



Green Steel Survey Report

Transition to Green Steel in the Korean Steel Industry

Current Perception of Domestic Companies on Green Steel and Policy
Recommendations for Its Activation



Korea Sustainability Investing Forum(KoSIF)

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Index

Steel Industry Begins Paradigm Shift to Green Steel	4
Introduction	
Greenhouse gas emissions from the steel industry and hydrogen reduction steelmaking process	
 Transition to Green Steel: The Current State of Domestic Companies	 8
Experience and plans in green steel production / purchase	
Green Steel production / purchase goal	
 The Transition to Green Steel: The Future as Seen by Domestic Companies and Their Top Priority Policies	 12
Future perception of green steel	
Barriers and policy support	
 Policy Recommendation	 16
 References	 18

Introduction

The reason significant costs arise in the process of changing the existing production system for the decarbonization of steel

1. When transitioning from the existing blast furnace-basic oxygen furnace method to hydrogen reduction steelmaking process, the facilities used previously cannot be reused and must be replaced.

2. The transition to a hydrogen reduction steelmaking process also necessitates considering the costs of establishing hydrogen production and supply infrastructure.ⁱ

The beginning of the decarbonization of the steel industry, transitioning to the paradigm of green steel

The forces that controlled iron have dominated the world. From ancient societies that conquered surrounding forces still in the Bronze Age based on powerful iron weapons to the European Coal and Steel Community, which became the precursor to the European Union, it is evident that up until half a century ago, the production capacity of steel was directly linked to the power of a nation and its ability to wage war. Today, the importance of steel in terms of security has significantly faded. After the end of the Cold War, riding the wave of capitalism and trade liberalization, the production bases of manufacturing industries including steel have long since moved from Europe and the United States to Asia in search of cost efficiency.

Now, the strategic importance of steel, which had become so common that everyone had forgotten about it, is once again receiving attention due to climate change. However, the focus of interest has shifted. Whereas in the past, the important factor was how much steel could be produced, the paradigm has now changed to who can produce steel on a large scale without carbon emissions and how quickly they can do so.

Iron is a core material that supports our daily lives and is a resource without substitutes. However, our society emits a tremendous amount of greenhouse gases in the process of making steel, and its production structure makes it very difficult to reduce greenhouse gas emissions.

To decarbonize steel, the existing production system must be completely revamped, which involves significant sunk costs and requires new investments. The crux of the problem ultimately comes down to who will bear these costs. Considering the impact of iron on our daily lives and on climate change, it's not feasible to leave the responsibility solely to the production companies. It's not so much that the steel companies' responsibility of some companies from leading to a failure that affects all of humanity.

Survey respondents: Industry sectors of Steel Consumer and Producer Companies

Number of companies(%)

Classification	Industry Sector	Number of Companies
Consumption	Subtotal	150(100)
	Construction	13(9)
	Metal Processing	7(5)
	Mechanics	37(25)
	Automotives	52(35)
	Electrical and Electronics	17(11)
	Shipbuilding	24(16)
Production	Primary Metal Manufacturing	50(100)

Green Steel Awareness Survey: The First Step Towards Achieving Carbon Neutrality in Steel

It is true that the introduction of the EU Carbon Border Adjustment Mechanism (CBAM) has heightened interest in greenhouse gas reduction within the domestic steel industry. However, it should not be forgotten that the Emissions Trading System, which is celebrating its 10th year, has hardly contributed to the actual reduction of greenhouse gases in the steel industry. For the decarbonization of steel, not only are the self-driven efforts of steel companies necessary, but supportive regulations are also required.

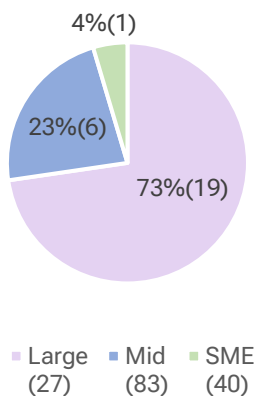
However, the market demand for green steel is equally important. No company can ignore demand. If consumers willing to pay more for carbon-free steel increase, the decarbonization transition of steel companies will also accelerate. Conversely, in the absence of market demand, no matter how much regulation is strengthened, companies will first seek ways to evade it.

This report is the first in the country to survey not only steel producing companies but also consuming companies' perception of green steel. Through the survey, we analyzed the willingness to produce/buy green steel, future production and purchase goals, willingness to pay extra, and necessary policies among 50 steel production/sales companies and 150 consumer companies.

