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Near-Zero Steel by Policy Design:

China and the EU, with a Focus on Germany

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Authors

Dr. Chun Xia-Bauer, Dr. Lukas Hermwille, Dr. Anna Leipprand, Maike Venjakob [Wuppertal Institute]
Xinyi Shen [Centre for Research on Energy and Clean Air]
Dr. Hui Kong [Beijing Institute of Technology]

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Executive Summary

Germany/the European Union (EU) and China are entering a critical phase in steel decarbonisation, moving beyond incremental efficiency gains towards the large-scale deployment of near-zero production routes. This is not only a climate challenge. It is also a structural industrial transformation that will shape competitiveness, investment decisions and trade relations over the coming decades.

Key challenges for steel decarbonisation

In both jurisdictions, the transition is constrained by a combination of shared bottlenecks and country-specific binding constraints.

- **Diverging production structures**: China's steel industry remains overwhelmingly based on blast furnace–basic oxygen furnace (BF–BOF). Germany, despite a higher electric arc furnace (EAF) share, still relies on a small number of integrated BF–BOF sites for primary steel production.
- **A bankability gap for near-zero routes is real:** In both countries, deep decarbonisation means a structural shift away from coal-based BF–BOF. Yet near-zero routes, for example, H_2-DRI (typically paired with EAF), face a major bankability gap because of high upfront capital needs and exposure to operating costs, especially electricity and renewable hydrogen prices.
- **Margin pressure reinforces incumbent lock-in:** Persistently weak margins favour continued reliance on incumbent routes and delay investment in breakthrough technologies. In Germany, profitability is under pressure from war-related demand disruption, high energy and production costs, tariff uncertainty, weak demand and import pressure linked to global excess capacity. In China, weak demand, structural overcapacity, and a growing use of trade remedies similarly weigh on profitability and weaken incentives for early transition investment.
- **Reinvestment cycles are key decision points:** Germany faces near-term choices between relining and replacement at integrated sites, with implications for emissions profiles over decades. China's younger BF-BOF fleet will also require substantial reinvestment before 2030, making the 2020s a decisive period for avoiding long-term carbon lock-in.
- **Energy-system and scrap constraints are binding:** In both countries, access to affordable renewable electricity and renewable hydrogen limits scaling hydrogen-based steelmaking. In China, scrap supply is fragmented and pro-cyclical. Periods of weak steel prices compress EAF margins, reduce scrap collection incentives, and further destabilise supply.
- **Demand for low-carbon steel remains weak**: In both jurisdictions, demand for low carbon steel in the automotive sector is still limited and fragmented, while in buildings and infrastructure it remains largely confined to a small number of flagship projects.

Steel decarbonisation policies in place and mutual learning

Both Germany/the EU and China have developed broad policy frameworks for steel decarbonisation, anchored in overarching climate commitments but marked by different strengths and limitations. A comparative mapping of these frameworks suggests several areas for mutual learning, as both sides face similar structural constraints but are testing different policy responses.

In terms of **strategic direction-setting**, both jurisdictions have established policy frameworks that provide directionality and signal preferred technology pathways. The key difference is that the EU relies more heavily on carbon pricing, while China relies more on central coordination. China benefits from stronger alignment across climate, industry, and air pollution policies. However, its transition pathway remains largely anchored in incremental improvements within a BF-BOF-dominated production system, with only limited explicit mechanisms to phase down high-emission assets. By contrast, in Germany/the EU, the EU Emissions Trading System (ETS) provides a clearer long-term signal to shift investment away from carbon-intensive production. China's ETS is expanding, but carbon pricing remains far less central to its decarbonisation model than it is in the EU. A credible, pre-committed tightening pathway would enhance its effectiveness as an investment-grade instrument. Two features are particularly distinctive in China: capacity governance serves as a dual lever, both curbing overcapacity and steering technological transition, while air pollution policy creates important synergies for steel decarbonisation.

