond incremental support expansion and explicitly design a framework to share investment, market, and policy risks with the private sector. At the same time, fiscal resources currently allocated to marginal efficiency improvements in blast furnace-based processes should be fundamentally reassessed. Budgetary priorities should shift away from extending the lifespan of high-emission production systems and toward supporting blast furnace closures and H_2-DRI deployment.

Ultimately, the government must clearly define the principles and boundaries of support for commercial facility conversion. This includes pre-establishing maximum support ratios relative to total investment costs, specifying combinations of subsidies, loans, and tax incentives, and clarifying public–private risk-sharing arrangements. Execution criteria—such as blast furnace closure requirements, emissions reduction benchmarks, and transition timelines—must also be made explicit.

Resources such as emissions trading revenues, government bonds, and transition finance instruments should be strategically prioritized for industrial decarbonization, particularly H_2-DRI conversion. In parallel, steelmakers must transparently present their transition roadmaps, including blast furnace closure plans and emissions reduction outcomes, and assume responsibility for ensuring that public support translates into actual commercial deployment and early production.

Only through such a mutually reinforcing risk-sharing structure and disciplined resource allocation framework can Korea align itself with countries already entering the commercial phase of H_2-DRI. This constitutes a minimum prerequisite not only for achieving carbon neutrality by 2050, but also for securing the long-term global competitiveness of Korea's H_2-DRI technology in the emerging green steel market.

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