Survey Respondent Company Overview

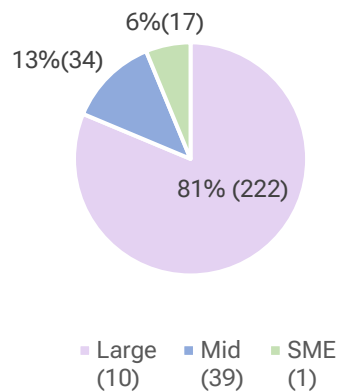
<Consumer Companies' Average Annual Purchase Volume(Based on the Last 3 years)>

% (Average 10 thousand t)



< Production Companies' Average Annual Production Volume(Based on the last 3 years)>

% (Average 10 thousand t)



Greenhouse gas emissions from the steel industry and hydrogen reduction steelmaking process

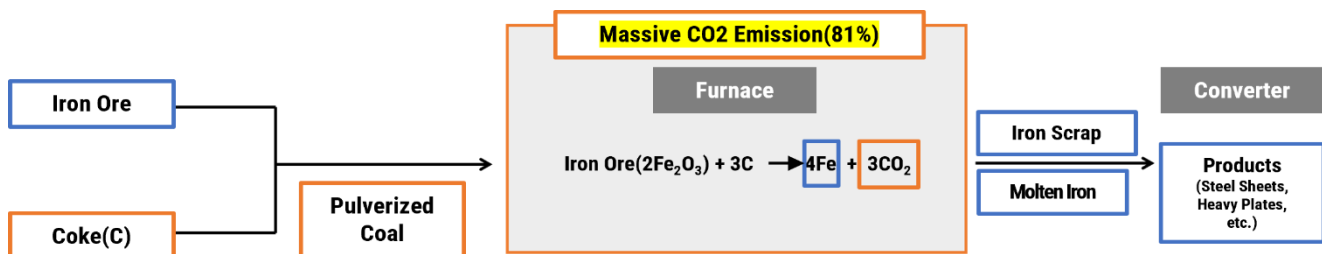
The steel industry is a high greenhouse gas emitting sector: A large amount of carbon is emitted from the blast furnace-electric furnace steelmaking process

The steel industry is a major emitter of greenhouse gases, accounting for 7% of global emissions. Historically, it has been a leading source of emissions, contributing 9%ⁱⁱ. In South Korea, it emitted 93.1 million tons, making up 14.2% of the country's total emissions.ⁱⁱⁱ According to the Korea Energy Economics Institute, in 2018, the domestic steel sector accounted for 37.2% of emissions from major industrial sectors.^{iv} Greenhouse gas emissions from the steel sector have increased by 24% since 2010, significantly exceeding the manufacturing industry's average growth rate of 15.2%.

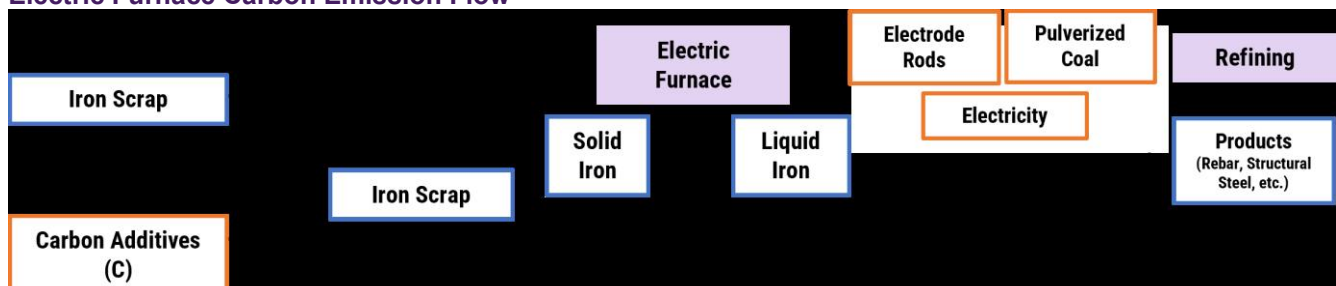
Steel production processes can be broadly divided into blast furnace-basic oxygen furnace (BF-BOF) method and the electric arc furnace (EAF) method. The BF-BOF method involves removing rust attached to natural iron ore in a blast furnace and simultaneously melting the iron ore into molten iron in the smelting process, removing impurities dissolved in molten iron in the basic oxygen furnace during the steelmaking process, and then processing the steel for its intended use in the rolling process. In the smelting process, to remove rust, from the iron ore, coke (C) is used to eliminate the oxygen (O₂) from the iron oxide through a reduction process, during which carbon and oxygen combine to produce a large amount of carbon dioxide (CO₂).