- On **innovation support**, both sides have defined strategic R&D priorities consistent with their preferred technology pathways. Germany/the EU has established more structured funding pipelines across technology-readiness levels. China could accelerate learning on breakthrough routes by drawing on German/EU practice and establishing dedicated R&D support that combines steel-specific and industry-wide programmes within a predictable TRL-based funding pipeline. Preparation to establish a National Low-Carbon Steel Technology Innovation Centre is a credible first step, provided they are matched with dedicated funding and clear decarbonisation criteria. Europe, for its part, can learn about how China's scale and coordination may accelerate deployment once technologies mature.
- In **financial support for low-carbon production,** both sides deploy CAPEX and OPEX instruments aligned with their prioritised technology pathways. On the CAPEX side, the EU Innovation Fund recycles ETS auction revenues into competitively allocated investment support. As China's ETS expands and matures, revenue recycling could in time provide a more predictable and rules-based funding channel for breakthrough CAPEX. China is building a layered support architecture that combines public grants, policy bank concession loans, and the development of transition finance to ease capital access for emissions-intensive industries such as the steel industry. On OPEX support, the two jurisdictions diverge more clearly. Germany's project-level hedging instruments, based on carbon contracts for difference (CCfD) logic, more directly address operating-risk gaps. China has relied more on conditional electricity pricing. In this area, China could draw lessons from CCfD-type instruments to mitigate the high cost of renewable hydrogen and narrow the cost gap between hydrogen-based and conventional steel production.
- **Demand** for low-carbon steel remains weak in both jurisdictions, despite the **gradual emergence of supporting policy measures**. In automotive, forthcoming EU regulation could help create a lead market for low-carbon steel through binding emissions targets. In buildings, standards still do not adequately capture the low-carbon characteristics of products, and procurement frameworks are insufficient to generate predictable demand at scale. Most demand-side measures depend on high-resolution, verifiable carbon-intensity data based on robust methodologies. China's product-level accounting and data collection systems are still at an exploratory stage, though they are developing rapidly, including for steel and steel products. In Germany/ the EU, the most operationalised steel-relevant data framework is found in the construction sector. This is now being complemented by an emerging economy-wide framework for mandatory sustainability-related product requirements. These developments create scope for mutual learning: the EU and Germany can share practical experience in methodology design, data governance and verification, while China's rapid implementation offers lessons in scaling product-level systems across emissions-intensive industries. Such exchange could focus on practical convergence: clearer system boundaries, more comparable emissions factors, and interoperable documentation for product-level carbon footprints and carbon-intensity disclosure.
- In **securing renewable hydrogen**, both sides are pursuing systematic approaches to affordable renewable hydrogen that offer transferable lessons for other countries. Both the EU and China see hydrogen-based ironmaking as a strategic option for deep decarbonisation, but most announced projects remain at an early stage, under feasibility assessment, or in 'hydrogen-ready' configurations rather than full commercial deployment. Mutual learning could therefore focus on how policy

frameworks can support systematic scale-up.

- Finally, on **enhancing access to affordable renewable power supply**, Chinese government is pushing heavy industry towards higher renewable electricity uptake by setting province-level renewable power consumption ratios for key energy-intensive industries. This could accelerate electrification, especially when combined with direct renewable power connections and the continued expansion of green electricity trading and longer-term contracting arrangements. On dedicated connections, China could draw on Germany's experience, where comparable models rest on firmer legislative foundations, thereby reducing regulatory discretion and improving bankability. In China, multi-year and cross-provincial green power procurement is still developing and new direct-connection rules are opening additional pathways for industrial buyers. Germany provides a useful practical reference because long-term corporate power purchase agreements (PPAs) is embedded in a more mature regulatory environment. For both jurisdictions, exchange could also cover how industrial users can provide flexibility to increasingly renewable-based power systems, and how the resulting revenues and cost savings might strengthen the business case for electrification investment.

Steel decarbonisation is a shared challenge for Germany/the EU and China: emissions must fall, the sector must remain investable and competitive, and the transition must be socially manageable. In the current context of trade tensions and geopolitical strain, this strengthens the case for more structured dialogue, mutual understanding and targeted cooperation. Such engagement will not remove underlying trade frictions, but it can reduce misperceptions, limit escalation around trade instruments, and support a clearer investment runway for near-zero steel.

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1. Introduction

The steel industry is responsible for roughly 2.8 gigatonnes of CO_2 emissions each year, around 8% of global energy-related CO_2 emissions[1]. This places the sector at the centre of the climate agenda. At the same time, steel remains a key input for construction, transport, machinery, and clean-energy infrastructure. Decarbonising steel is therefore a multi-objective task: reducing emissions while maintaining industrial competitiveness and managing the distributional and employment implications of transition.

This challenge is especially significant in China, the world's largest steel producer. With over 1 billion tonnes of crude steel in 2024, more than half of global output[2], the steel industry remains highly carbon-intensive and is estimated to account for around 15% of China's total CO_2 emissions (1.8 billion tonnes in 2024)[3], making it the country's largest industrial emitter. [4] Decarbonisation efforts also unfold against persistent overcapacity and weak profitability, which can depress incentives for capital-intensive retrofits and complicate the retirement of high-emitting assets.

