Finance and state support for low-carbon steel

Sangeeth Selvaraju

Policy Report

December 2025

The Just Transition Finance Lab was launched in February 2024 with the goal of being a centre for experimentation and excellence in the financial solutions needed for a just transition. The Lab is grateful for the core support of its Founding Funders: Antin Infrastructure Partners, Barclays, HSBC and Laudes Foundation.
www.justtransitionfinance.org

The Grantham Research Institute on Climate Change and the Environment hosts the Just Transition Finance Lab. The Institute was established in 2008 at the London School of Economics and Political Science. It brings together international expertise on economics, as well as finance, geography, the environment, international development and political economy to establish a world-leading centre for policy-relevant research, teaching and training in climate change and the environment. It is funded by the Grantham Foundation for the Protection of the Environment, which also funds the Grantham Institute – Climate Change and the Environment at Imperial College London.
www.lse.ac.uk/granthaminstitute

About the author

Sangeeth Selvaraju is a Policy Fellow at the Grantham Research Institute on Climate Change and the Environment.

Acknowledgements

The author would like to thank Daisy Jameson, Hugh Miller, Bonnie Zuo, Max Åhman, Simon Nicholas, Erik Goto, Kenta Kubokawa, Rowan Conway and staff at the International Energy Agency for their comments and feedback. The author would also like to acknowledge the support of Mateus Getlinger-Santomauro and Guillaume Bastos Martin in preparing the literature review and graphics. Georgina Kyriacou edited the report.

This report was first published in December 2025 by the Grantham Research Institute on Climate Change and the Environment.

Suggested citation: Selvaraju S (2025) *Finance and state support for low-carbon steel*. London: Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science.

Contents

Summary

Decarbonising industry is a major 21st century challenge that requires international partnership, cooperation and corporate strategy. Historically 'hard-to-abate' sectors like steel are now central to this policy debate. The steel sector, once shielded by free allowances under the EU Emissions Trading System (ETS) in Europe, now faces a new reality as the Carbon Border Adjustment Mechanism (CBAM) phases out these exemptions. Advanced economies such as Japan, Australia, Canada and South Korea are deploying ambitious plans to decarbonise their steel sectors, backed by substantial fiscal resources.

Against this backdrop, large emerging market and developing economies (EMDEs) like India, Indonesia, and Vietnam are rapidly industrialising and driving new steel demand. But while steelmakers in the EU are investing in decarbonisation, this is proving more challenging for EMDEs. A major obstacle is the high associated cost and techno-economic limitations of implementing new methods, such as hydrogen-based iron reduction.

Through our analysis we seek to understand the use of direct state subsidies as a critical enabling factor in EMDEs' transition to decarbonising steel. This mechanism plays a crucial role in shaping the industrial decarbonisation policy package in EMDEs; without it, there is a risk that high-carbon capacity could be locked in for decades. Given the limited fiscal capacities of most EMDEs, international cooperation and partnerships will also be key.

The core contribution of this report is its novel dataset on state subsidies for low-carbon steel projects worldwide. This dataset lays a foundation for future research on resource allocation and green industrial policy, enabling deeper analysis of how public finance shapes technology adoption and competitiveness in the steel sector: it provides evidence for what the optimal policy package could be, given natural resource endowments, fiscal space and other existing climate policies that can be used together in the context of state capital expenditure (CapEx) and operational expenditure (OpEx) subsidies (other policy instruments such as offtake agreements are acknowledged). We note that the rapid industrial transition to low-carbon steel creates several just transition implications for EMDEs, but these sit outside the scope of this report.

Key findings

- **State support dominates project viability.** Most low-carbon steel projects in advanced economies rely heavily on public financial support to proceed. Transition costs for hydrogen-based steelmaking are estimated to be approximately double those of conventional fossil fuel-based production.
- **Forms of support vary.** While we address some OpEx schemes, the focus of this report is the CapEx support. Evidence from OECD studies on conventional steel shows that the bulk of state support in markets like China typically comes through below-market-rate borrowing and income tax concessions. These instruments may also apply to low-carbon steel projects, but this nuance is not captured in our dataset, highlighting an important area for future research.
- **Conventional steel expansion remains common in EMDEs.** Despite global decarbonisation efforts, high-carbon steelmaking capacity is expanding rapidly in EMDEs, posing a major challenge to climate change mitigation efforts as it locks in further greenhouse gas emissions.
- **Availability of cheap low-carbon electricity and scrap steel will play into competitive advantages for developed economies.** Countries with a ready supply of low-carbon electricity at lower prices can cut down on the outsized share of the levelised cost for direct reduction iron production and green hydrogen. Similarly, scrap steel availability will determine whether countries can invest in primary or secondary steelmaking, with the former involving higher costs as well as greater emissions.
- **Germany has the highest total committed CapEx support for low-carbon steel projects**, followed by other nations including France, Japan and the Netherlands. Given the limited international

public finances available to support industrial decarbonisation in EMDEs, it becomes even more vital that the role of international partnerships and cooperation is anchored by countries like those of the EU and Japan that are already supporting this decarbonisation domestically.

Recommendations

To address these challenges, the international community could consider:

- **Establishing an international fund** to support breakthrough low-carbon steel projects anchored and supported by Japan and the EU as major steelmakers making significant decarbonisation efforts.
- **Leveraging partnerships with EMDEs** to enable low-carbon ironmaking and integrating emerging Asian economies into global supply chains for inputs like hot briquetted iron (HBI).
- **Designing support mechanisms** that provide both CapEx and OpEx support for private and state-owned steelmakers.
- **Exploring pathways for international participation** in green 'lead markets' (a tool to create demand for climate-neutral products) to accelerate technology diffusion.

There is an urgent need to decarbonise steel in EMDEs and for coordinated global action to prevent decades of emissions lock-in. While progress will be challenging, our dataset and analysis open new avenues for research and policy innovation.

1. Introduction

This report highlights the choice of a particular policy tool, direct state subsidies, for decarbonising steel and the crucial role these subsidies are playing in shaping industrial decarbonisation policy packages. Challenges concerning the high costs of transformation to low-carbon steel production in emerging markets and developing economies (EMDEs) require international attention to avoid locking in high-carbon capacity for decades. The report examines the role of state support in that context. The dependence on state subsidies and grants to ensure the viability of low-carbon projects furthers the need for cooperation beyond state borders, especially for EMDEs.

The importance of steel and its decarbonisation

Steel is a vital global commodity and the backbone of development and industrialisation efforts around the world, serving as an essential input across virtually all sectors in modern society. Its strategic importance extends beyond its direct economic contribution, as steel availability and pricing significantly influence competitiveness across downstream industries including automotive, construction, machinery manufacturing and, increasingly, defence. It has been the source of jobs and a symbol of industrialisation for most countries. The first blast furnace steel dates from 1709 in England and this product has since ushered in growth and prosperity for the developed, and more recently, developing world. Given this commodity's vital importance and unique political economy features, steel remains an incredibly challenging sector to fundamentally change.

Decarbonising the steel sector is one of the key challenges facing the world in the coming decades. The sector accounts for 7 to 9% of greenhouse gas emissions globally (Muslemani et al., 2021), though its contribution to national emissions varies greatly. In fast-growing economies like India and China the steel sector accounts for 12% and 15% of emissions, respectively (Åhman and Arens, 2024; Xinyi Shen, 2024), while in earlier industrialised countries like Germany, steel accounts for 7% of emissions (Schreck et al., 2023). Until recently, the European steel sector was shielded from carbon taxes with free allowances under the EU emissions trading system (ETS). The roll-out of the carbon border adjustment mechanism (CBAM) will also see the phaseout of such exemptions. In all cases, decarbonising this sector is challenging given the growing global demand and techno–economic limitations of the high-temperature processes necessary to steel's manufacture that historically have been met by fossil fuels.

A few developing countries will account for most of the capacity expansion in the steel sector globally, driven mostly by domestic demand and high projected GDP growth in those countries. If the expansion of steel capacity in these countries is left to conventional steelmaking, the vast subsidies in other markets for the noble mission of mitigating steel sector emissions will have little effect. A comparative study investigating project pipelines for blast furnaces versus green iron and steel projects found that the former outweigh green projects by massive proportions (Åhman et al., 2023). The efforts of developed economies to decarbonise their steel sectors will be significantly offset by the expansion of conventional capacity in developing countries unless we look to more international cooperative partnerships backed by international financing to green the sector.

The primary stage of steelmaking consists of reducing iron ore into molten pig iron through a blast furnace at extremely high temperatures, facilitating the chemical removal of oxygen from iron oxides. About 80% of emissions from steelmaking occur in this phase, where coke combustion and the subsequent oxidation of the carbon monoxide generated result in a substantial CO_2 release. The secondary stage involves the transfer of molten pig iron to blast furnace–basic oxygen furnaces (BF-BOFs), where controlled oxygen injection reduces carbon content to commercially viable levels (typically 0.3–2%, depending on grade specifications). The ironmaking process takes place either in a blast furnace (BF) or through a process of direct-reduced iron (DRI). Steelmaking is the next step, and usually occurs via a basic-oxygen furnace (BOF) or in an electric arc furnace (EAF). When recycled steel is used, the ironmaking phase is skipped, and an EAF can be used. There are significant differences in the emissions from these different iron and steelmaking routes.

The BF-BOF route has the highest emissions, followed by the DRI EAF route, with variations depending on the type of gas (natural gas or hydrogen) is used. Recycling steel with an EAF has the lowest emissions, though once again emissions vary between plants depending on whether the electricity sources are renewable or not. Currently, around 70% of global steel production relies on the carbon-intensive BF-BOF route (European Commission Joint Research Centre, 2025).

Steelmaking's carbon-intensive industrial process gives cause for concern, given its expected rapid growth in production capacity over the next few years, especially in EMDEs. As new investments in steelmaking in India, the ASEAN region, and to a lesser extent China are made at an accelerated pace, addressing decarbonisation for net steel capacity creation will prove critical to the low-carbon transition globally over the coming decades (IEA, 2023). As old steel plants come to the end of their life or conventional carbon-intensive steelmaking technologies need to be retrofitted, there is an opportunity to decarbonise the steel sector and meet ambitious climate targets in developed countries. These efforts have mostly been underway in countries where there is a replacement of existing steel production capacity like in Germany and France. While steelmakers in the EU are investing in decarbonisation, this is proving more challenging for EMDEs. A major obstacle is the high associated cost and techno-economic limitations of implementing new methods, such as hydrogen-based iron reduction.

China's Ministry of Industry and Information Technology recently published a draft policy on 'Measures for Capacity Replacement in the Steel Industry', which ties capacity to low-carbon development. Article 11 of this policy stipulates that the replacement of BF-BOFs with EAFs must bring about a 60% reduction in carbon emissions for equal-capacity replacement to be approved (Ministry of Industry and Information Technology of the PRC, 2025). This makes it likely that there will be efforts to either adapt existing steel plants or vie for state support for new capital expenditure (CapEx) in breakthrough technologies. Most countries and governments are driven to keep their national steel industries intact, through a mixture of national pride, trade union pressure, national security concerns (that are now largely outdated)[1] and more recently as a symbol in trade wars. Thus, decarbonising the steel industry has become mired in the political economy of steelmaking; furthermore, it cannot be unbundled from the ferocious rise of China as the global powerhouse of steelmaking. China alone makes half of the world's steel and has a low cost of conventional steelmaking and due to extensive subsidies and state support has developed a large overcapacity which further depresses steel prices globally. A particular of state support used in China has been below-market rate loans to Chinese steel firms from Chinese financial institutions (OECD, 2024b).

Aims of the report

With the evolving global landscape of the steel sector, the confluence of national security concerns, friend shoring (securing supply chains in friendly or allied countries), climate action ambitions and green industrial policy, this report aims to draw attention to the climate challenge emerging from the steel sector within a rising group of EMDEs. It examines one specific policy tool for decarbonising steel that has gained significant momentum for many countries pursuing these policies: direct fiscal support. Section 2 reviews the different low-carbon steel definitions to explain the different global standards that have emerged. It points to the central role of scrap steel in decarbonisation and the challenge developing countries face in decarbonising using scrap steel. We show the anticipated capacity expansion of the steel sector in developing countries and show how the major steel producing companies in those countries are mostly adding conventional steelmaking technologies. We reference the cost of steelmaking by different technologies in the major steelmaking countries, which evidences the projected lower costs of lower carbon steelmaking in developing countries. Section 3 then present results from the database we have created of direct capital support that steel companies around the world have received to implement low-carbon steel projects. Section 4describes the evolving complex landscape in international steel decarbonisation and makes recommendations for international cooperation.

The scope of the report is limited to the CapEx grants and steel-specific funds set up by countries in the dataset, while also providing a qualitative overview of certain select OpEx schemes. Other policy tools

[1] See Conway (2024) and his work on the need for virgin steel linked to defence. In essence, while the defence industry will continue to need steel especially given geopolitical tensions, the need is not as great as during World War II. The nature of warfare has changed, and very small shares of overall national steel production are needed to meet steel demand from the defence industry. See also the American Iron and Steel Institute's assessment of the defence industry's needs for American steel.

include carbon pricing, green lead markets, offtake agreements, tax rebates and concessional financing but are outside the scope. The optimal policy package is naturally quite localised and is likely a combination of some or all of the above options.