The electric arc furnace (EAF) method primarily uses iron scrap, which has less rust, as the main raw material, and thus relatively less coke is used. Greenhouse gas emissions mainly come from the production of the electricity used to melt the scrap metal, with emissions levels being about 25% of those from the blast furnace-basic oxygen furnace (BF-BOF) method. However, there is a clear limitation that using iron scrap alone cannot meet the growing global demand for steel.

Blast Furnace-Converter Carbon Emission Flow ^v



Electric Furnace Carbon Emission Flow



Hydrogen Reduction Steelmaking, Noted as a Carbon Reduction Solution for the Steel Industry

Hydrogen reduction steelmaking is gaining attention because it offers a method to continue using iron without emitting greenhouse gases. Hydrogen reduction steelmaking uses hydrogen instead of carbon(coke) to reduce iron ore(iron oxide), which is the third most abundant mineral on Earth after sand and aluminum. The reduced iron is then melted using an electric furnace. If the electricity used in the electric furnace is produced from renewable energy, it is possible to produce steel without emitting carbon.

Recently, leading global steel companies such as ArcelorMittal and Thyssenkrupp have been accelerating the commercialization of hydrogen reduction steelmaking with the support of governments around the world. In South Korea, POSCO is known to be aiming to complete a pilot production plant by 2028.^{vi}

Primary Uses of Steel Products Based on Their Production Method: Blast Furnace-Converter vs. Electric Furnace

Iron scrap often contains alloy steel, which is iron mixed with other metals such as chromium, nickel, and manganese, making it difficult to separate impurities. Because of this, steel produced through the blast furnace-converter method is processed into steel sheets or heavy plates and used in industries that require high quality, such as automobiles, ships, and electronics. On the other hand, products from electric furnaces are mainly processed into rebar or structural steel and have been primarily used in the construction industry.

Hydrogen Reduction Steel Production Plans of Global Steel Producers ^{vii}

Corporation Name	Technology	Capacity (Mt)	Planned operation year	Classification
POSCO	Hydrogen Reduction Steel	1	2028	Pilot
ArcelorMittal		2.3	2025	Commercial
Thyssenkrupp		2.5	2026	Commercial
SSAB		1.3	2026	Commercial
H2 Green Steel	Hydrogen Reduction Steel-Electric Arc Furnace	2.5	2025	Commercial

Experience and plans in green steel production/purchase

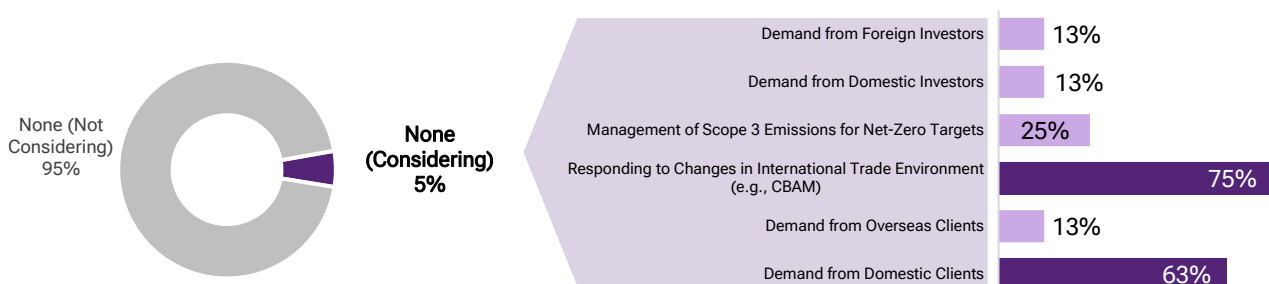
In the transition to green steel, production companies are preparing, while consumer companies hesitate.

None of the production and consumer companies that responded to the survey reported having experience producing or purchasing green steel. When asked about plans, 38% (19 companies) of the production companies indicated they were considering the production of green steel in the future. In contrast, only 5% (8 companies) of consumer companies reported considering the purchase of green steel, revealing a significant perception gap between production and consumer companies.