Europe is the world's second largest steel-producing region. The EU-27 produced 129.5 million tonnes of crude steel in 2024.[5] Within Europe, Germany is the EU's largest producer (37.2 Mt in 2024). The steel industry accounts for roughly one third of Germany's industrial greenhouse gas emissions.[6] German producers also face strong competitiveness pressures, such as high and volatile energy costs, investment uncertainty, and intensifying import competition, at precisely the moment when decarbonisation requires extensive capital commitments.[7]

This policy report maps steel decarbonisation in Germany and China through a policy design lens. It assesses how each country: (i) sets direction for steel decarbonisation; (ii) supports knowledge development of breakthrough decarbonisation technologies; (iii) mainstreams low carbon production at scale; (iv) facilitates market formation to accelerate uptake of low carbon steel products, and (v) enables low-carbon energy, feedstocks, and infrastructure. The purpose is twofold: to **compare the policy mixes** in both jurisdictions for accelerating steel decarbonisation and their implications for industrial competitiveness and to **distil practical lessons for mutual learning.**

The next section outlines the key challenges and maps the policy landscape in Germany and China. The following section compares the policies and identifies mutual learning opportunities that could accelerate steel decarbonisation in both jurisdictions.

[1] (IEA, 2023)
[2] (World Steel Association, 2025)
[3] (Zhou, 2025)
[4] (C Steel News, 2025)
[5] (World Steel Association, 2025)
[6] (Wirtschaftsvereinigung Stahl, 2025)
[7] (Choksey, 2025)

2. Key challenges to steel decarbonisation in Germany and China: a snapshot

China and Germany start from different steel production structures. In ***China, steelmaking remains dominated by the Blast Furnace–Basic Oxygen Furnace (BF-BOF) route***, which accounts for nearly **90%** of total output, while ***electric arc furnaces (EAFs)*** contribute only around **10%**.[8] ***Germany's route mix is more balanced: around 30%*** of output already comes from ***EAF***, while the rest is produced at integrated BF-BOF sites making primary steel.[9] In both countries, transition away from BF-BOF for primary steel, which relies heavily on coke and coal and has intrinsically high emissions, is a key decarbonisation challenge.

A widely recognised deep decarbonisation alternative for primary steel is renewable-hydrogen-based direct reduced iron (H_2-DRI), typically paired with EAF, but it requires ***high upfront CAPEX***. For example, OECD (2025) estimates investment costs for an H_2-DRI-EAF operation at around €574 per tonne of annual capacity, about 30% higher than a greenfield BF-BOF plant.[10] For secondary steel, scrap-based electric arc furnace (EAF) production, supplied with renewable electricity, is widely regarded as a central pillar of steel decarbonisation.[11]

Beyond today's production structure, Germany and China face shared and distinct structural challenges on the path to deep decarbonisation. These are linked to industry structure and market dynamics, plant age and reinvestment cycles, investment headroom, and the availability of competitively priced renewable electricity, renewable hydrogen, and enabling infrastructure.

[8] (OECD, 2025b)
[9] (Wirtschaftsvereinigung Stahl, n.d.)
[10] (OECD, 2025c)
[11] (Agora Industry et al., 2024)

2.1 Industry landscape and development

Germany:

The steel industry combines ***highly concentrated primary production with a dispersed secondary and speciality steelmaking.*** Primary steel is produced at just six integrated BF–BOF sites, whereas secondary steelmaking is spread across a geographically dispersed set of medium-sized EAF producers.[12] Since 2022, EU ***steel demand has remained weak*** due to war-related disruption, high energy and production costs, trade uncertainty, reduced demand from downstream sectors such as automotive, and increased import pressure from global overcapacity.[13] In 2025, ***capacity utilisation in Germany fell below 70 percent***, indicating sub-scale operations. This has reduced margins and weakened the financial case for deep decarbonisation projects, delaying final investment decisions.

China:

The producer base ***remains fragmented.*** More than 80 percent of firms have less than 5 million tonnes of capacity, accounting for about 40 percent of output. Many operators face technical constraints and limited financial capacity for retrofit.[14,15] ***Structural overcapacity*** continues to compress prices and margins, reducing available capital for investment in new technologies.

EAF production remains exposed to high electricity and scrap costs. When prices fall, margins turn negative and output is reduced. Firms respond by maintaining high utilisation of BF-BOF assets to spread fixed costs, while ***EAF utilisation stays low***. In 2024, BF-BOF plants operated above 80% utilisation and EAFs around 50%. This indicates a persistent cost disadvantage for EAFs.[16]

China's steel overcapacity has led to record export volumes, resulting in more frequent use of ***trade remedies***. [17] This increases the risk of abrupt market access restrictions. Near-zero investments depend on stable, long-term offtake agreements, which are now less certain. At the same time, carbon-leakage measures such as the ***Carbon Border Adjustment Mechanism (CBAM)*** reduce the cost advantage of higher-emissions production for goods entering the EU. Compliance, reporting, and administrative requirements also create challenges for non-EU exporters.