2. Defining low-carbon steel

As decarbonisation efforts advance, a key challenge is the ability to differentiate and value companies that produce or use low-carbon steel. Multiple initiatives and standards have emerged to try to better define 'low-carbon steel' and set emission thresholds. In this section we briefly discuss the different steelmaking methods to provide context for the standards and definitions, then examine the different low-carbon steel standards.

Low-carbon steel production

Conventional steel is produced through a process in which iron ore is converted to liquid iron in a blast furnace, is further reduced with carbon, and then with the addition of scrap steel and alloying elements is turned into liquid steel. This is the most emissions-intensive steelmaking process, often known as blast furnace–basic oxygen furnace (BF-BOF) steelmaking.

A key technological advancement in steelmaking has been the electric arc furnace (EAF), which produces significantly lower emissions because it can use up to 100% scrap steel and can be powered by renewable energy. This is one way of producing transformational low-carbon steel. The other is through the new green hydrogen-based direct reduced iron (H_2DRI) process. Direct reduction plants (DRPs) employ solid-state processing of iron ore using a reduction gas (either hydrogen or natural gas) which avoids having to melt iron ore to achieve its desired metallic state. Currently, there are hundreds of direct reduction plants globally that reduce iron using natural gas (NG DRI). These have lower emissions than a blast furnace but are still emissions-intensive. The DRPs can be fuelled by hydrogen but the conversion loss of using electricity to convert water to hydrogen and then injecting it has yet to be made commercially viable in most places. The viability is largely dependent on low electricity prices or securing offtakers who are willing to invest in thisthis technique. Other pilots and technology ventures are experimenting with DRPs that can reduce iron with electricity without the need for hydrogen. However, at the time of writing we are yet to see a scaled plant using this process.

Carbon capture and storage (CCS) was previously considered an option to decarbonise conventional blast furnaces, but is now less favoured. Pilots of CCS utilisation do exist in many steel plants around the world but due to cost and technological concerns do not provide a viable decarbonisation pathway for the steel sector. Currently, there are no commercial-scale CCS projects for BF-BOF-based production; the Al Reyadah CCS project by Emirates Steel for a DRI primary steel plant has been operational since 2016 but a study found that it only captured 26.6% of the gas-based plant's emissions in 2023 (IEEFA, 2024). Other than this one plant in the Middle East, there are no commercial-scale plants using this technology and therefore whether or not CCS will become a viable technology option for steel decarbonisation is yet to be determined. For the purpose of this report, we do not include CCS technology options given that we were able to find only the one plant named above.

Scope 1, 2 and 3 emissions in the steel sector

The steel industry's emissions are typically categorised using the Greenhouse Gas Protocol framework, which sets three distinct scopes. Scope 1 refers to a company's direct emissions, associated with the day-to-day activities that the company owns or controls, such as emissions from blast furnace operations. For steel producers, these emissions come from any carbon emitted during the steelmaking process and depend largely on how the steel is made. Traditional steelmakers using BF-BOFs typically exhibit substantially higher Scope 1 emissions compared with EAF operations.

Scope 2 is categorised by indirect emissions associated with a company's electricity consumption. For steel producers, this encompasses electricity used to power industrial facilities, with EAF steelmakers being particularly sensitive, as steelmakers have the highest emissions here. The impact of Scope 2 emissions is heavily reliant on the source of electricity for the country's grid.[2]

[2] Note that some producers operate captive power plants that are not attached to the grid.

Scope 3 considers all emissions for which a company is indirectly responsible, up and down its value chain. For steel producers, this encompasses upstream emissions from raw material extraction, processing and transportation, as well as downstream emissions from steel product use and end-of-life treatment.

Steel production involves high proportions of emissions at Scopes 1 and 2, with on-site Scope 1 emissions being very high (Nimbalkar, 2022). Scope 3 emissions remain substantial and difficult to measure; for example, methane emissions from coking coal used to fuel BFs and which fall under Scope 3 are seldom reported on, despite the vast volumes in which this potent greenhouse gas is emitted (Ember, 2025).

Emerging standards for low-carbon steel

From the Scope 1–3 framework, agencies and organisations have created different standards for 'low-carbon steel', defining the amount of CO_2 output that companies should aim for in order for the steel to be categorised as such.

The International Energy Agency (IEA) has developed a framework for defining both 'near zero emission production' and a broader category, 'low-emissions production', for steel, which includes considerations for Scope 1, Scope 2 and partial upstream Scope 3 emissions, such as from the production of other material inputs in steelmaking. The proposed threshold is established on a sliding scale between zero and 100% scrap use, relative to how much recycled scrap is used in steel production. To be considered as 'near zero emissions steel', crude steel produced with no scrap must remain below 400kg CO_2 equivalent per tonne (CO_2e/t), while production with 100% scrap input must not exceed 50kg CO_2e/t. The IEA has also established looser performance levels (classes A to E) to be considered 'low-emissions production', from stricter to more relaxed emission targets, respectively. Class E's threshold for 0% scrap use is set at 2,400kg CO_2e/t, six times the near-zero threshold (IEA, 2022).

In parallel with the IEA's framework, ResponsibleSteel, an international non-profit dedicated to promoting the responsible sourcing, production and recycling of steel, provides certificates to companies to acknowledge sustainable production in the sector. This organisation offers two types of certification: i) Core Site Certification, which ensures comprehensive management of ESG (environment, social and governance) sustainability risks, and (ii) Steel Certification, which requires steelmakers to also demonstrate progress in achieving decarbonisation and responsible sourcing. In the case of Steel Certification, based on a scrap-variable scale, the steelmaking site is awarded an emissions classification ranging from progress level 1 (better than industry average) to progress level 4 (near-zero emissions). In addition to market products being labelled 'ResponsibleSteel certified', the steel products must have a Product Carbon Footprint (PCF) or Environmental Product Declaration (EPD) that clearly states its Global Warming Potential (GWP). At 0% scrap use, Level 1 has a set target of 2,800kg CO_2e/t, while Level 4 is set at 400kg CO_2e/t, in line with the IEA's near zero emission production.

The German Steel Association WV Stahl has developed the Low Emission Steel Standard (LESS), expanding the IEA's system boundaries beyond crude steel production, covering downstream processes and specific quality grades (Stahl, 2024). LESS establishes distinct limit values for different steel alloys, types of steel, emissions targets of quality steel (QST) and structured and reinforced steel (BST) through two categories: performance and composition. The LESS label is now established as its own organisation, and makes use of this methodology to classify companies and provide information on the class of performance of steel production (LESS AISBL, 2025).

Another important framework comes from the Climate Bonds Initiative. The organisation works on certifying climate bonds by analysing the climate integrity of companies' assets, and it has developed specific Steel Criteria that set a climate change benchmark for decarbonisation measures. The framework adopts a split trajectory approach, including both primary and secondary pathways. For primary steel production, the intensity threshold in 2020 was 2,380kg CO_2e/t, decreasing every five years to 120kg CO_2e/t by 2050. For secondary (scrap-based) steel products the threshold in 2020 was 750kg CO_2e/t steel, gradually decreasing to 120kg CO_2e/t steel by 2050. Company emissions are assessed against a combined pathway derived from the primary and secondary trajectories. If emissions are below target, the entity qualifies for Tier 1 certification, indicating alignment with a pathway to limiting warming to 1.5°C. If emissions exceed the target, the entity may receive a Tier 2 certification, provided it demonstrates a credible plan to align with 1.5°C by 2030 (Climate Bonds Initiative, 2024).

An additional initiative is the Steel Climate Standard, developed by the Global Steel Climate Council (GSCC), which provides a framework aimed at guiding the steel industry towards decarbonisation. It sets a target for carbon intensity for steel products in 2050 of 120kg CO_2e/t of hot-rolled steel. Companies seeking certification must develop a customised decarbonisation trajectory based on their baseline year emissions and the Steel Climate Standard Decarbonisation Glidepath. The GSCC framework does not differentiate based on primary or secondary production. To obtain the certification, companies are required to undergo third-party verification of their baseline and set a science-based emission target (SBET) within two years of joining the GSCC, and to establish interim targets to be achieved within five to 10 years from the base year (GSCC, 2024).

The China Iron and Steel Association (CISA) submitted a proposal in 2024, developed with dozens of steel companies and research institutes, called the 'Methods for the assessment of China decarbonized ecological future-oriented (C2F) steel', referred to as the Chinese Method C2F Steel (CMC2FS) (CISA, 2024). The standard delineates the emission accounting boundaries and emission sources, along with the requirements and evaluation methods for hot-rolled steel products with an alloy content of less than 10%. Most of the performance levels are the same as those determined by the IEA, with class A, the most stringent, set at 400kg CO_2e/t and 50kg CO_2e/t, respectively for 0% and 100% scrap use. Due to the production structure in China and low availability of post-consumer steel scrap, with the primary route representing around 90% of the total production, most of the Chinese production ranks among the higher emission thresholds.

Finally, the Indian Ministry of Steel has also set out its own standards for green steel and produced a green steel taxonomy. The framework establishes green steel as being steel with CO_2e emission intensity of less than 2.2t CO_2 per tonne of finished steel, introducing a star rating system where five-star steel has an emissions intensity below 1.6t/tCO_2, four-star 1.6–2.0t, and three-star 2.0–2.2t (Ministry of Steel, 2024). These ratings will be incorporated into government public procurement of steel in India. The EU has also been developing a proposal for a green steel labelling system as part of its European Steel and Metals Action Plan (European Commission, 2025).

With a wide variety of definitions and emission thresholds, it may seem daunting to assess low-carbon steelmaking. However, some common threads can enable a broader understanding that is important to supporting companies and countries in moving forward into more sustainable production patterns. Exact threshold values might differ across methods, but the scrap sliding scale approach is essential to ensure comparability in decarbonisation efforts across both iron-based and scrap-based steelmakers. Overall, these different frameworks provide a significant foundation to understand both what companies and countries should strive for regardless of their own emissions, and what customers should expect and value when accessing this market.

Table 2.1 compares the standards discussed above.

Table 2.1. Comparison of the different low-carbon steel standards

Initiative/ standard	Methodological approach	Quantitative threshold (0% scrap use)	Quantitative threshold (50% scrap use)*	Quantitative threshold (100% scrap use)
International Energy Agency (IEA)	Sliding scale	400kg CO_2e/t	225kg CO_2e/t	50kg CO_2e/t
Responsible Steel	Sliding scale	400kg CO_2e/t	225kg CO_2e/t	50kg CO_2e/t
Low Emission Steel Standard (LESS)	Sliding scale	(i) Quality steel (QST): (500kg CO_2e/t) (ii) Structural and reinforcement steel (BST): (490kg CO_2e/t)	(iii) Quality steel (QST): (165kg CO_2e/t) (iv) Structural and reinforcement steel (BST): (185kg CO_2e/t)	(v) Quality steel (QST): (170kg CO_2e/t) (vi) Structural and reinforcement steel (BST): (120kg CO_2e/t)
Climate Bonds Initiative	Weighted pathway	(i) Primary steel (iron ore-based): 1,800 kg CO_2e/t by 2030; 120kg CO_2e/t by 2050 (ii) Secondary steel (scrap-based): 320 kg CO_2e/t by 2030; 120kg CO_2e/t by 2050		
Steel Climate Standard	Product-based Pathway (company-specific trajectory based on decarbonisation pathway for flat and long product)	(i) Flat products: 1,310 kg CO_2e/t hot rolled steel by 2030; 120kg CO_2e/t hot rolled steel by 2050 (ii) Long products: 1,110kg CO_2e/t hot rolled steel by 2030; 120kg CO_2e/t hot rolled steel by 2050		
Chinese Method C2F Steel (CMC2FS)	Sliding scale	400kg CO_2e/t	225kg CO_2e/t	50kg CO_2e/t

Note: The values for 50% scrap use are an estimation based on each method's standards.
Source: European Commission Joint Research Centre (2025)

The role of scrap steel in decarbonisation

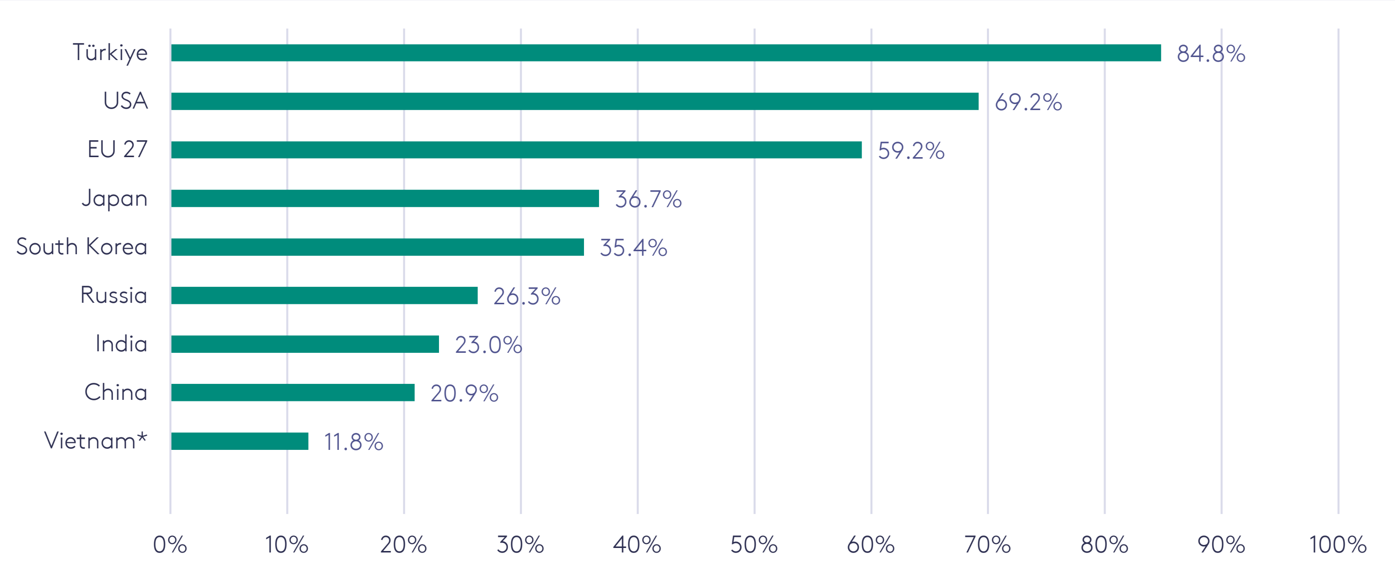
Scrap steel and circularity have a crucial role to play in decarbonising the steel sector. As the Introduction suggests, the most cost-effective and technologically available path to decarbonisation would be using electric arc furnaces (EAFs), renewable energy and scrap steel. However, there are some key considerations when exploring decarbonisation solely via the greater use of scrap steel. Estimates suggest that even if it were possible to recycle all the available scrap steel, improve circularity in the steel sector and undertake all the other necessary actions, the demand for steel would still outpace the supply that scrap steel alone could meet (Lee et al., 2024; Oda et al., 2013; Pauliuk et al., 2013).