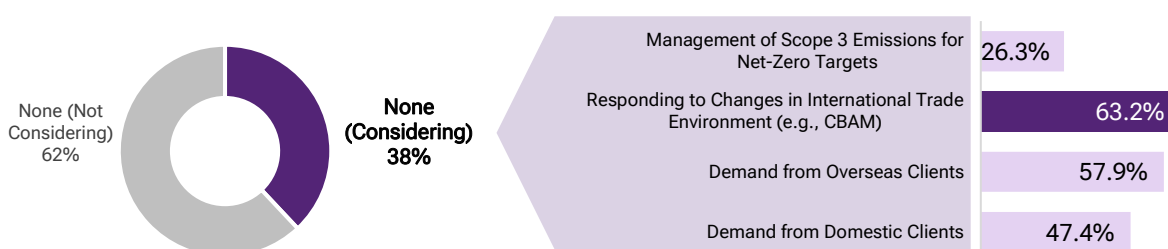
Production companies identified the biggest reasons for considering green steel production as changes in the external trade environment, such as the Carbon Border Adjustment Mechanism (CBAM), and client demands. It's noteworthy that a high number of companies responded to meet not only the demands of overseas clients but also those of domestic clients. Judging from the responses of domestic steel-consuming companies, rather than having received actual requests from domestic clients, their answers were based on the anticipation of such demands in the future. The anticipated timeline for the start of green steel production was 3-5 years (8 companies) and 6-10 years (5 companies), with 4 companies planning to start production within the next 1-2 years.

Among the 8 consumer companies that expressed an interest in purchasing green steel, the automotive sector had the most, with 5 companies, followed by the shipbuilding and electronics sectors, with 2 and 1 companies respectively. These 8 companies cited "responding to changes in the international trade environment, such as the CBAM" and "demands from domestic clients" as the key reasons for considering the purchase of green steel.

Consideration for Purchasing Green Steel by Consumer Companies and Reasons (Allowing for two Responses)



Consideration for Producing Green Steel by Production Companies and Reasons (Allowing for two Responses)



The need to respond to changes in international policy markets and to accompany domestic decarbonization promotion policies

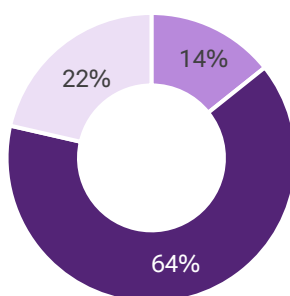
Companies that directly purchase steel include not only B2C companies that sell finished products to individual consumers but also B2B companies that supply intermediates to client companies. Notably, in the automotive sector, a significant number of mid-sized and small enterprises (4 companies) were considering purchase of green steel. It appears that mid-sized and small enterprises within the supply chain have begun to recognize that carbon-related regulations or demands, currently focused on large export companies, will ultimately extend as requirements for the supply chain.

In a situation where the overall willingness to purchase green steel among domestic consumer companies is low, it has been identified that the interest of some companies in the automotive and shipbuilding sectors, which have shown some intention, originates not from domestic policies but from changes in overseas policies or market environments. Most of the companies that have expressed their intention to purchase green steel selected both 'domestic customer demand' and 'changes in the international trade environment', indicating that these companies anticipate the impact to propagate in the sequence of 'overseas policy/market changes → export-oriented large corporations → supply chain companies'. In fact, the most common projected time frame for purchasing green steel among these companies is within the next 3 to 5 years, which coincides with the end of the transition period and the full implementation of the EU CBAM (Carbon Border Adjustment Mechanism).

Considering that about 70% of domestic steel production is for domestic consumption, policies that can stimulate the consumption of green steel within Korea are essential for the decarbonization of the steel industry. ^{viii}

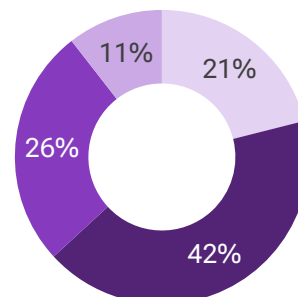
Considered timeline to start the purchase or production of green steel

<Consumer companies>



■ 1yr ~ 2yrs ■ 3yrs ~ 5yrs ■ 6yrs ~ 10yrs

<Producer companies>



■ 1yr ~ 2yrs ■ 3yrs ~ 5yrs ■ 6yrs ~ 10yrs ■ after 11yrs

Green steel production/purchase goal

Lack of demand signals and cost issues hinder the establishment of green steel goals