[12] (EUROFER, 2025)
[13] (Climate Bonds Initiative, 2025)

[14] (Zhou, 2025)
[15] (C Steel News, 2025)
[16] (CEIC Data, n.d.) For BF–BOF production, the utilisation figures are based on data from 247 steel enterprises over 2012–2025, while the EAF utilisation data for 2018–2024 cover 87 independent EAF steel producers.
[17] (Reuters, 2025)

2.2 Asset age and reinvestment

Germany:

Many integrated ***BF-BOF assets are mature.*** Decisions in the 2020s focus on ***whether to reline or replace these assets.*** Relining is a capital-intensive process that extends coal-based operations by 15 to 20 years. Without a credible transition plan, this approach risks locking in emissions for multiple decades.

China:

BF-BOF fleet is relatively young.[18] Early large-scale retirement would result in ***significant stranded-asset costs***. However, delaying action until asset retirement is not compatible with deep decarbonisation. Analysis indicates that 78% of China's coal-based steelmaking capacity will require ***major reinvestment before 2030***,[19] suggesting that the ***next relining period represents a critical window for transition.***

2.3 Availability of affordable renewable electricity, renewable hydrogen, and scrap

Germany:

Recent assessments estimate that the levelized cost of domestically produced renewable hydrogen exceeds €7.50 per kilogram. Cost-effective deployment will require prices to fall to €3.00 per kilogram or less.[20] In addition to ***high unit costs, the volume of renewable electricity required*** makes full domestic sourcing structurally unlikely.[21] Recent cancellation of major hydrogen-steel investment by Arcelor Mittal and delayed FIDs by Salzgitter[22] and thyssenkrupp indicate that project delivery depends on credible expectations of affordable renewable electricity and hydrogen, rather than subsidies alone. For EAF operations, exposure to high power prices remains significant. ***Electricity prices for large energy-intensive industrial customers*** in Germany are ***substantially higher*** than in the United States, China, and India,[23] resulting in a persistent operational cost disadvantage.

China:

Currently, ***economically viable renewable hydrogen remains limited and unevenly distributed*** across regions. In 2024, total hydrogen production was 36.5 million tonnes, primarily from coal and natural gas, with only 0.32 million tonnes produced via electrolysis using renewable or grid electricity. The strongest wind and solar resources are located in North-west and North China, which are emerging as hubs for renewable hydrogen development,[24] but these regions are not the main steelmaking centers. For EAF operations, ***high industrial power prices*** create a persistent operating cost disadvantage compared to coal-based BF-BOF.[25] ***Scrap supply is also constrained.*** It remains fragmented and unreliable, with prices moving pro-cyclically with steel prices and limited by a collection-cost floor. When prices approach this floor, collection declines, further reinforcing supply instability.

Unlike conventional BF-BOF routes, H_2-DRI demands ***high-grade iron ore***.[26] In China, only a **small proportion of domestic iron ore** is suitable for DRI processing. Large-scale adoption of H_2-DRI would therefore increase dependence

[20] (Matthes & Brauer, 2025)
[21] (Bundesministerium für Wirtschaft und Klimaschutz (BMWK), 2024)
[22] (Handelsblatt, 2025)
[23] (International Energy Agency, 2025)

[18] (Oxford Institute for Energy Studies, 2024)
[19] (Agora Energiewende, 2021)
[24] (National Energy Administration, 2025)
[25] (Oda, 2025a)
[26] (Devlin et al., 2023)

on imported high-grade ore and pellets. China already relies on imports for an estimated 70 to 80 percent of its iron ore supply.[27]

2.4 Demand for low carbon steel

Beyond the broader downturn in steel demand in both countries, ***demand for low-carbon steel remains low***. The automotive sector requires high-quality steel, and DRI-based metallics are well suited due to their low residual content, which supports the production of premium flat products and non-oriented electrical steel.[28] Despite some recent commitments from German and Chinese companies, actual purchase volumes are small and dispersed.[29] In both the EU and China, use of low-carbon steel in ***buildings and infrastructure*** is largely restricted to a ***few flagship projects***.[30]

Overall, both Germany and China must transition to near-zero-emission steelmaking and both face weak demand for low-carbon steel; however, their binding constraints differ, largely shaping which policy levers will be effective and how they should be prioritised. The next section maps steel decarbonisation policies in both countries across five industrial transformation policy dimensions: (i) set direction for decarbonisation; (ii) support knowledge creation and development; (iii) mainstream low-carbon production at scale; and (iv) accelerate uptake of low-carbon steel and downstream products, and; (v) enable the provision of low-carbon energy, feedstocks, and enabling infrastructure.[31]

[27] (Wei et al., 2024)
[28] (Oda, 2025a)
[29] (Transport & Environment, 2024a)
[30] (Deutsche Bahn, 2025) (Haffner, 2025)
[31] The policies can be found in the policy inventories in https://www.eu-china-bridge.eu

3. Policy landscape for steel decarbonisation in Germany and China

Steel decarbonisation policies and governance in both jurisdictions are embedded in wider climate strategies and industrial governance.