The major steelmaking countries that have the greatest share in recycled steel and EAFs are listed in Figure 2.1. Türkiye is a unique case in that the scrap steel it uses for recycling is mostly imported from the EU, the world's largest market for steel, which also receives a large proportion of the exported recycled steel from Türkiye. The United States is among the leading countries for recycling steel and was one of the first of the major steelmaking countries to take up 'mini mills' at scale, the previous term for EAFs. The underlying economics of blast furnace (BF)-based steelmaking were not strong enough in the US and thus without a captive market like Japan or relentless state support like the EU's, the share of BF steelmaking withered. The US uses its domestic scrap steel extensively and recycles its steel, therefore, and is able to make most high-quality steel products via recycling and EAFs. As a result, US steelmaking has an low overall emissions intensity. The EU also recycles its steel but due to high electricity costs, among other reasons, does not recycle and use as much of its scrap steel for domestic recycling as the US does.

The key factor here is whether a country is able to rely on its own scrap steel for recycling, or can import scrap steel, such as is the case for Türkiye. Whether a country has a greater share of scrap is primarily determined by when it industrialised; those that did so longer ago possess a stock of steel that has reached the end of its life and is ready to be recycled. As the ambition and imperative to decarbonise the steel sector grows, scrap steel will become a more vital commodity. Early signs of protectionism of scrap exports can be witnessed in the EU steel action plan, where there is a warning of 'scrap leakage' from the EU (European Commission, 2025).

Global patterns of supply and demand for the trade and use of scrap steel will produce a new context where the common goal of decarbonising the steel sector will be challenged by the realities of differentiated access to scrap. Not only does the availability of scrap differ across locations, but the fact that lower availability impacts mostly EMDEs has significant impacts on technology choice for these countries. Lower availability of scrap in effect limits technology choice away from EAFs to primary steelmaking, which requires more expensive technologies. Therefore, scrap steel is not likely to play a major role in decarbonisation efforts in EMDEs, which will mean these countries will have to contend with more expensive options to decarbonise their steel industries.

Figure 2.1. Recycled steel as a share of total steel production, 2024 (%)

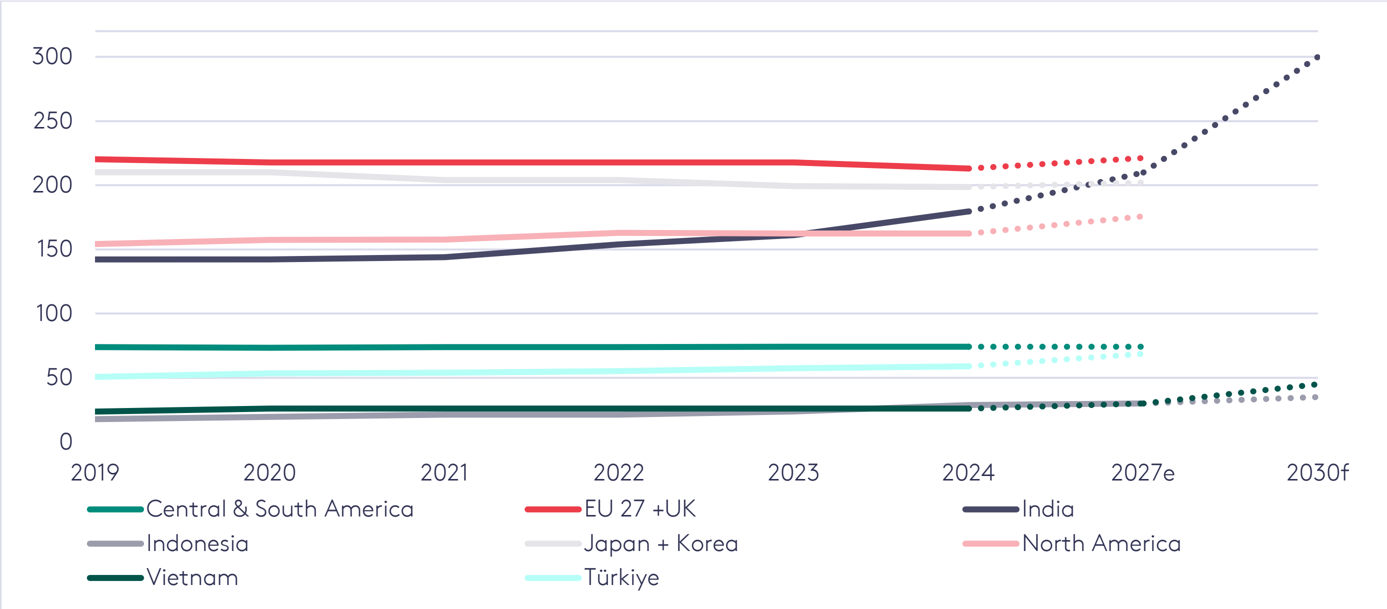


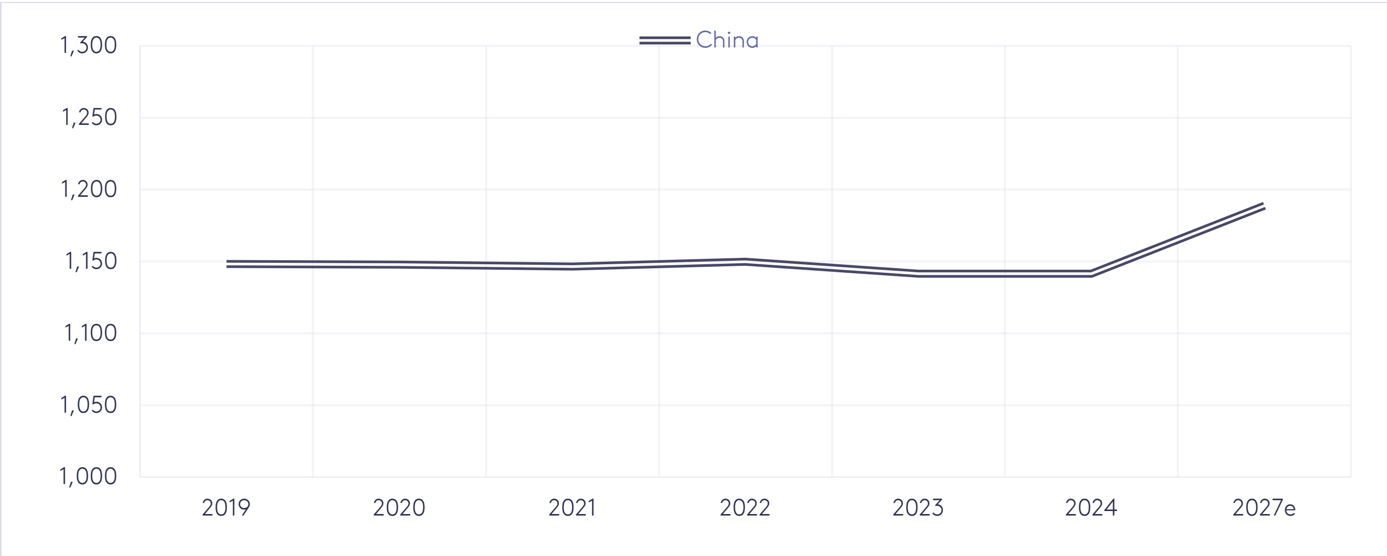
*Source: Bureau of International Recycling, Steel Radar for Russia (2025). *The Vietnam figure was estimated from quarterly scrap import data (OECD, 2024a).*

Current and projected capacity for low-carbon steelmaking

Global steel demand is projected to be flat overall in this decade, except for a few spots of rapid growth in steel capacity (OECD, 2024a). The world is currently struggling with steel overcapacity, caused primarily by China which has made profitability of the steel sector a concern for steelmakers from Europe to India. As a result, most steelmaking countries are not adding significant new capacity, but many are replacing existing capacity. The expansion of steel capacity is happening mostly in India, a country with very ambitious steel targets to 2047 (see Figure 2.2). A smaller but sizable expansion of steel capacity can also be seen in Indonesia and Vietnam. Most of this expansion will be through blast furnace-basic oxygen furnaces (BF-BOF).

Figure 2.2. Nominal crude steel capacity in major steelmaking countries and regions, 2019–2030 (million tonnes)





Note: 2027e figures are OECD estimates of installed capacity; we have taken their high scenario. 2030f figures are forecasts of steel capacity expansion taken from the high-growth steel markets where national governments in India, Vietnam and Indonesia have all stated capacity targets for 2030. The dotted lines represent estimates and forecasts.
Source: OECD (2025b, 2024a); IESR – Indonesia; Vietnamnews – Vietnam; India Steel Policy – India.

In this report we are primarily concerned with the expansion of capacity by either existing steelmaking facilities or on greenfield sites. For most companies in the countries where we see capacity expansion, namely India, Indonesia and Vietnam, there are very few low-carbon steel projects within the expansion plans. Among the companies that do have some low-carbon steel in their expansion plans, there are a few EAFs. In the case of those that are potentially direct reduced iron (DRI) EAFs, it is unclear if those projects will materialise (CTA, 2025a, 2025b, 2025c). The annual reports of the large Indian firms have laid out scenarios of capacity expansion wherein they mention potential DRI-EAF plants. However, in those scenarios, they set them up in phases and our assessment of those phases makes execution of those commercial-scale DRI-EAF plants seem unlikely. In the case of the largest firms in Indonesia and

Vietnam, we see limited low-carbon steel in their capacity expansion.[3] There have been many announcements of EAFs in Vietnam, but we are unable to corroborate these announcements.

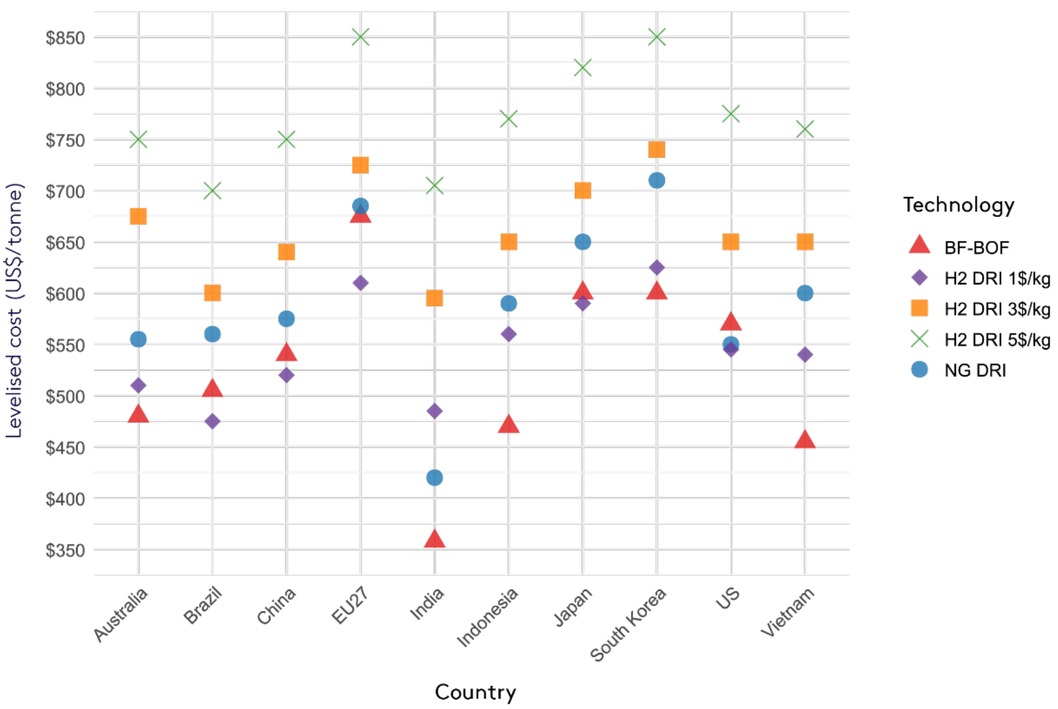
The expansion of blast furnaces and blast oxygen furnaces in these markets mostly occurs on brownfield sites, where existing plants are being expanded. In a few instances, gas-based DRI facilities are being expanded, such as in the case of JSW Steel and its Vijayanagar plant.[4]

These expanded BF-BOFs and new BF-BOFs will lock in steel emissions for decades to come. BF-BOF plants can last 40 to 50 years (GEM, 2022). While that might still be within the net zero target years for some of the countries expanding steel, unless a proper accounting of new emissions is budgeted against that net zero year, one must assume these will be unabated current and future emissions.