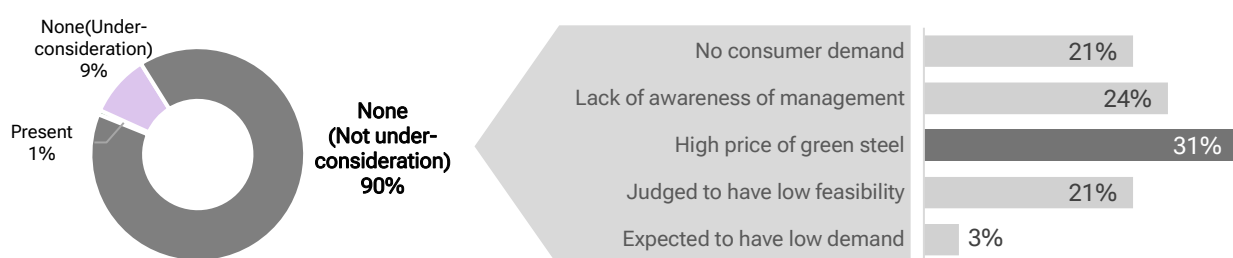
Not many companies have established goals for transitioning to green steel. Among consumer companies, only one company responded that it has a green steel purchase goal, and 14 companies (9%) stated they plan to establish goals in the future. In the case of producer companies, none stated they had established goals, but 42% (21 companies) indicated plans to set goals in the future. Overall, producer companies are more positive about the future demand for green steel compared to consumer companies. Supply can also create demand. If consumers believe that a certain good does not exist or cannot be sufficiently supplied, they often do not even establish a purchase plan for that good in the first place. In such cases, demand can explode when sufficient goods are supplied to the market. However, due to the nature of the steel industry, aggressively expanding supply without clear market demand involves too much capital investment. Demand signals must accompany the rapid expansion of the green steel supply.

For consumer companies, more than half (62%) cited high prices for not having or considering setting goals. Producer companies also cited cost increase (31%) and lack of consumer demand (21%) as the main reasons. Excluding the 21% of companies that cited 'lack of technological feasibility', we assume that the rest are willing to set and implement production goals if there is appropriate demand.

Consumer Companies: Status of Goal Setting and Reasons for Lack of Goals (Allowing for two Responses)



Producer Companies: Status of Goal Setting and Reasons for Lack of Goals (Allowing for two Responses)



Analysis of the Costs Associated with Transitioning to Green Steel and Its Impact on Final Products

Ultimately, the greatest concern expressed by both producer and consumer companies was the issue of cost increase and its acceptability. Half (58%) of the producer companies anticipated that the production cost of green steel would be 10-20% higher than that of conventional steel, and 37% predicted an increase of 21-40%. On the other hand, half of the consumer companies surveyed responded that they were unwilling to pay additional costs for green steel, while the other half indicated they could bear an extra cost of 10-20%, revealing a gap in cost perception between producer and consumer companies.

In the international market, companies like SSAB and H2GreenSteel have projected that the production cost of green steel would be approximately 20-30% and 25% higher, respectively, compared to conventional steel, which is not significantly different from the expectations of domestic producer companies.^{ix} Additionally, recent analyses on the impact of green steel on the final product prices are noteworthy. A study from abroad estimated that the use of green steel would result in a 1% increase in the final price of automobiles and a 2-6% impact on the cost of electricity produced by wind power.^x This analysis suggests that the actual impact on consumer price acceptability of final products incorporating green steel may not be as significant as initially feared. Especially considering the potential for a "greenium" (consumers' willingness to pay extra for eco-friendly products), appropriate consumer pricing support policies could help form an initial market.

Range of possible purchasing/producing company surcharge amounts

Range	Consumer companies	Producer companies	Global company expectations
No willingness to incur additional costs	50%	-	
10% ~ 20% increase	50%	58%	
21% ~ 40% increase	-	37%	✓
41% ~ 50% increase	-	-	
51% ~ 60% increase	-	5%	

Future perception of green steel

Future Competitiveness of the Transition to Green Steel (5-point scale, Strongly Agree)

Consumer companies(By Industry)

Classification	average points
Construction	3.23
Metal processing	2.86
Mechanics	3.32
Automotives	3.71
Electrical and Electronics	3.76
Shipbuilding	3.92
Total Avg	3.57

Producer Companies(By Size)

Classification	average points
Large	4.0
Mid	3.6
SME	5.0
Total Avg	3.72

*SME: 1 response

Green Steel: A Key to Future Competitiveness, with Producers More Optimistic on Demand than Consumers

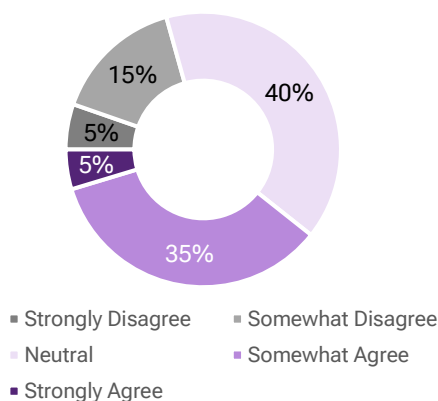
Both consumer and producer companies generally agree on the importance of green steel for future competitiveness. When analyzing the importance of green steel on a 5-point scale, ranging from 'not at all important' (1 point) to 'very important' (5 points), producer companies scored an average of 3.75, while consumer companies scored 3.57, showing no significant difference in perception levels. Upon further analysis of producer companies by company size, large enterprises scored higher (4.0 points) than medium-sized companies (3.6 points). Among consumer companies, significant differences were observed between industries, with shipbuilding (3.92 points), electronics (3.76 points), and automotive (3.71 points) industries scoring higher than domestic market-focused industries.