Germany:

Germany's industrial decarbonisation pathway is ***set in national law but operates within the broader framework of EU climate governance***. The Federal Climate Change Act commits Germany to ***climate neutrality by 2045*** and to cut economy-wide emissions by at least 65 percent by 2030 compared to 1990, exceeding current EU-level targets. Governance is ***multi-level***: the EU sets binding climate objectives and key market rules, notably the EU ETS, and defines the limits of permissible industrial support through state-aid control. Germany implements these through domestic programmes and co-financing, such as de-risking instruments for early adopters. Delivery relies on national agencies and state authorities for permitting and infrastructure planning.

China:

China's climate strategy is anchored in the "dual carbon" targets to peak CO_2 emissions before 2030 and reach carbon neutrality by 2060, operationalised through a top-level "1+N" policy architecture (overarching guidance with sectoral plans). Governance is ***top-down and target-driven.*** The national government sets targets and priorities and assigns responsibility to provincial governments for delivery. ***State-owned enterprises (SOEs)*** have significant financial, technical, and organisational capacity, and play a central role in low-carbon transformation. They are expected to meet decarbonisation and energy efficiency targets, protect the value of state-owned assets, and demonstrate best practices for the wider industry.

3.1 Policies setting direction for steel decarbonisation

Two distinct architectures of "directionality" policies

Germany:

National directionality policies anchored in EU climate governance. ***National*** policies that set directions are dominated by ***fiscal and innovation*** support for low-carbon technologies, ***complemented by the 2020 steel industry strategy, hydrogen policies, carbon management policies*** explicitly referring to steel, and overarching climate strategies. The EU-level decarbonisation signal is anchored in the ***EU Emissions Trading System (EU ETS)*** (in place since 2005, covering iron and steel), and it is being tightened as free allocation will progressively be phased out in tandem with the CBAM phase-in from 2026.

China:

Steers through a dense policy package that includes ***economy-wide and steel-specific climate and sustainable-development plans, industrial development strategies, air pollution control measures*** (partly overlapping with decarbonisation objectives), and ***infrastructure and renewable-energy deployment policies***. This directionality is reinforced by ***technology catalogues*** that signal which technologies should be supported and which new projects or production activities should be restricted or prohibited. These catalogues influence investment decisions by linking permitting and access to support instruments to a formal classification of encouraged, restricted, and eliminated activities. This approach reduces uncertainty for selected pathways but may limit flexibility for future investment choices.

Technology pathways signalled within current policy mixes

The policy mixes in both countries reveal identifiable technology pathways.

- ***Both China and Germany*** treat scaling ***scrap-based EAF as a near- to mid-term lever***. ***In China,*** policy targets an increase in the EAF share from approximately ***15 percent in 2025 to 20 percent by 2030***. Progress to date has not met these targets.
- ***Hydrogen-based steelmaking is considered a central transition option for primary steel*** in both countries, though their approaches differ. ***Germany*** focuses on ***DRI/EAF*** using ***renewable hydrogen***. ***China*** supports a ***wider range of hydrogen applications***, including H_2-DRI, integration of hydrogen into BF-BOF operations, and hydrogen-rich smelting reduction, without restricting support to renewable hydrogen.
- ***China places greater emphasis*** than Germany on ***energy efficiency improvements*** as a near-term transition strategy. The government has set binding targets for large-scale industries to reduce energy consumption per unit of added value by 13.5 percent, supported by a range of policies. This is further reinforced by the China Iron and Steel Association's extreme energy efficiency programme, which has been in place since 2022.[32]
- ***Carbon capture, utilisation and storage (CCUS)*** is generally considered a ***complementary*** measure. Its large-scale deployment is contingent on the development of CO_2 transport and storage infrastructure, and it is typically reserved for later stages or for addressing residual emissions.

ETS design: mature development in the EU, deliberately low stringency in China's first phase

Steel is included in emissions trading in both jurisdictions. However, the systems differ in terms of maturity and short-term stringency.

Germany:

EU ETS has operated since 2005 and includes iron and steel. The system has tightened over time, increasing expected carbon cost exposure for emission-intensive production routes. The scheduled end of free allocation within the next decade is influencing ***investment decisions, with producers considering transformative options***. In the near and medium term, remaining free allowances may help finance early hydrogen-based investments by reducing transition costs.[33]

China:

National ETS has ***recently expanded*** beyond the power sector to include industries such as ***steel***. The ***first compliance deadline is at the end of 2025*** for 2024 emissions. In the initial phase, allocation is structured to keep compliance costs low and introduce a carbon price signal with ***modest stringency***. This approach is similar to the early phase of the EU ETS, which was characterised by largely free allocation. The system's influence on investment will depend on future changes to allocation and carbon pricing.