Economics of low-carbon steelmaking

The economics of steelmaking are, as for most resource-intensive industries, highly dependent on the location/price of resources and energy prices. Historically, steel plants were located near iron ore and coking coal mines as these were the key ingredients for making conventional BF-BOF steel. Figure 2.3 shows the levelised cost of steel in different steelmaking countries. The costs are indicative estimates as steel plant costs naturally vary significantly. We have compiled these estimates from Global Efficiency Intelligence (Hasanbeigi et al., 2024) for all countries except India, which is not covered. For India we have estimated the costs using the literature on low-carbon steelmaking and green hydrogen pricing (Åhman and Arens, 2024; CEEW, 2023; Johnson et al., 2023; Tongia and Patel, 2024).

Figure 2.3. Levelised cost of steel production (LCOS) (US$/tonne)



Notes: Share of scrap in BF-BOF and DRI routes researched by Global Energy Intelligence amounts to 5% (Hasanbeigi et al., 2024). That study assumes a 60kg of hydrogen/t steel for the H_2 DRI routes, assuming 56 kWh needed per kg of H_2 is produced with the electrolyzer efficiency of 70%. We make the same assumptions for the India estimates. The natural gas DRI estimates are based on the following assumptions: 10.9 GJ/T-DRI, NG price of 13.5 US$/MMBtu (CEEW, 2021; Chatterjee, 2010). For India, we use an electricity price of INR 5.8/kWh and a total electricity consumption of 3.28 MWh/t steel, 2.75 MWh for H_2 production and 0.53 MWh for shaft/EAF.
Sources: Compiled by the author for all countries except India from the following sources: Hasanbeigi et al. (2024); Hasanbeigi, Springer, Savel, Truong, et al. (2025); Hasanbeigi, Springer, Savel, Valeriz, et al. (2025). India estimates compiled by author (Åhman and Arens, 2024; CEEW, 2021, 2023; Tongia and Patel, 2024).

[3] Note that a project by an Indian firm to supply green hydrogen-derived iron to a Vietnamese steelmaker has been announced, but there is no certainty that it will go ahead (Collins, 2025).

[4] See this roadmap by TERI which explores different phasing-out scenarios of gas-based DRI.

The prices show a great divergence in the levelised cost of crude steelmaking in different countries, even for BF-BOF. We must note that this is for crude steel and that quality of steel and usability of this crude steel might not be the same across different steel plants with variation across countries depending on the quality of their inputs. However, it is a good overall indication of the fundamental underlying costs of steelmaking via these different technologies. As mentioned above in relation to the lower-carbon iron-making direct reduction plants (DRPs), low-carbon electricity is an outsized share of the levelised cost. Thus, countries that are able to produce cheap low-carbon electricity and, as a result, either green hydrogen or iron reduction directly via electricity, will have a competitive advantage in low-carbon steelmaking.

The levelised cost for low-carbon steel made using green hydrogen has the potential to be quite competitive in the international low-carbon steel market, especially given lower electricity prices in many emerging markets like India.

Estimates for the use of green hydrogen vary between 50 and 80kg (Bhaskar et al., 2020) for a tonne of steel, given losses of energy and other constraints. Our assessment of 60kg used in the estimates for Figure 2.3 falls within this range. The low natural gas (NG) DRI estimate for India is constrained by limited natural gas availability in India and a reliance on imported gas, which would expose any of the levelised cost of steel (LCOS) for NG DRI to international liquefied natural gas (LNG) gas prices.

There are several political economy factors at play here, which may be observed in the large variations in the estimates for most countries. In the case of India, the estimated average cost of BF-BOF steelmaking may appear exceptionally low, but this is likely to be a reflection of the reality due to the vast heterogeneity and complex cost structures in Indian steelmaking (Dasgupta, 2017). However, the overall cost structure reflects the very high cost of conventional and low-carbon steel in many developed markets relative to the cost in EMDEs. This contrast is even more stark when it comes to the low-carbon steel options, whose main variable is the price of low-carbon electricity. The fundamental advantage of many EMDEs and markets like Australia in this regard is now well-known and it has been suggested to export hot briquetted iron or DRI from these countries (Agora Industry et al., 2021; Li et al., 2025).

3. State support for low-carbon steel projects

There has been growing recognition that low-carbon steelmaking is not yet commercially viable and therefore requires state support. Many countries around the world have responded and begun specific low-carbon steel support programmes for projects. We have collected project-level information from a selection of countries where specific subsidies to steel companies for projects and low-carbon-steel-specific state support have been announced. Our findings are presented in this section.

There are a variety of forms of state support for low-carbon steel projects. We focus on direct state CapEx support, though we also describe some of the larger OpEx state support programmes set up in Europe and Japan. We have attempted to isolate the subsidies to the low-carbon steel alone to be able to draw conclusions on what makes low-carbon steel projects financially viable in different locations and markets. However, many schemes, particularly for green hydrogen, often mention steel among other sectors but do not offer any breakdown of the allocation to the steel sector. We recognise that some schemes, including green hydrogen projects such as the European Hydrogen Bank, may have some overlaps with decarbonisation of the steel industry. However, the scope of this report does not lend itself to such investigations at present. Thus, we have only incorporated the schemes where either the breakdown is available or where the scheme is specific to the steel sector (see further below).

In presenting the findings, we first show all the low-carbon steel projects where we have information on what the value of state support was, the size of the plant, the technology of production, and the total cost of the project. Our goal is to demonstrate the varying levels of state support that have been agreed upon for a low-carbon steel project to be announced. It is not necessarily the case that all projects in our dataset will be built. Our analysis also reflects projects that are currently in limbo.

We separate the analysis of direct CapEx grants for projects and overall state allocation for supporting low-carbon steel in dedicated funds. Since some states have also set up separate schemes to support low-carbon steel via either OpEx or other support schemes, we briefly touch on the regions that have set up such schemes, as those allocations are not captured in our dataset.

Method and dataset

We employ a mixed method approach combining analysis of steel production capacity, carbon intensity assessments, and a novel database of state support for low-carbon steel projects that have been announced. We collected these data through company annual reports, press releases, EU documents, official policy announcements and Kallanish Commodities' green steel monitor. We use the latter as a proxy to estimate and demonstrate that for low-carbon steel projects to take off in most places in the world, significant grants and subsidies will be essential. As mentioned above, we do not presume that all the projects will materialise, but merely present these as projects for which governments and companies have issued either a press release or made a public announcement with details of financing and showed intent to construct said projects. For instance, appearing in our dataset are low-carbon steel projects led by ArcelorMittal with state support in Germany that have since been dropped by the company (as reported in Reuters, 2025). We therefore make the distinction between the announcement and firmer commitment of funds.

Over the years, many pilot projects have been supported in various countries worldwide to test different technologies for producing low-carbon steel. We have aimed to include only projects that were of commercial or near-commercial scale, although this distinction is not always clear. Consequently, some projects with low production volumes, state support and investment are included in our dataset. We have assessed these projects as not being pilots and thus included them in the analysis. The full list of projects that we included in our analysis in Figure 3.1 can be found in the Appendix. The figure only includes projects for which we were able to find all necessary data. Other types of state support have been announced and or committed but are not project-specific (see also the Appendix and Figure 3.2). For instance, a project in the Netherlands by Tata Steel has been in discussion for state support from the Dutch government (The Economic Times, 2024), but we are unsure if commitment has been made to the project. Therefore, it is included in Figure 3.2 but not in Figure 3.1. In addition, some countries have announced state support for the steel industry, but not in relation to a specific project. The country-level support for steel can be found in Figure 3.3, and the full list of such schemes is provided in the Appendix. For example, the UK has announced a green steel fund of £2.5 billion, which has not been allocated to a specific project. Thus, the £2.5 billion is included in Figure 3.3, as is the UK's support for the Port Talbot steelworks in Figures 3.1 and 3.3.

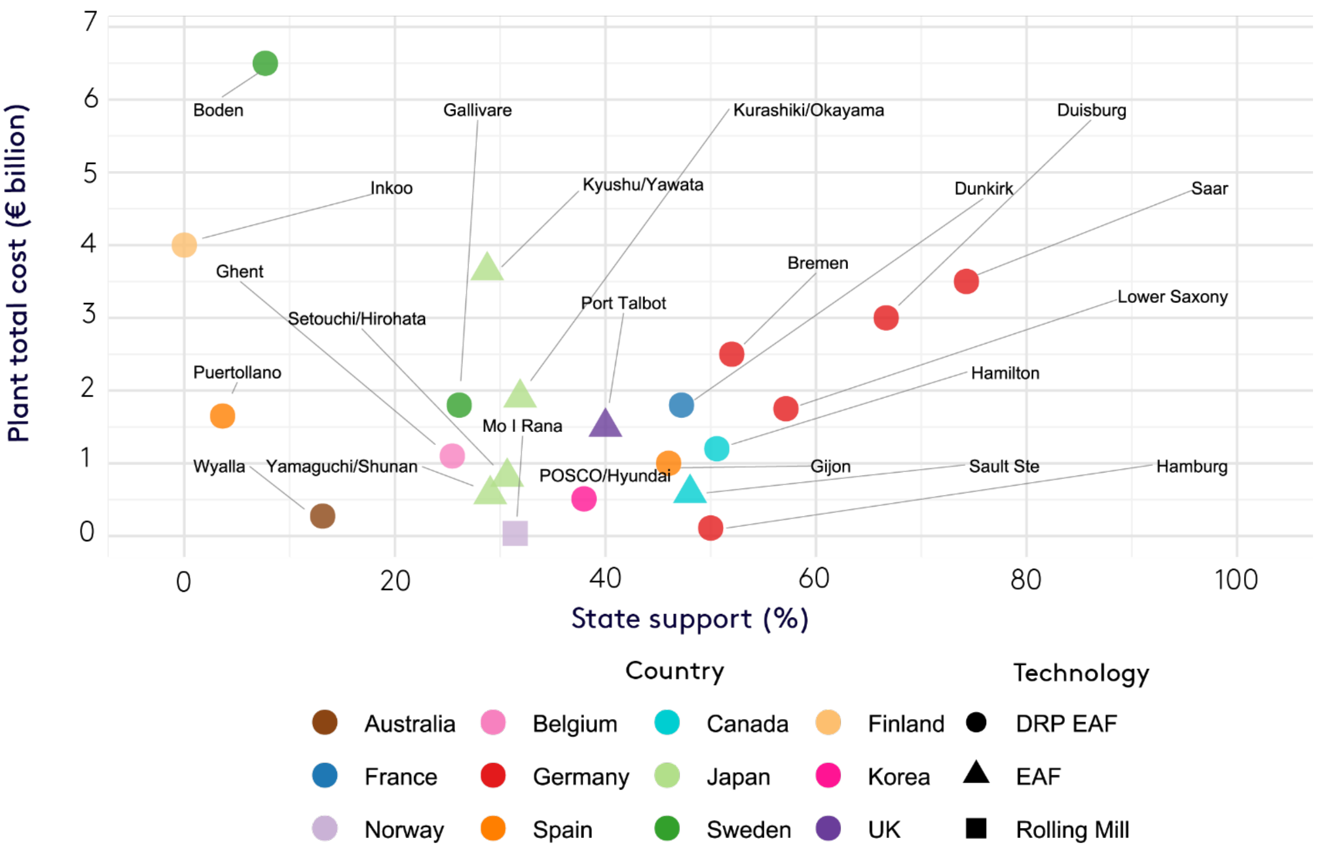
Limitations to our dataset are discussed in Box 3.2 at the end of this section.

Findings from a global comparison

Our analysis of direct CapEx support for low-carbon steel projects reveals stark geographical disparities in both the scale and distribution of state support globally. Figure 3.1 illustrates the range of CapEx support provided to individual low-carbon steel projects worldwide, showing that European projects dominate the landscape. Projects in Germany, such as those in Duisburg and Lower Saxony, have secured substantial state backing, ranging from 30% to over 50% of total project costs. This aligns with findings that European steel decarbonisation efforts require significant public funding, as the transition costs for hydrogen-based steelmaking are estimated to be approximately double those of conventional coal-based production (IEA, 2022; Vogl et al., 2021).

In light of ArcelorMittal's recent withdrawal from hydrogen-based direct reduction iron (H_2DRI) projects in Europe, we have expanded the scope of the category to include direct reduction plants (DRPs). Most countries have supported the low-carbon ironmaking and steel process while a few, notably Japan, have given state support to large steel firms to turn off blast furnaces and set up electric arc furnaces (EAFs) only. The UK has done the same with the Port Talbot steelworks in South Wales. A Canadian EAF project at Sault Ste. Marie, Ontario has also received support, with similar conditions.