On the other hand, there was a difference in perception levels between producer and consumer companies regarding the future demand increase for green steel. Based on the same 5-point scale, producer companies scored an average of 3.52, while consumer companies scored only 3.18. Similar to their recognition of importance, consumer companies, particularly those with a high export ratio like the automotive and shipbuilding sectors, viewed the future demand increase more positively. In summary, producer companies were more optimistic about future demand increase than consumer companies, and within consumer companies, export-oriented sectors were more positive than domestic market-focused sectors.

Projected Increase in Future Demand for Green Steel

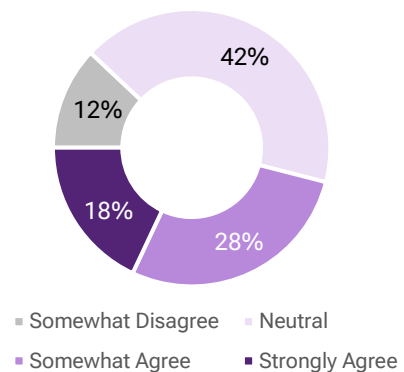
(5-point scale, Strongly Agree)

< Consumer companies >



Avg 3.18
(5 points: Strongly Agree)

< Producer companies >



Avg 3.52
(5 points: Strongly Agree)

* Targets set

; Setting short-term goals (for a period between 5 to 10 years from now) implies that targets have been officially approved after passing the SBTi (Science Based Targets initiative) validation process.

** Committed

; A company has established a clear plan for reaching net-zero by a long-term target date (typically by 2050) and has officially communicated this to the SBTi (Science Based Targets initiative). Although the validation process has not yet been completed, this signifies a commitment to achieving the set goals.

Increased Green Steel Procurement Expected to Drive Scope 3 Emission Reduction Targets

The purchase of green steel to implement Scope 3 reduction targets is expected to increase. Throughout the survey, consumer companies' awareness of green steel appeared lower compared to producer companies. However, it is expected that this phenomenon will improve in the medium to long term. Among domestic companies, 63 have joined the Science Based Targets initiative (SBTi), and those companies are required to establish and implement reduction targets, including Scope 3 emissions. Since achieving Scope 3 targets is practically impossible without reducing emissions through the purchase of steel, which is among the raw materials with high greenhouse gas emissions, the awareness level of consumer companies is expected to gradually increase. For reference, 943 companies in Japan have joined the SBTi, and domestic companies are also increasingly being asked by investors and clients to establish and implement SBTs, leading to an expected continuous increase in domestic company memberships.

Currently, domestic companies are still at the stage of establishing or re-establishing a system for calculating Scope 3 emissions, which is why the level of awareness regarding the purchase of green steel necessary for implementing Scope 3 reduction targets is considered low. Domestic construction companies such as Hyundai Construction and SK Ecoplant have joined or are preparing to join the SBTi, suggesting that in the medium to long term, the purchase of green steel by domestic companies, particularly in the construction industry which consumes the most steel, will increase. To prevent potential imbalances in the supply and demand of green steel, monitoring the demand and timing for green steel necessary for companies to achieve their net-zero targets and establishing an information-sharing system between demand and supply companies will also be necessary.

SBTi Status of Domestic Construction Companies Scope 3^{xi}

Company name	Category	Near term	Net-zero
Hyundai Construction	Company	Targets set*	Committed**
POSCO E&C	Company	Targets set	-
SK Ecoplant	Company	Targets set	-

The Dilemma of Domestic Companies: Having Net-Zero Goals but Not Purchasing Green Steel

Despite many companies establishing strategies to achieve net-zero goals, the lack of response regarding the purchase of green steel is noteworthy. Some consumer companies are setting net-zero targets, including their supply chains, implying that purchasing green steel is essential across industries. However, survey results indicate that a significantly larger number of companies (149 consumer companies) have not established any plans or targets for purchasing green steel compared to those that have (1 consumer company). This suggests that some companies have not yet responded to green steel purchasing or have not even set plans for it. If the steel issue is not resolved across all sectors, achieving net-zero targets will be challenging. This highlights the importance of establishing clear plans and targets for green steel and considering practical solutions for achievement.