China's capacity governance as a dual lever: curbing overcapacity while steering steel's technological transition

China: Industry development, climate, and environmental policies have prioritised the ***retirement of inefficient and outdated capacity, encouraged consolidation*** through mergers and acquisitions among qualified producers, and ***tightened controls on new build***. New capacity is channeled through "***capacity-***

[32] (China Metallurgical News (CMN), 2025)
[33] Expert interview#1

capacity-swap" rules: firms must retire existing capacity to secure approval for additions, with swap ratios differentiated by region and technology. ***Enforcement has tightened*** in recent years: in heavily air-polluted areas, firms are typically required to close at least 1.5 units of capacity for every 1 unit of new capacity proposed. The Work Plan for Stabilising Growth in the Steel Industry (2025–2026), which defines the national policy direction for China's steel sector over the next two years, extends preferential treatment under the capacity-swap mechanism to ***hydrogen-based steelmaking projects***.

This approach to capacity governance has several ***structural effects***. It encourages mergers and organisational restructuring, accelerates the closure of inefficient plants, and increases market concentration. Higher concentration can improve capacity utilisation.[34] However, the system tends to favour firms with access to capital and the ability to secure approvals, which are typically larger companies. Smaller private producers often lack the financial resources for major upgrades and are more likely to exit the market.

The ***EU/Germany do not use an equivalent capacity-swap governance regime*** to steer technology mix. Instead, policy aims to increase the expected carbon cost exposure of emissions-intensive assets through the ***EU ETS*** and the gradual reduction of free allocation linked to the CBAM.

Synergies between steel decarbonisation and air pollution policy in China

A critical but often overlooked layer of directionality is the ***intersection of air quality regulations and decarbonisation policies.***

Air pollution control is ***central in Chinese steel policy*** due to the sector's significant emissions of particulate matter, sulfur dioxide, and nitrogen oxides. National policy requires that by 2025, 80 percent of crude steel capacity ***completes ultra-low-emissions upgrades***, and eligible projects can access public support. Since 2020, policy has more explicitly prioritised ***"synergistic" cuts in air pollutants and CO_2***, including the retirement of inefficient capacity, increased use of electric arc furnaces, substitution of raw materials and fuels, and targeted deployment of CCUS.[35] This approach is considered essential for steel sector decarbonisation in China.[36]

[34] (Shi et al., 2023)
[35] (Economic Daily, 2024)
[36] Expert interview#2

3.2 Policies to support R&D on breakthrough technologies for steel decarbonisation (TRL1-6)

Germany:

A layered TRL pipeline linking early R&D towards demonstrations within the multi-level governance.

German steel decarbonisation innovation benefits from a ***structured*** support framework. It ***combines national and EU instruments***, organised around technology readiness levels (***TRLs***), to bridge early-stage research with pilot towards demonstration activities (Table 1).

For ***early-stage R&D***, Germany supports higher-risk process innovation through ***federal programmes*** such as KlimPro-Industrie II, which is positioned as industrial, application-oriented research for decarbonisation across basic material industries, with support limited to projects up to TRL 5. In steel, it covers areas such as by-product and residue valorisation and alternative process inputs and energy carriers, including CO_2-based blast furnace concepts and hydrogen as an energy carrier, ***rather than focusing specifically on breakthrough near-zero-emission steelmaking technologies.***[37] For pilots, the federal BIK programme (Bundesförderung Industrie und Klimaschutz) supports ***industrial decarbonisation and carbon management*** (CCU/CCS), and its research strand funds industrial research, experimental development and feasibility studies to reduce the risk of innovative low-carbon technologies. Steel, however, has not yet featured among the projects funded under this strand.[38]

EU instruments extend the pathway into first-of-a-kind (FOAK)-ready demonstration. The steel-specific Research Fund for Coal and Steel (RFCS) supports a staged pipeline.[39] Horizon Europe's Clean Steel Partnership is intended to advance "clean steel" building blocks towards deployability, with the aim of reaching about TRL 8

[37] (ReInvent, n.d.)
[38] (Bundesministerium für Wirtschaft und Energie, n.d.)
[39] (European Commission, 2025b)

China:

Clear strategic direction, but no dedicated central "funding stack"; Firm-led funds filling part of the gap, at limited scale.

R&D investment of China's steel firms remains limited. In 2024, R&D intensity was below 1.5%,[41] despite a national target set in 2022 for the industry to work towards that level by 2025. To strengthen incentives for innovation, a recent steel industry policy includes higher R&D spending as a core evaluation criterion for nationally leading steel enterprises. In 2022, the Ministry of Science and Technology (MoST) introduced a ***national R&D strategy*** to accelerate the large-scale deployment of low- and zero-carbon technologies across key industries in support of national dual-carbon targets. In steel, R&D efforts are expected to focus on integrated optimisation of all-scrap EAF processes, hydrogen-rich or pure hydrogen smelting technologies, as well as integrated steel–chemical co-production technologies. The MoST plan also provides a guiding framework for provincial governments to prioritise R&D efforts related to industrial decarbonisation.