Figure 3.1. CapEx support for low-carbon steel projects

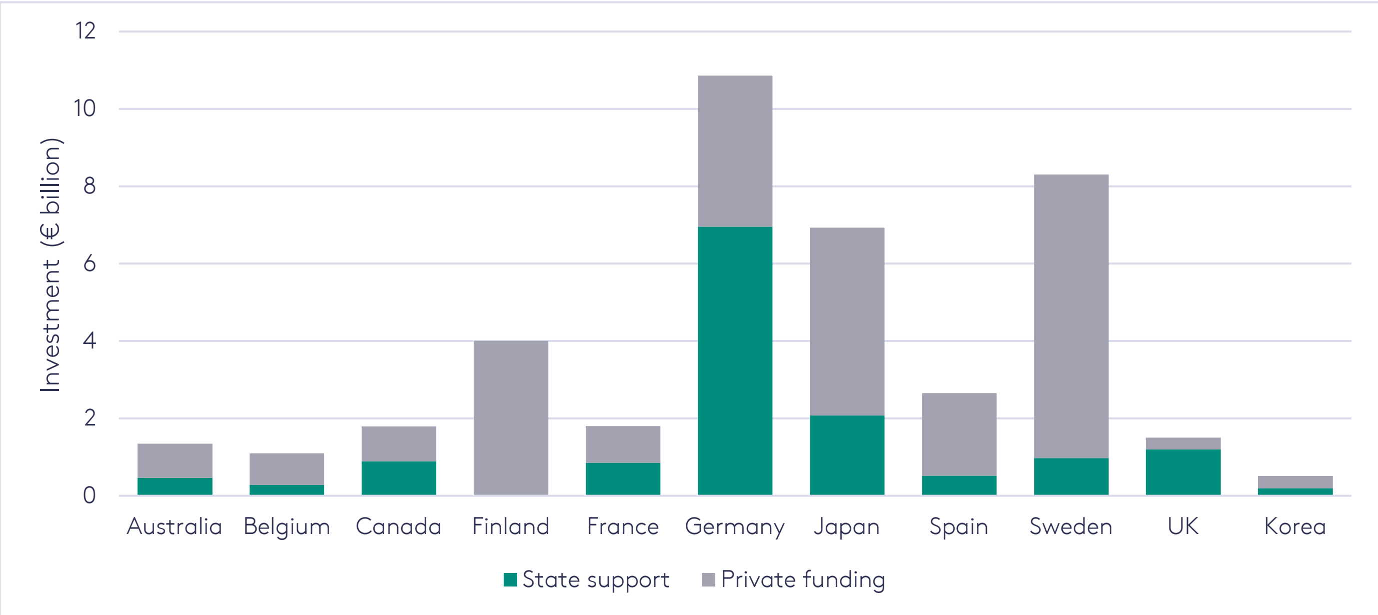


Note: The projects are named by their location. They are detailed further in Appendix Table A1. The Mo i Rana plant was a very small investment in the millions and therefore appears low on the chart.
Source: Compiled by author from EU documents, government announcements/policies, company press releases and news articles; see Appendix Table A2 for details.

The projects that have needed the least state support are located in areas with plenty of access to low-cost renewable electricity: the projects in Sweden, Finland and Spain are such examples. The Stegra project located in Boden, Sweden, also secured off-takers who were willing to pay a premium for its steel, further reducing the need for state support (ICIS, 2025). The project announced in Australia also seems to have a similar advantage.

Figure 3.2 aggregates this project-level data by country, revealing that Germany has the highest total committed CapEx support for low-carbon steel projects, followed by other European nations including France, Belgium and the Netherlands. State aid in these countries also comes in the form of loan and credit guarantees. This concentration of support in Europe reflects the continent's ambitious climate targets and the recognition that steel decarbonisation requires substantial public intervention to overcome market failures and first-mover disadvantages. Notably, while Japan has announced significant support through its Green Innovation Fund, the committed project-level support remains lower than in its European counterparts, despite Japan's steel industry accounting for approximately 14% of its national CO_2 emissions.

Figure 3.2. Countries supporting low-carbon steel via CapEx grants to specific projects

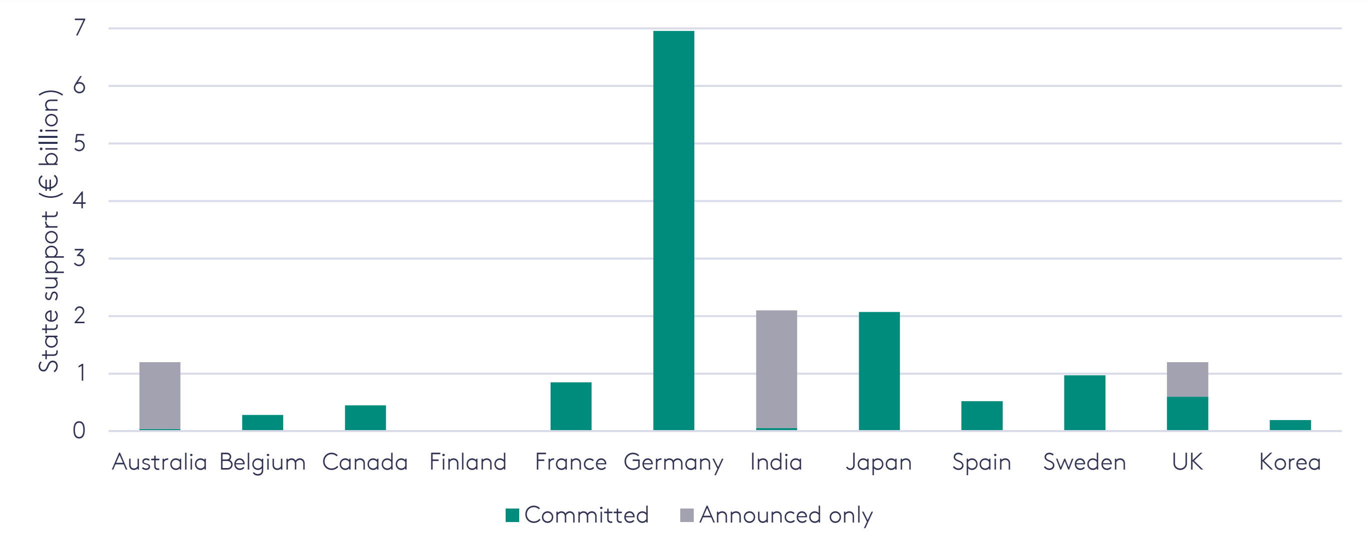


Source: Compiled by author from EU documents, government announcements/policies, company press releases and news articles; see Appendix Table A2 for details.

Figure 3.3 presents a broader picture by distinguishing between announced and committed state support for low-carbon steel. The data reveal a significant gap between policy announcements and actual financial commitments in most countries. While countries such as India have announced ambitious support schemes totalling 15,000 crores[5] INR for steel decarbonisation, the translation into committed project-level support remains limited. This implementation gap is particularly pronounced in EMDEs, where despite rapid capacity expansion plans, the financial mechanisms for supporting low-carbon steel transitions remain underdeveloped. The contrast is striking when compared with European countries, where announced funds are more rapidly translated into committed project support, facilitated by established frameworks such as the EU Innovation Fund.

[5] 1 crore indicates 10 million Indian rupees.

Figure 3.3. State support announced or committed by countries for low-carbon steel



Source: Compiled by author from EU documents, government announcements/policies, company press releases and news articles; see Appendix Table A2 for details.

The geographical concentration of support raises critical questions about global steel decarbonisation pathways. While developed nations are investing heavily in transforming existing capacity, EMDEs (excluding China) – where the majority of new steel capacity is being added – receive minimal support, domestic or international, for low-carbon technologies. This disparity suggests that without international cooperation and financial mechanisms, the global steel sector may face a two-speed transition, potentially undermining collective climate goals. Box 3.1 below explores one such pathway, through the Climate Investment Funds' Industrial Decarbonisation Accelerator.

OpEx support in Europe

Europe has positioned itself at the forefront of the global steel decarbonisation effort, deploying the world's most comprehensive and financially ambitious support mechanisms to transform one of its most carbon-intensive industries. Recognising that the transition to green steel faces fundamental economic barriers that market forces alone cannot overcome, European governments have committed to unprecedented levels of public investment and innovative policy instruments. This support is likely to continue as states strive to stem the exodus of many steel firms from the European market and the widespread withdrawal from low-carbon steel projects.

Operational expenditure (OpEx) support is critical for European steel decarbonisation, as green production routes face substantial cost disadvantages compared with conventional methods. The financial need through to 2030 is estimated at €54 billion for OpEx, significantly exceeding the €31 billion required for capital investments. This OpEx challenge stems primarily from higher energy costs associated with hydrogen-based steel production (Eurofer, 2022). Hydrogen-based steel is about twice as expensive as coal-based steel, with green hydrogen prices reaching €5–6/kg, compared with €2.40/kg for grey hydrogen. The future costs of hydrogen-based steel production are highly uncertain, since they depend on the future costs of renewable hydrogen and electricity.

Carbon Contracts for Difference (CCfDs) are a project-based financial instrument through which the government would guarantee companies a fixed carbon price level for emission reductions below a benchmark over a specified period. They are essential during the transition phase (Somers, 2022). When the realised carbon price is below the CCfD price level, the government pays the industrial company a premium on the carbon price. On the other hand, when the carbon price exceeds the agreed CCfD price level, the company pays the difference back to the government. Thereby, CCfDs act as a hedging instrument against the incremental costs and uncertainties of climate-friendly steel production by reducing the carbon-price risk for the companies and enabling long-term financial planning (Richstein, 2017; Richstein et al., 2024; von Lüpke et al., 2022). CCfDs address both operational and capital expenditure challenges in steel decarbonisation. Additionally, they are designed to absorb losses and can act as an additional subsidy instrument. Energy-intensive industries will be compensated by climate protection agreements for a period of 15 years to cover their additional costs. CCfDs

The European Commission approved a €4 billion German CCfD scheme in February 2024, with the first auction launching on 12 March 2024, and companies given four months to submit bids. In October 2024, 15 companies received a maximum of €2.8 billion in total to reconfigure their manufacturing processes, though the Economy Ministry noted the earmarked sum of €2.8 billion is unlikely to be used in full, depending on energy and carbon price developments. While specific allocations to individual companies were not disclosed, companies from sectors including steel, cement, paper, glass and chemicals are eligible, with five of the funded companies planning to decarbonise using hydrogen (BMWE, 2024; European Commission, 2024). The first round of disbursements did not include steel companies, though a second round was announced earlier this year. It is not clear if steel companies are to be allocated some of this support, but they are part of the group of firms that are eligible to make applications.

OpEx support in Japan

In Japan, OpEx support has been defined within boundaries that limit a firm's access to tax credits depending on their transition from BF-BOFs to EAFs. Firms already operating EAFs are not eligible for the subsidy offered under the so-called 'Tax System to Promote Domestic Production in Strategic Domains'. This programme offers JPY 20,000/tonne (around US$130) for green steel production. However, the ministerial orders only cover plants that are in the process of converting their equipment. State support is further dependent on quality controls for the EAFs, including a requirement for companies that have transitioned from BF to EAF to achieve 50% carbon emission reductions compared with their pre-transition operations and produce high quality steel. These quality controls do not address 'tramp elements' (impurities such as copper and tin) in scrap-based EAF-made steel.

In January 2025, a new subsidy criterion was added to the scheme to subsidise clean electric vehicles (CEVs) using 'green steel'. A subsidy of up to JPY 50,000 (around US$330) is to be given to each vehicle made using 'green steel' on top of the JPY 850,000 given for low-emission vehicles. However, not only was this announcement surprising, with no blue-ribbon panel discussing its design or implications, but the scheme fails to define what qualifies as 'green steel'. Another concern has been whether mass-balanced products may be defined as green steel in this case. The Japan Iron and Steel Federation's (JISF) updated guidelines have endeavoured to reflect concerns about classifying mass-balance-approach steel as 'green' and are using a new term, 'GX steel', which is "steel to drive the 'Green Transformation (GX)" (JISF, 2025). The Japanese government's Study Group defines GX steel as "steel products that have a significant environmentally favourable impact due to additional direct emission mitigation actions on a company-by-company basis, and that experience a significant price increase compared to general products when the costs associated with these actions are included" (METI, 2025, p. 27).

It is unclear whether EAF-made steel made by existing, rather than transitioning, producers would qualify for this subsidy. Scrap-based steel, which is far more cost-competitive, is even less likely to be accredited under this scheme. However, in March 2025, the Japanese government explained several items for the CEV subsidy, stipulating conditions for CEV electricity consumption per kilometre, the installation of charging points for CEVs, stability of supply, and sustainability in terms of the life cycle assessment (LCA) of the vehicles, among other conditions. The announcement also clarified that the subsidy of JPY 50,000/CEV is to be awarded separately where CEVs are produced using GX steel. This updated definition indeed points to a strong likelihood that the JPY 50,000/CEV subsidy will be awarded mostly to mass-balanced steel rather than EAF scrap-based steel which has no additionality or significant price rise. The scheme's targeting of new low-carbon products with additionality will thus leave out the already low-carbon EAF scrap-based steel. On the other hand, the CEV subsidy has been designed in the wider context in which most of the 'high-grade non-oriented electrical steel sheet' used in the automotive industry is currently made through the BF-BOF route, and demand cannot be met by the existing fleet of EAFs. Therefore, the scheme's main goal is to stimulate the expansion of 'next-generation EAFs'.