Barriers and Policy Support

Comparison of Domestic and International Policy Support Funds^{xii}

Consumer Companies (by Industry)

Country	Support funds
South Korea	20.97 billion ^{xiii}
EU	800m euro ^{xiv} (1.15 tn KRW)
United States	85 billion ^{xv} (113.6 tn KRW)

Steel Companies' Barriers: Consumer companies face cost burdens, while producer companies struggle with securing technology

The biggest barrier to purchasing green steel identified by consumer companies was indeed the cost burden (61%). As mentioned earlier, the impact of green steel on the price of the final product can vary depending on the amount of steel input into the product. Therefore, for consumer companies to strategically consider the adoption of green steel, it appears necessary to support their purchasing decisions by conducting government-level research not only on the difference in production costs between conventional steel and green steel but also on the impact on consumer prices by product, the possibility and acceptability of cost pass-through, and more.

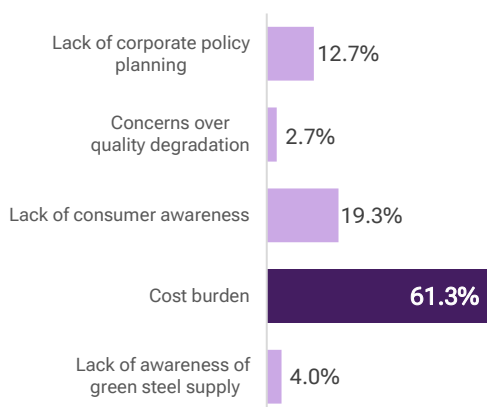
Producer companies identified not only the overall lack of demand signals but also the 'difficulty in securing funds for green steel investments' and 'difficulty in securing technology' as the biggest barriers. This opinion was common regardless of the size of the company, and even for relatively large companies with easier access to funding, it is not easy to procure the substantial funds needed for equipment replacement for hydrogen reduction steelmaking and securing renewable energy. The reality is that direct support for the green steel transition of steel companies in our country is significantly lacking compared to the United States or the EU.

Suppose direct support is difficult due to financial conditions. In that case, there is a need to actively explore indirect support methods, such as improving the financial procurement environment by creating funds for green steel or guarantee support.

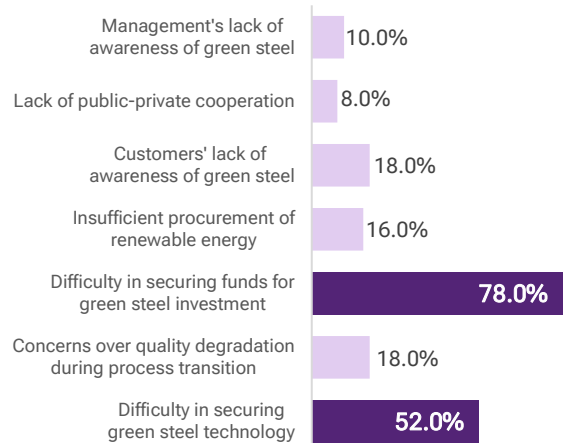
Barriers Hindering the Transition to Green Steel

(Allowing for two Responses)

<Consumer companies>



<Producer companies>



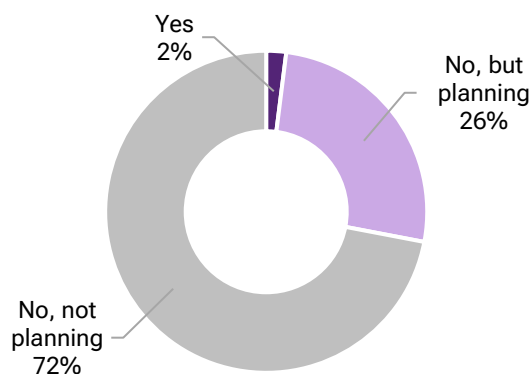
Insufficient procurement of renewable energy essential for green steel production, lack of related goal setting by production companies.

For production companies to complete a hydrogen reduction steelmaking system, not only production facilities but also green hydrogen used as a reducing agent and renewable electricity needed for melting iron must be accompanied. Among the production companies, only one had established a goal for securing renewable energy, and only 26% had stated plans to do so. Along with a green steel production strategy, establishing renewable energy goals and detailed strategies, which are core to green steel production, is urgent. Especially, with the influence of RE100, not only the steel but also manufacturing, service, and energy companies are required to use renewable energy electricity, necessitating the expansion of renewable energy production and national-level management of renewable energy demand by industry.