The main constraint is ***the absence of dedicated central government funding*** earmarked for R&D and demonstration of breakthrough steel decarbonisation technologies. Innovation activity is therefore ***driven largely by major SOEs*** and ***leading private steel firms***, which incubate and pilot technologies, often in collaboration with research institutes. Some SOEs also fund pilots led by those institutes. One example is China Baowu's Low-Carbon Metallurgy Innovation Fund, in operation since 2021, which supported 58 projects between 2021 and 2023 with total funding of RMB 95.23 million.[42,43] China is now ***preparing to establish a National Low-Carbon***

[41] This target does not specify the share of investment to be directed towards low-carbon technologies.
[42] (CBCSD, 2023)
[43] (CSTEELNEWS, 2025)

by 2030 and enabling large-scale demonstrations. German stakeholders are active in flagship projects covering H_2-DRI and low-carbon EAF process innovation, including MaxH_2DR and GreenHeatEAF.[40]

Steel Technology Innovation Centre, which will receive ***dedicated funding***. The proposed focus areas suggest an effort to cover the main breakthrough routes and enabling systems: hydrogen-based steelmaking, near-zero-emissions EAFs, high-scrap BOF processes, CCUS applications, and enhanced heat and resource recovery.[44]

Table 1 : Support framework for German steel decarbonisation projects

Programme	Governance	TRL level supported
KlimPro-Industrie II	Germany	Up to TRL 5
BIK – Modul 1 (research module)	Germany	TRL ≥ 4
Horizon Europe – Clean Steel Partnership (CSP)	EU	Up to TRL 8 by 2030
Research Fund for Coal and Steel (RFCS): Steel Research Projects	EU	start at TRL 1-3 and achieve TRL 4-5
RFCS: Steel Pilot and Demonstration projects	EU	start at TRL 4-5 and achieve TRL 7-8

3.3 Policies to support CAPEX and OPEX for low carbon and circular steel production

Germany:

CAPEX support through EU state-aid-cleared FOAK conversions, national programs, and EU de-risk instruments.

Germany's capital-side support for H_2-DRI/EAF rests on two instruments: (i) ***EU state-aid-cleared "flagship" grants*** that de-risk first-of-a-kind (FOAK) assets (Table 2), and (ii) programme-based CAPEX schemes that fund decarbonisation technologies.

Germany has also implemented national programmes to provide additional CAPEX support:

China:

CAPEX support through targeted public finance and green/transition financing.

China combines ***central budgetary investment, technology-steering instruments, and expanding green/transition finance to mobilise CAPEX*** for industrial decarbonisation and upgrading in steel.

- Central budgetary investment (***annual programme***): a dedicated annual programme supports decarbonisation and circular-economy projects, typically covering about 20 percent of total capital expenditure. Steel plant retrofits are eligible.

[40] (European Health and Digital Executive Agency, 2024)

[44] (CSTEELNEWS, 2024)

Table 2 EU- state-aid-cleared "flagship" grants for H_2-DRI/EAF CAPEX

Beneficiary / Project	Total Volume (EUR)
thyssenkrupp (tkH2Steel)[45]	€550m
ArcelorMittal (Bremen/Eisenhüttenstadt)[46]	€1.3 billion
Salzgitter AG (SALCOS)[47]	€1.0 billion
Saarstahl (Dillinger Hüttenwerke) Power4Steel[48]	€2.6 million

- ***BIK***, the country's main programme for industrial decarbonisation, finances CAPEX for decarbonisation and carbon management alongside R&D. In its first completed funding round (2025), one of the largest awards was €200 million for HKM Duisburg (€140 million federal plus €60 million state) to replace a blast furnace with a large ***EAF,*** electrifying the melting step.[49]
- ***Energy Transition Living Labs*** (Reallabore der Energiewende) supports industrial-scale testing of innovations in real-world settings (up to TRL 9); includes €37 million in support for an H_2-DRI project.[50]
- the ***Environmental Innovation Programme (UIP)*** supports FOAK demonstrations and early deployment of large-scale environmental technologies, often to the benefit of small and medium-sized enterprises ***(SMEs)***.

These national funds are ***complemented by a set of centrally managed EU instruments*** intended to bridge the valley of death in energy-intensive industries.