State support in China

Half of the world's steelmaking capacity is in China, making it a dominant player in steel-related issues and among the leading origins of global steel oversupply. In the aftermath of the World Trade Organization membership expansion at the turn of the 21st century, global steel markets were flooded with cheaper, conventionally-made steel from China, inviting retaliation from the EU, India, the USA and Japan, which took measures to reduce Chinese steel imports (Bureau of Industry and Security, 2025). These measures included making distinctions between types of steel through the introduction of steelmaking specifications. Establishing 'green steel' as a category of steelmaking has been part of this effort, as most Chinese steelmaking uses conventional BF-BOF with high emissions (Chen et al., 2021).

Until recently, efforts to decarbonise the Chinese steel sector were stalling, with investments in conventional steelmaking exceeding US$100 billion from 2021 to 2024 (Shen, 2024). Since the early 2020s, state-owned steel enterprises have announced a raft of green steel projects, ranging from the construction of EAF plants to adapting existing furnaces to process scrap steel, and installing technologies for carbon capture, utilisation and storage (CCUS). Investments in these projects reflect their ambition and size, with some pilot projects designed for modest capacity – for example, the Angang Group Green Hydrogen Zero Carbon Project at its Bayuquan plant, which has a capacity of only 10,000 tonnes per year (GMK Center, 2025) – while others have necessitated investments in the billions of yuan, such as the full-scale Jing'an Nonferrous Metal Materials Company's green hydrogen-based EAF plant construction at Naiman Banner in Inner Mongolia (SMM, 2023).

The dominant form of state support in China to subsidise conventional steelmaking is the offer of below-market-rate debt products. This is done on a monumental scale: China's rate of subsidisation is ten times that of OECD countries, with average subsidies being five times higher than the other partner economies (OECD, 2025b). State-owned enterprises (SOEs) receive the highest rates. The OECD reports that national and regional governments play a pivotal role in providing financial incentives for the steel sector, more recently focusing on support mechanisms aimed at energy efficiency and reducing emissions (ibid.). The OECD estimates below-market-rate borrowing by comparing "the actual interest rates charged to firms against hypothetical benchmark interest rates that could have been charged in a private market, based on the characteristics of the borrower" (ibid.).

The Chinese government makes direct investment policies and tax incentives in addition to subsidies. Further financial channels such as bonds, equity financing and funds are also being developed. For example, the China Baowu Steel Group has launched a 'Low-Carbon Transformation "Belt and Road" Corporate Bond', from which 70% of the funds raised must be used for low-carbon and Belt and Road Initiative (BRI) projects (China Baowu Steel Group Corporation Ltd, 2024). Similarly, Baosteel has a 'Green Corporate Bond' (Boashan Iron & Steel Co., Ltd., 2022), while HBIS recently released a prospectus for its third 'Green Medium-Term Note' with issuance of up to RMB 10 billion in green perpetual bonds (HBIS Group Co., Ltd., 2025). Moreover, the Chinese government has mandated measures applicable to investments in low-carbon technologies, establishing funding limits for projects depending on their specifications. For example, under the 'Administrative Measures for Special Investments in Energy Conservation and Carbon Reduction from the Central Budget', a project for advanced low-carbon technologies may receive up to 30% in government funding, while circular economy projects will only receive half as much from the government (National Development and Reform Commission, 2024). Wider climate projects linked to heavy industry decarbonisation come in various forms, including the establishment of ecological buffer zones, as is the case in Dali City's Erhai Lake (NGDF, 2021).

Chinese state subsidies to steel firms remain highly opaque. China has announced a series of low-carbon steel projects, but the level of state support made to these firms either through national government or provincial governments remains unclear. Some early evidence about these low-carbon steel products suggests that below-market-rate borrowing methods are being leveraged to subsidise these projects in a similar way to conventional steel firms. There is a clear need for state-driven financial assistance in China to boost the transition of the steel sector. Recommendations have been made by the Climate Bonds Initiative (CBI) for an expansion of interest subsidies and other below-market-rate borrowing to overcome the stagnation in the Chinese steel sector's green transition (CBI, 2025). Some banks are already offering transition loans of this kind, such as in Huzhou where banks are offering loans with a 50-

basis point interest subsidy for firms on the condition that they meet their scheduled transition targets (ibid.). Although many green steel projects, including several that involve installing H_2DRI technologies and EAFs, are only due to become operational from late 2025 at the earliest, there is an observable shift in the scale of transition finance in China. In 2024, the balance of China's green loans reached the equivalent of US$5.1 trillion – an increase of 21.7% from the previous year (ibid.).

Table 3.1 below lists some of the projects that have been launched in China in recent years for which we do have investment numbers (note that the list is not exhaustive and some projects do not have available breakdowns but only total investment figures). The full list of low-carbon steel projects in China that we were able to find is provided in Appendix Table A2.

Although specific details and figures remain difficult to obtain, CBI has been able to collect a series of announcements made by provincial state-owned banks that speak to below-market-rate borrowing for the steel sector. The Hebei steel guidelines released in 2023, though not issued directly by the People's Bank of China (PBOC), are a significant document outlining the investment requirements for such a large-scale transition. Hebei is the largest steel-producing province in China and the origin of 11% of the world's steel (CBI, 2024). The Hebei branches of several Chinese banks had sourced a total of 26.3 billion yuan in transition loans for steel companies located there by the end of 2024. These loans are between 50 and 150 basis points lower than non-transition loans. Other provinces, such as Jiangsu, have seen loans of 100 million yuan offered at discounts of 30 basis points (CBI, 2025). The PBOC has also extended its green lending scheme until 2027, offering 60% of funding for loans for a year at a rate of 1.75% (Green Central Banking, 2024). The Jiugang project in Gansu, listed above, provides another clear example of below-market borrowing rates, with the first 1-billion-yuan instalment of a 2.6-billion-yuan package for equipment upgrades provided at an estimated 50 basis points lower than the loan interest rate of the same period (Jiugang Group, 2025). This below-market-rate loan makes up more than half of the 4.4-billion-yuan invested in the decarbonisation project so far.

We are unable to put a numerical value on the extent of state support that China is providing for low-carbon steel, given the political economy of state support in China and the dynamics of the regional and national governments in handing out state support. While China is currently following a similar strategy as it did for conventional steel when it comes to low-carbon steel, by supporting these firms and projects with below-market-rate debt products, the extent of this support is unclear. This is because project-level financing information is unavailable; the OECD uses the firm-level balance sheet to make its estimates. Given that a firm may have multiple high-carbon and a few low-carbon projects, distinguishing the financing for the low-carbon project becomes a challenge. Nevertheless, it is clear that the state in China is supporting low-carbon steel projects and will likely increase the extent of its support in the coming years

Table 3.1. Financing green transition projects in the Chinese steel sector

Company	Project/plant and location	Technology	Type of green steel	Year online	Total investment in yuan (calculated at Market Exchange Rates)	Size of plant	Notes
Gansu Jiu Steel Group Hongxing Iron and Steel Co. Ltd.	Jiugang Steel Plant, Gansu	Smelting and rolling mill equipment upgrade	Low-carbon technical upgrades	2025	4.4 billion yuan, of which 2.6 billion yuan in credit loans from Jiayuguan bank branches	1.76 Mt/year	1 billion yuan loan already disbursed has a term of 15 years and an interest rate of around 50 basis points lower than loan interest rate for the same period.
Baosteel Zhanjiang Iron & Steel Co., Ltd (Baowu Steel Group)	Energiron H_2-DRI Plant and EAF, Zhanjiang, Guangdong	Energiron ZR (Zero Reformer) direct reduction technology, developed with Tenova and Danieli EAF supplied by Hitachi Energy	H_2-DRI, using natural gas, coke-oven gas and H_2 as reducing agents	2024	4.5 billion yuan	1 Mt/year	Largest DRI plant in the world using H_2, integrated with EAF project. Hybrid-ready design capable of achieving up to 96% metallisation with variable carbon content (0.5% with extensive H_2 use, up to 4.5% using NG).
Baotou Iron and Steel Group	CCUS Project, Baotou, Inner Mongolia	CCUS	CCUS	2023	180 million yuan loan from Ping An Bank (total amount not available)	2 Mt/year	Phase 1 to end in 2025 at capacity of 0.5 Mt/year, with aim of CO_2 reduction of 365,300 t/year. First 'whole chain' CCUS project in China.
HBIS Group	Green H_2-based EAF, Naiman Banner, Inner Mongolia	H_2-DRI integrated plant	Hydrogen steel production	2025	4.8 billion yuan	2 Mt/year	Large-scale hydrogen EAF; among China's biggest 'green steel' builds.
Inner Mongolia Jing'an Nonferrous Metal Materials Co., Ltd.	Naiman Banner, Inner Mongolia	Green H_2-based EAF	H_2 EAF	2025	5 billion yuan	2 Mt/year	Large-scale hydrogen EAF; among China's biggest 'green steel' builds.
ArcelorMittal × China Oriental (JV)	Jiuyuan Plant, Baotou, Inner Mongolia	EAF for hot-rolled steel	EAF low-carbon	2026	4.7 billion yuan	2.5 Mt/year	Government support confirmed as part of total investment.

Sources: Projects compiled by author from press releases, announcements (see notes to Table A2).

Box 3.1. Climate Investment Funds' Industrial Decarbonisation Accelerator

The Climate Investment Funds (CIF) launched its Industrial Decarbonisation Accelerator (IDA) Programme in 2024 to provide concessional financing for breakthrough industrial decarbonisation projects with typical ticket sizes ranging from US$10 to $50 million per project, structured to leverage additional commercial and development finance at ratios of 1:3 to 1:5. The fund aims to mobilise up to US$1 billion in concessional financing to support hard-to-abate industrial sectors, including steel, cement and chemicals, in EMDEs (CIF, 2024a). Initial pledges totalled approximately US$150 million from contributor countries including Canada, Germany, Japan and the United Kingdom. The fund explicitly targets middle-income countries in Asia, Latin America, Africa and Eastern Europe, where industrial emissions are growing rapidly but access to decarbonisation finance remains limited.

Eligible project types include capital expenditure for technology transitions (such as hydrogen-based DRI plants, EAFs and carbon capture systems); early-stage commercial demonstration of breakthrough technologies; and technical assistance for developing bankable project pipelines. Priority is given to projects that demonstrate potential for replication, include local capacity-building, and align with just transition principles (CIF, 2024c; World Bank, 2024; UNIDO, 2024). As of early 2025, the IDA CIF Programme had announced initial project development support in India, Indonesia, South Africa and Morocco, with a focus on steel sector transitions in India and Indonesia, given their significant planned capacity expansions. However, no major steel projects have yet received final funding approval, and the fund's impact on the scale of investment needed, which could be tens of billions of dollars across EMDEs, remains uncertain (CIF, 2024b).

The fund operates through multilateral development banks, including the World Bank, Asian Development Bank and Inter-American Development Bank, which serve as implementing agencies and provide co-financing alongside CIF resources (World Bank, 2024).

Box 3.2. Limitations to the dataset

Our dataset is not exhaustive and reflects the challenges of data availability and project status across different jurisdictions. Several significant projects and funding mechanisms were *excluded*, such as:

- Norway's Celsa, which has won a NOK 121 million subsidy for a hydrogen-based rolling facility.
- Voestalpine in Austria, which has secured a €300 million loan from the European Investment Bank for material efficiency.
- Acciaierie D Italia, which in 2025 is in the process of being sold but is in negotiations for an injection of state support for decarbonisation.
- Romania's LIBERTY Galati Steel, which is also facing viability concerns but might get state support for decarbonisation.
- Italy's Arvedi project, which applied for state support and funding but it is unclear it has been successful.
- Two projects in the USA were announced in 2024 for US$500 million each in state support for SSAB and Cleveland Cliffs, respectively. That funding has subsequently been rolled back.

Another major limitation of the dataset is its use of financing information from announcements and commitments as a proxy for the composition financing needs for low-carbon steel projects to reach a Final Investment Decision and, ultimately, construction and completion. As a result, it is unclear if there are cost overruns and further subsidies that are needed for project completion. Since many of these projects are at a nascent stage in their development, in a few years there would be more data points from the project details.

Since we began this study, some firms and projects in our dataset have abandoned their projects, citing reasons such as high energy costs. Notably, Arcelor Mittal announced in June 2025 that it will abandon two of its projects in Germany despite significant subsidies (Reuters, 2025). Similarly, the Stegra project in Sweden has announced financing woes and seems to have a €1.5 billion financing gap (Milne, 2025). We have kept these projects in our data; our core argument on the fundamental financing and underlying challenges is made even more pertinent in light of these exits. Despite extensive support from the state, the underlying unit economics do not support the viability of these projects so we believe it is important to include them in the analysis.

Another limitation is the type of finance this dataset and report cover. We only look at direct CapEx support in the form of grants or subsidies. We have separately addressed some of the OpEx schemes that have been made available. However, as the OECD has shown in its studies for conventional steel, the vast majority of state support in China comes in the form of below-market-rate borrowing and income-tax concessions (OECD, 2025b). Below-market-rate loans and tax concessions may also be used for low-carbon steel projects, but this nuance is not captured in this report.

For projects in EMDEs, we rely more heavily on company announcements and media reports due to limited independent verification mechanisms. Some announced projects, particularly in India and Indonesia, may face implementation challenges not yet publicly disclosed. We have attempted to corroborate information across multiple sources, but we cannot guarantee accuracy for all entries.