Production companies have identified investment in renewable energy facilities and financing as the main barriers to procuring renewable energy for green steel production. Following these concerns are the high cost of renewable energy electricity and a shortage of renewable energy power. This suggests a challenging domestic situation for transitioning to green steel to reduce carbon emissions. It is a critical time for government support in facility investment and the revitalization of the renewable energy market, based on the obstacles highlighted by production companies.

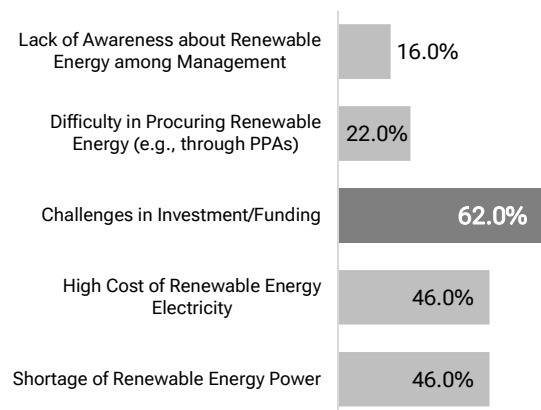
Perception of Renewable Energy Among Production Companies

<Presence of Renewable Energy Procurement Goals>



<Main Barriers to Procuring Renewable Energy

(Allowing for two Responses)



Policy recommendation

"As interest in carbon reduction in the global steel industry increases, the response of domestic steel consumption and production companies is also becoming more important. Green steel is produced through processes that reduce carbon emissions and contains less carbon than traditional steel."

"In the blast furnace-basic oxygen furnace process, there are instances where power is self-supplied through byproduct gas generation; however, this byproduct gas does not occur in the hydrogen reduction steelmaking process."

"Green hydrogen refers to hydrogen obtained through water electrolysis using renewable energy sources such as solar and wind power, and it is considered the most environmentally friendly method of producing hydrogen."

1. Policies to Promote Green Steel Consumption

Lack of Green Steel Demand can hinder the activation of relevant markets. Without clear demand from consuming companies, the production of green steel is realistically challenging. According to survey results, the establishment of objectives and considerations by demand companies was even less than that by production companies.

- **Green Steel Monitoring:** Prevent price discrepancies that may arise in the demand-supply market, and operate towards a sustainable green steel market through adjustments in volume, etc.
- **Government-Led Demand Stimulation:** Initial green steel demand markets can be created through the expansion of public procurement of green steel and the introduction of a green steel certification system.
- **Research on the Impact of Green Steel Pricing:** Research on the impact of consumer prices of products using green steel, costs, and acceptability can encourage companies' decision-making in purchasing green steel.
- **Establishment of Green Steel Standards:** Enhancing the interest of companies in green steel and the transparency of products can strengthen market competitiveness and enable responses to regulations such as the Carbon Border Adjustment Mechanism.

2. Financial Support Policies for Green Steel Facility Investment

The construction and operation of green steel production facilities require an initial investment of several billion dollars, and this high-cost structure poses a significant financial burden to investors and companies, making the transition to green steel challenging.

- **Fundraising through Fund Creation:** Establishing a special fund for green steel facilities, led by the government, and jointly participated by the private sector, can provide the capital needed for the construction and operation of green steel production facilities and mitigate the initial investment cost issue.
- **Project Financing (PF) and Interest Rate Reduction Benefits:** By utilizing project financing (PF) from the financial sector, benefits such as interest rate reductions are provided to financial institutions investing in green steel projects, thereby expanding financial support. This can reduce the financial burden of green steel projects and encourage participation from financial institutions.

3. Policies for Expanding Renewable Energy in Green Steel Production

It is estimated that the hydrogen reduction steelmaking process will consume about 20-100% more electricity than the traditional blast furnace-basic oxygen furnace method. Therefore, there is a high likelihood of power shortages during the transition to green steel.^{xvi}

- Expansion of Renewable Energy Sources: Addressing the power shortage issue by securing renewable energy through the additional construction of renewable energy power plants and diversification of procurement.

Securing Green Hydrogen: The use of green hydrogen is essential in the process of reducing iron ore in the hydrogen reduction steelmaking process. If the renewable energy power mentioned earlier is secured, green hydrogen can also be produced using renewable energy power. This approach not only supplies renewable energy and green hydrogen but also addresses the power shortage issue.



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- ⁱ Lee Kyung-soo, Yoo Ji-Young, 2021, "Key Technologies for Carbon Neutrality (Draft) - Focus on R&D Investment Technologies for Achieving Carbon Neutrality", p.53
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