Despite these limitations, we believe our database represents the most comprehensive compilation of state support for low-carbon steel projects available at the time of writing and provides crucial insights into the geographical distribution and scale of public intervention in steel sector decarbonisation.

4. Conclusion: an evolving and complex landscape

As the capacity expansion of high-carbon steel assets doubles in this decade in EMDEs such as India, the challenge of decarbonising these assets after they are built will be significant. The experience from other sectors that are taking high-carbon assets offline in high-growth economies can provide learning for the steel sector about the use of different policy tools such as subsidies, along with insights about how to mitigate the impacts of rapid transitions on livelihoods, communities and workers. Each national context will be different, and so the just transition implications will differ between sectors and places. The just transition also remains an important consideration in the transition of all hard-to-abate sectors.

In this report, we have demonstrated that most steel decarbonisation projects are financially unviable without state support. Some regions and countries will have underlying advantages in the new green economy as the availability of resources such as cheap renewable electricity and scrap steel will shape where steel plants are best placed geographically in a low-carbon world.

In this context, supporting the green premiums for the new capacity for low-carbon steel in EMDEs becomes crucial if we are to decarbonise the steel sector globally. Existing financing tools such as the Climate Investment Funds' Industrial Decarbonisation Accelerator (see Box 3.1), while a good first step, mostly offer loans, whereas the work of this report shows that most low-carbon steel projects have had grants and subsidies as components to make their project finance work.

However, and while the focus of this report has been on state aid, in a context of dwindling development aid budgets from developed countries and subsequent challenges in securing grant climate finance for EMDEs, other options must be put on the table to address this challenge too. These options include global green lead market[6] partnerships (Quitzow et. al 2014; Beise and Rennings, 2005). There is also scope for more research into the potential for policy packages covering larger sections of the supply chain. Fiscal support will clearly be vital in steel decarbonisation; future research could explore mechanisms to design fiscal instruments in a cross-border manner and how to create optimal policy packages for specific regions and projects.

Many civil society and business-led market coalitions and associations have been announced in recent years, but few have really made clear the willingness to pay premiums and have yet to fully materialise. While some offtake agreements through initiatives such as the First Movers Coalition, SteelZero and the Sustainable Steel Buyers Platform have made some headway, business-led efforts remain limited. Thus, it would be vital to engage relevant governments directly if such an option were to be explored further.

Another option that has been suggested by multiple studies and researchers is to break up the steel value chain. This would entail making the green iron or hot briquetted iron in markets where there is either ample iron ore or low electricity prices and/or an existing steel industry.

Overall, some creativity is needed to increase the viability of opportunities for international partnerships and collaboration to enable the economics, finance and transition in the steel sector. The findings from this report point to a need for innovation on the matter of international cooperation. EMDEs especially face important challenges when it comes to decarbonising their steel sectors. Both CapEx and OpEx support is essential to ensure the viability of low-carbon projects. Moreover, issues surrounding essential transition resource availability, such as cheap low-carbon electricity and scrap steel supply, may be addressed through transnational partnerships to bridge Global North–South divides.

[6] A tool to create demand for climate-neutral products, green lead markets are fundamental to industrial decarbonisation.

Recommendations

The international community could consider:

- **Establishing an international fund** to support breakthrough low-carbon steel projects anchored and supported by Japan and the EU as major steelmakers taking significant decarbonisation efforts.
- **Leveraging partnerships with EMDEs** to enable low-carbon ironmaking and integrating emerging Asian economies into global supply chains for inputs like hot briquetted iron (HBI).
- **Designing support mechanisms** that provide both CapEx and OpEx support for private and state-owned steelmakers.
- **Exploring pathways for international participation** in lead markets to accelerate technology diffusion.

As countries and firms navigate the landscape of decarbonising the steel sector with linked priorities in the defence, geopolitical and re-industrialisation paradigms, the case for more bilateral and plurilateral cooperation in this endeavour has never been more important. We believe the fundamental value of this report lies in its novel dataset which sheds light on key issues such as resource allocation for the transition. We hope that this report may serve as a launchpad for further research on green industrial policy.

References

Agora Industry, Wuppertal Institut and Lund University (2021) *Global Steel at a Crossroads. Why the global steel sector needs to invest in climate-neutral technologies in the 2020s*. https://www.agora-energiewende.org/fileadmin/Projekte/2021/2021-06_IND_INT_GlobalSteel/A-EW_236_Global-Steel-at-a-Crossroads_WEB_V2.pdf

Åhman M, Nykvist B, Torres Morales E, Algers J (2023) Building a stronger steel transition: Global cooperation and procurement in construction. *One Earth*, 1421-1424.

Åhman M and Arens M (2024) Are electricity prices and cross-subsidies a barrier to decarbonising India's steel industry? *Utilities Policy* 91: 101853.

Beise M and Rennings K (2005) Lead markets and regulation: a framework for analyzing the international diffusion of environmental innovations. *Ecological Economics*, *52*(1), pp.5-17.

Bhaskar A, Assadi M and Nikpey Somehsaraei H (2020) Decarbonization of the iron and steel industry with direct reduction of iron ore with green hydrogen. *Energies* 13(3). MDPI: 758.

BMWE (2024) First round of carbon contracts for difference launched. Press release, 12 February. German Federal Ministry for Economic Affairs and Energy. https://www.bundeswirtschaftsministerium.de/Redaktion/EN/Pressemitteilungen/2024/03/20240312-first-round-of-carbon-contracts-for-difference-launched.html

Boashan Iron and Steel Co. Ltd. (2022) *Green Corporate Bond (Phase I) (Low-Carbon Transition) Prospectus Summary*.

Bureau of Industry and Security (2025) *Section 232 Investigation on the Effect of Imports of Steel on U.S. National Security*. U.S. Department of Commerce. https://www.bis.doc.gov/index.php/232-steel

Bureau of International Recycling 2025) *Steel Radar for Russia*.

Carbon Transition Analytics [CTA] (2025a) *JSW Steel: Company Report*.

Carbon Transition Analytics [CTA] (2025b) *Tata Steel: Company Report*.

Carbon Transition Analytics [CTA] (2025c) *JSPL: Company Report*.

CEEW (2021) *Greening Steel Moving to Clean Steelmaking Using Hydrogen and Renewable Energy*. New Delhi, India: Council on Energy, Environment and Water. https://www.ceew.in/publications/decarbonising-steel-production-using-hydrogen-and-renewable-energy-in-india

CEEW (2023) *Evaluating Net-zero for the Indian Steel Industry*. New Delhi, India: Council on Energy, Environment and Water. https://www.ceew.in/publications/how-can-india-decarbonise-for-net-zero-steel-industry

Chatterjee A (2010) *Sponge Iron Production by Direct Reduction of Iron Oxide*. PHI Learning Pvt. Ltd.

Chen J, Li S, Li X, Li Y (2021) *Pursuing Zero-Carbon Steel in China: A Critical Pillar to Reach Carbon Neutrality*. Rocky Mountain Institute (RMI).

China Baowu Steel group Corporation Ltd. (2024) *Public Offering of Technology Innovation and Low-Carbon Transformation "Belt and Road" Corporate Bonds (Phase I)*.

Climate Bonds Initiative [CBI] (2024) *The Steel Eligibility Criteria of the Climate Bonds Standard & Certification Scheme*. https://www.climatebonds.net/files/documents/Steel_Criteria_Feb-2024.pdf

Climate Bonds Initiative [CBI] (2025) *Targeted Incentives Key to Accelerating China's Steel Sector Transition*.

Climate Investment Funds [CIF] (2024a) *CIF Invites Countries to join $1Bn effort to Decarbonize Industry*. Press release, 3 October. https://www.cif.org/news/climate-investment-funds-invites-countries-join-1bn-effort-decarbonize-industry

Climate Investment Funds [CIF] (2024b) *CIF 2024 Year in Review: Key climate finance achievements*. https://www.cif.org/news/looking-back-2024-our-year-review

Climate Investment Funds [CIF] (2024c) *Industry Decarbonization Program*. https://www.cif.org/industry-decarbonization

Collins L (2025) *Hydrogeninsight*. https://www.hydrogeninsight.com/industrial/indias-acme-to-supply-millions-of-tonnes-of-green-hydrogen-derived-iron-to-vietnamese-steel-maker/2-1-1885032?zephr_sso_ott=W5NGBj

Conway E (2024) *Material World*. Penguin.

Dasgupta S (2017) *Economics of the Indian Steel Industry*. Routledge.

Economic Times, The (2024) Dutch may pay as much as €3 billion to clean up Tata Steel plant. *The Economic Times*, 5 June. https://economictimes.indiatimes.com/news/international/business/dutch-may-pay-as-much-as-3-billion-to-clean-up-tata-steel-plant/articleshow/110731391.cms?from=mdr

Ember (2025) *Global Electricity Review 2025*. https://ember-energy.org/latest-insights/global-electricity-review-2025

Eurofer (2022) Map of key low-CO_2 emissions projects in the EU steel industry. https://www.eurofer.eu/issues/climate-and-energy/maps-of-key-low-carbon-steel-projects

European Commission (2024) *€4 billion German State aid scheme*. https://ec.europa.eu/commission/presscorner/detail/en/ip_24_845

European Commission (2025) *A European Steel and Metals Action Plan*. https://single-market-economy.ec.europa.eu/document/download/7807ca8b-10ce-4ee2-9c11-357afe163190_en?filename=Communication%20-%20Steel%20and%20Metals%20Action%20Plan.pdf

European Commission Joint Research Centre (2025) *Defining low-carbon emissions steel: a comparative analysis of international initiatives and standards*. LU: Publications Office. https://data.europa.eu/doi/10.2760/4271464

Fischedick M, Marzinkowski J, Winzer P, Weigel M (2014) Techno-economic evaluation of innovative steel production technologies. *Journal of Cleaner Production* 84. Elsevier: 563–580

GMK Centre (2025) *China's Ansteel completes pilot project for hydrogen-based DRI production*. https://gmk.center/en/news/china-s-ansteel-completes-pilot-project-for-hydrogen-based-dri-production/

GSCC (2024) *The Steel Climate Standard*. Global Steel Climate Council. https://globalsteelclimatecouncil.org/the-standard/

Hasanbeigi A, Springer C, Savel C, Truong TQ, Resky Valeriz D, Yurnaidi Z, Trong Duc Anh V (2025) *Net-Zero Roadmap for Vietnam's Steel Industry*. Global Efficiency Intelligence and ASEAN Centre for Energy. https://static1.squarespace.com/static/5877e86f9de4bb8bce72105c/t/688a45bbcbf50e3e48bb2693/1753892283598/Vietnam+steel+roadmap-7.4.2025Clean-E.6.pdf

Hasanbeigi A, Springer C, Savel C, Valeriz DR, Yurnaidi Z, Trong Duc Anh V (2025) *Net-Zero Roadmap for Indonesia's Steel Industry*. Global Efficiency Intelligence and ASEAN Centre for Energy. https://static1.squarespace.com/static/5877e86f9de4bb8bce72105c/t/6881f311f1011e67207f77a9/1753346838765/Indonesia+steel+roadmap-+7.4.2025Clean-E.6.pdf

Hasanbeigi A, Springer C, Zuo B, Jackson A, Daseul K, Haerim Heo E. (2024) *Green Steel Economics: Comparing Economics of Green H 2 DRI and Traditional Steelmaking Around the World*. Technical Report, Global Efficiency Intelligence, TransitionAsia, Solutions for our Climate. https://static1.squarespace.com/static/5877e86f9de4bb8bce72105c/t/669de2f613dcdf700774b846/1721623332020/Green_Steel_Economics_240721.pdf

HBIS Group Co. Ltd. (2025) *Prospectus for the Third Green Medium-Term Note*.

Independent Commodity Intelligence Services [ICIS] (2025) Stegra signs 'very important' seven-year offtake deal for green steel with Microsoft. https://www.icis.com/explore/resources/news/2025/09/26/11141130/stegra-signs-very-important-seven-year-offtake-deal-for-green-steel-with-microsoft/

Institute for Energy Economics and Financial Analysis (2024) *CCUS for steelmaking rapidly losing its lustre*. CCUS for steelmaking rapidly losing its lustre | IEEFA

International Energy Agency [IEA] (2022) *Achieving Net Zero Heavy Industry Sectors in G7 Members*. Paris: OECD Publishing. https://www.oecd.org/en/publications/achieving-net-zero-heavy-industry-sectors-in-g7-members_f25c9648-en.html

International Energy Agency [IEA] (2023) *Steel*. https://www.iea.org/reports/breakthrough-agenda-report-2023/steel

Japan Iron and Steel Federation [JISF] (2025) *GX Steel Guidelines*.

Johnson S, Deng L and Gençer E (2023) Environmental and economic evaluation of decarbonization strategies for the Indian steel industry. *Energy Conversion and Management* 293: 117511.

Lee J, Voigt N, Feth M, Chhibbar G (2024) Shortfalls in scrap will challenge the steel industry. *Boston Consulting Group*. Epub ahead of print 2024.

Low Emission Steel Standard AISBL (2025) *About LESS*. https://lowemissionsteelstandard.org/

Li Z, Åhman M, Algers J, Chhibbar G (2025) Decarbonizing the Asian steel industries through green Hot Briquetted Iron trade. *Resources, Conservation and Recycling* 219: 108275.

METI (2025) *Green Steel for GX*.

Milne R (2025) Swedish start-up races to avoid Northvolt-style collapse. *Financial Times*, 21 October. https://www.ft.com/content/e0b56145-801c-4783-80f3-0a79e80799b9

Ministry of Steel (2024) *Green Steel Taxonomy for India*. https://steel.gov.in/sites/default/files/2025-03/Taxonomy%20Brochure.pdf

Muslemani H, Liang X, Kaesehage K, Ascui F, Wilson J (2021) Opportunities and challenges for decarbonizing steel production by creating markets for 'green steel' products. *Journal of Cleaner Production* 315. Elsevier: 128127.

National Development and Reform Commission (2024) *Notice on Issuing the 'Administrative Measures for Special Investments in Energy Conservation and Carbon Reduction from the Central Budget' (NDRC Environmental Resources Regulation [2024] No. 338)*.

National Green Development Fund (2021) *Supporting the Erhai Lake Basin – Systematic Ecological Restoration*.

Nimbalkar S (2022) *Potential Decarbonization Strategies and Challenges for the U.S. Iron and Steel Industry*. U.S. Department of Energy.

Oda J, Akimoto K and Tomoda T (2013) Long-term global availability of steel scrap. *Resources, conservation and recycling* 81. Elsevier: 81–91.

OECD (2024a) *Latest developments in steelmaking capacity and outlook until 2026*. 12 June. OECD. https://one.oecd.org/document/DSTI/SC(2024)3/FINAL/en/pdf

OECD (2024b) *The quantitative impacts of subsidies on steel firms: An econometric analysis of the impact of subsidies on steel firms' financial performance and crude steelmaking capacity*. OECD Science, Technology and Industry Policy Papers 167, OECD Science, Technology and Industry Policy Papers, September. https://www.oecd.org/en/publications/the-quantitative-impacts-of-subsidies-on-steel-firms_cb4e21a6-en.html

OECD (2025a) *OECD Steel Outlook 2025*. OECD Steel Outlook. OECD Publishing. https://www.oecd.org/en/publications/oecd-steel-outlook-2025_28b61a5e-en.html

OECD (2025b) The drivers and impacts of subsidies to steel firms. *OECD Science, Technology and Industry Policy Papers*. OECD Publishing. Epub ahead of print 8 October 2025. DOI: 10.1787/33e4b097-en

Pauliuk S, Milford RL, Muller DB, Allwood JM (2013) The steel scrap age. *Environmental Science & Technology* 47(7). ACS Publications: 3448–3454.

Quitzow R, Walz R, Köhler J and Rennings K (2014) The concept of 'lead markets' revisited: Contribution to environmental innovation theory. *Environmental Innovation and Societal Transitions*, 10: 4-19.

Reuters (2025) ArcelorMittal drops plans for green steel in Germany due to high energy costs. *Reuters*, 20 June. https://www.reuters.com/sustainability/climate-energy/arcelormittal-drops-plans-green-steel-germany-due-high-energy-costs-2025-06-19/

Richstein JC (2017) *Project-based carbon contracts: A way to finance innovative low-carbon investments*. DIW Berlin Discussion Paper. Epub ahead of print 2017.

Richstein JC, Anatolitis V, Blömer R, Bunnenberg L, Dürrwächter J, Eckstein J et al. (2024) Catalyzing the transition to a climate-neutral industry with carbon contracts for difference. *Joule* 8(12). Elsevier: 3233–3238.

Schreck S, Kobiela G, Wolf S (2023) *Climate-neutral steel: Enabling industrial transformation in Germany*. Germanwatch Policy Paper.

Shanghai Metals Market (SMM) (2023) Another New Project for Hydrogen Direct Reduction Iron has been Announced. How Profitable Such Projects are Remains to be Seen. *SMM*, 26 October.

Shen X (2024) *Steel sector decarbonisation in China stalls, with investments in coal-based steel plants since 2021 exceeding USD 100 billion despite overcapacity and climate goals*. Centre for Research on Energy and Clean Air (CREA).

Somers J (2022) *Technologies to Decarbonise the EU Steel Industry*. Publications Office of the European Union

Stahl W (2024) *Introduction of a Low Emission Steel Standard (LESS)*. Epub ahead of print 2024.

Tongia R and Patel U (2024) *Benchmarking Green Hydrogen in India's Energy Transition*. (CSEP Technical Paper 4) New Delhi: Centre for Social and Economic Progress. https://csep.org/wp-content/uploads/2024/10/Benchmarking-Green-Hydrogen-in-Indias-Energy-Transition.pdf

UNIDO (2024) *Unlocking the finance needed to decarbonize heavy industries through partnerships*. United Nations Industrial Development Organization. https://www.unido.org/news/unlocking-finance-needed-decarbonize-heavy-industries-through-partnerships

Vogl V, Åhman M and Nilsson LJ (2021) The making of green steel in the EU: a policy evaluation for the early commercialization phase. *Climate Policy* 21(1). Taylor & Francis: 78–92.

von Lüpke H, Marchewitz C, Neuhoff K, Aebischer C, Kröger M (2022) Carbon contracts for difference as an instrument for strengthening climate cooperation between industrialized and emerging economies. *DIW Weekly Report* 12(38). Berlin: Deutsches Institut für Wirtschaftsforschung (DIW): 229–235.

World Bank (2024) *Financing Industrial Decarbonization: Challenges and Solutions for the Iron and Steel Sector*. Climate Policy Discussion paper.

Xinyi Shen (2024) *Steel sector decarbonisation in China stalls, with investments in coal-based steel plants since 2021 exceeding USD 100 billion despite overcapacity and climate goals*. 27 March. https://energyandcleanair.org/publication/steel-sector-decarbonisation-in-china-stalls/

Appendix

Table A1. Projects and government policies considered for Figures 3.1, 3.2 and 3.3

Country	Company	Project location/Policy announcement
Germany	Thyssenkrupp	Duisburg
Germany	Saltzgitter	Lower Saxony
Germany	ArcelorMittal	Bremen
Germany	Stahl	Saar
Germany	ArcelorMittal	Hamburg
France	ArcelorMittal	Dunkirk
Netherlands	Tata Steel	Ijmuiden
Sweden	Stegra	Boden
Sweden	Hybrit	Gallivare
Finland	Blastr	Inkoo
Norway	Celsa	Mo I Rana
Spain	ArcelorMittal	Gijon
Spain	Hyndum Steel	Puertollano
Belgium	ArcelorMittal	Ghent
Canada	Algoma	Sault Ste
Canada	ArcelorMittal	Hamilton
UK	Tata Steel	Port Talbot
UK	British Steel	Scunthorpe
UK	N/A	UK Green Steel Fund (NWF) £2.5 bn
Japan	Nippon Steel	Kyushu/Yawata
Japan	Nippon Steel	Setouchi/Hirohata
Japan	Nippon Steel	Yamaguchi/Shunan
Japan	JFE	Kurashiki/Okayama
India	N/A	Steel pilot scheme of INR 455 crores
India	N/A	Steel decarbonisation fund announcement of INR 15,000 crores
India	N/A	Steel decarbonisation fund secondary steel announcement of INR 5,000 crores
Australia	Posco	Port Hedland
Australia	Liberty Steel	Whyalla
Australia	N/A	Green Iron investment fund (not including Whyalla)
Australia	N/A	Made in Australia Innovation Fund
Japan	N/A	Green Innovation Fund
Korea	N/A	Support Scheme for Steel Improvements
Korea	Posco	POSCO/Hyundai

Table A2. Green steel projects in China (expansion of Table 3.1)

Company	Project/plant and location	Technology	Type of green steel	Year online	Total investment in yuan (calculated at Market Exchange Rates)	Size of plant	Information source	Notes
Gansu Jiu Steel Group Hongxing Iron and Steel Co. Ltd.	Jiugang Steel Plant, Gansu	Smelting and rolling mill equipment upgrade	Low-carbon technical upgrades	2025	4.4 billion yuan, of which 2.6 billion yuan in credit loans from Jiayuguan bank branches	1.76 Mt/year	GS News My Steel	1 billion yuan loan already disbursed has a term of 15 years and an interest rate of around 50 basis points lower than loan interest rate for the same period.
Baosteel Zhanjiang Iron & Steel Co., Ltd (Baowu Steel Group)	Energiron H_2-DRI Plant, Zhanjiang, Guangdong	Energiron ZR (Zero Reformer) direct reduction technology, developed with Tenova and Danieli	H_2-DRI, using natural gas, coke-oven gas and H_2 as reducing agents	January 2024	Data not available	1 Mt/year	Danieli Newsroom GEM	Largest DRI plant in the world using H_2. Hybrid-ready design capable of achieving up to 96% metallisation with variable carbon content (0.5% with extensive H_2 use, up to 4.5% using NG)
Baosteel Zhanjiang Iron & Steel Co., Ltd (Baowu Steel Group)	EAF, Zhanjiang, Guangdong	EAF supplied by Hitachi Energy	Green electricity to power EAF, melting DRI and scrap steel	Expt. End 2025	4.5 billion yuan	1 Mt/year (estimate only)	Hitachi Energy Newsroom GEM	Related to Baosteel H_2-DRI project by using the DRI-produced low-carbon virgin iron to make finished steel
Baotou Iron and Steel Group	CCUS Project, Baotou, Inner Mongolia	CCUS	CCUS	2023	180 million yuan loan from Ping An Bank (total amount not available)	2 Mt/year	Ping An Bank Newsroom	Phase 1 to end in 2025 at capacity of 0.5 Mt/year, with aim of CO_2 reduction of 365,300t/ year. First 'whole chain' CCUS project in China.

HBIS Group	HBZX Plant, Zhangjiakou, Hebei		Includes CCUS	2023	Not available	0.6 Mt/year	HBIS Group	First H_2-enriched gas-powered DRI industrial production in the world. Planned expansion of capacity to 1.2 Mt/year and additional 1.5 Mt/year in slab caster production.
HBIS Group	Green H_2-based EAF, Naiman Banner, Inner Mongolia	H_2-DRI integrated plant	Hydrogen steel production	2025	4.8 billion yuan	2 Mt/year	Green Steel Tracker	
Inner Mongolia Jing'an Nonferrous Metal Materials Co., Ltd.	Naiman Banner, Inner Mongolia	Green H_2-based EAF	H_2 EAF	2025	5 billion yuan	2 Mt/year	News.metal.com	Large-scale hydrogen EAF; among China's biggest 'green steel' builds.
ArcelorMittal × China Oriental (JV)	Jiuyuan Plant, Baotou, Inner Mongolia	EAF for hot-rolled steel	EAF low-carbon	2026	4.7 billion	2.5 Mt/year	GMK Center	Government support confirmed as part of total investment.
Rizhao Steel Holding Group	Rizhao Advanced Steel Base Phase I, Shandong	Environmental protection & efficiency upgrades	Cleaner production	Under construction since 2023	2.8 billion yuan	5 Mt/year	GEM	
Jianlong Steel	Saisipu Technology Co., Wuhai, Inner Mongolia	Technical upgrades (energy & emission)	Low-carbo upgrades	2026	486.3 million yuan	0.6 Mt/year	Seetao	
Vale S.A.	MoUs with ICBC & Bank of China	Project finance/credit agreements	Sustainable finance/support	2023			Vale Press Room	

			for green projects					
Xingtai Steel	Low-Carbon Hydrogen-Rich Ironmaking Upgrades, Xingtai, Hebei	Hydrogen-rich blast furnace and DRI transition	H_2 enrichment	2021		2.25 Mt/year	GEM	
Zhongjin Metallurgical Tech	Pilot project, Baotou, Inner Mongolia	H_2-DRI	Hydrogen DRI Pilot			0.3 Mt/year	GEM	

Sources: Compiled by author from company press releases, OECD Latest Capacity Developments in Steel 2026 (OECD, 2024), Green Steel Tracker (Industry Transition, 2024), and verified media and corporate announcements including:
Danieli (2024) 'New Energiron DRI Plant Starts Production at Baowu Zhanjiang'; Hitachi Energy (2025) 'Baowu Group and Hitachi Energy Forging China's Zero-Carbon Vision';
South China Morning Post (2023) 'Ping An Bank lends US $25 million to Inner Mongolia steel maker to capture carbon';
Danieli (2023) 'HBIS producing DRI using more than 60 percent hydrogen';
Industry Transition / Green Steel Tracker (2024) entry for HBIS Naiman Banner Hydrogen DRI Project;
Metal.com News (2024) 'Another New Project for Hydrogen Direct Reduction Iron Has Been Announced – Naiman Banner';
GMK Center (2024) 'ArcelorMittal and China Oriental set up an electric steel plant in Baotou';
Global Energy Monitor (GEM Wiki, 2023) entry for Rizhao Steel Holding Group Co. Ltd;
Seetao (2024) report 'Inner Mongolia Saisipu Technology Co., Ltd. Project by Jianlong Steel';
Vale S.A. (2023) 'Vale announces seven agreements in China to strengthen its strategic agenda';
Mysteel (factory.mysteel.com, 2021, archived) announcement of Xingtai Steel Low-Carbon Hydrogen-Rich Ironmaking Transformation Project;
and Lead the Charge (2023) 'Green Steel in China Case Study – Zhongjin Metallurgical Tech.'
Mysteel (m.mysteel.com, 2021, archived) announcement of Capacity Replacement Plan for Jiugang Hongxing Construction Project.