- The ***EU Innovation Fund***, financed by revenues from the EU ETS, is the EU's main vehicle for large-scale clean-tech grants and has supported steel decarbonisation in Germany e.g., HydrOxyHub Walsum (€49.2 million), a PEM electrolyser project supplying

- National Green Technology Demonstration Project List ("the List"): the ***whitelist-like*** instrument ***steers firms*** towards recognised best available technologies (BAT). Projects applying listed BAT are eligible for central budgetary support. The 2024 List includes ***hydrogen injection into blast furnaces, ultra-low emissions (air pollution) measures, and process optimisation.***
- ***Air-pollution control retrofit funding***: dedicated annual national funding has supported air-pollution control retrofits, notably ultra-low-emissions upgrades at steel plants.
- ***"Two-new" package for equipment renewal:*** Launched in 2024 and supported by ultra-long special treasury bonds, this package aims to stimulate consumption and promote industrial equipment renewal. For the latter, the government provides grants and subsidised loans to help enterprises, including steel producers, replace outdated machinery with ***more efficient and technologically advanced equipment.***[58]

China is also using ***transition finance*** more explicitly as a ***policy lever*** to crowd in capital for steel decarbonisation. Transition finance is intended to ***support credible, time-bound decarbonisation in hard-to-abate sectors*** where

[45] (European Commission, 2023a)
[46] (European Commission, 2024)
[47] (Salzgitter AG, 2023)
[48] (European Commission, 2023b)
[49] (Bundesministerium für Wirtschaft und Energie, 2025b)
[50] (thyssenkrupp, 2022)

[58] "Two new" refers large-scale equipment renewal and consumer goods trade-in.

renewable hydrogen to local steel industry and to transport businesses and other industries.[51]

- The ***InvestEU*** programme provides ***budgetary guarantees*** to implementing partners, increasing their capacity to bear risk and thereby supporting private lending for high-risk industrial transition projects.

OPEX: De-risking through electricity cost relief

CAPEX grants reduce investment barriers, but they do not resolve operating-cost exposure. For H_2-DRI/EAF projects, the main delivery risks remain the cost of electricity and renewable hydrogen. The cancellation of a major hydrogen-steel investment by ArcelorMittal and delayed final investment decisions by Salzgitter and thyssenkrupp indicate that investors still lack confidence in future electricity and hydrogen costs at the required scale.

The EU-approved state-aid package provides project-level OPEX hedges. For thyssenkrupp Steel Europe's tkH2Steel project in Duisburg, it includes an operating-cost hedge: alongside the €550 million direct grant, the European Commission approved a conditional payment mechanism of up to €1.45 billion to cover the additional cost of procuring and using renewable hydrogen instead of low-carbon hydrogen.[52]

Beyond project-specific aid, the German government provides broader electricity-cost relief for energy-intensive, trade-exposed industries:

- ETS indirect-cost compensation (Strompreis-kompensation, SPK) compensates eligible firms for indirect EU ETS CO_2 costs embedded in electricity prices and is explicitly framed as a measure to preserve competitiveness and prevent carbon leakage.[53]
- A discounted industrial electricity price is intended as a three-year measure for 2026-2028, subject to EU State-aid clearance and final implementation. Beneficiaries of such temporary electricity - price relief must

[51] (European Commission, n.d.-b)
[52] (European Commission, 2023a)
[53] (German Emissions Trading Authority, n.d.)

activities may ***not yet qualify as "fully green" but can align with a defined transition pathway***.[59]

- ***National guidance*** (2024): Inter-ministerial guidelines led by the People's Bank of China call for the expansion and standardisation of transition finance, including clearer standards and taxonomies.[60]
- ***Provincial guidance***: Several provinces have issued transition finance documents covering steel. Hebei, for example, has published sector-specific transition finance guidance for steel, backed by a ***whitelist catalogue*** of 176 eligible technologies. The catalogue includes technical descriptions, expected carbon-abatement effects, and application cases intended to help banks distinguish genuine transition investment from greenwashed upgrading. The Hebei guidance also requires firms to ***develop a credible decarbonisation transition plan*** and undergo formal assessment using local templates. The criteria include substantial contribution, technological advancement relative to benchmarks, avoidance of carbon lock-in, and just transition considerations.

OPEX support through performance-linked electricity pricing and tax incentives for air-pollution control and efficiency.

On the OPEX side, support for industrial electricity prices in China remains limited and fragmented. Pricing and relief measures are determined largely at provincial and local level rather than through a single nationwide mechanism. Central directives to increase renewable electricity consumption are sometimes translated into ***local measures that reduce the effective cost of procured renewable power***, either through subsidies or by lowering the premium attached to renewables' environmental attributes, for example through the pricing and settlement of green certificates or similar premia in green power transactions.[61] Beyond subsidies, policy also reinforces ***differentiated and tiered electricity pricing*** for

[59] (IEA, 2025)
[60] (People's Bank of China, 2024)
[61] (Greenpeace, 2025)

reinvest at least 50% of the aid in decarbonisation.[54] Furthermore, industry may benefit from reduced grid charges, through the Bandlastprivilegierung for highly intensive and constant electricity use. However, this regime is under review by the federal government.[55]

Another potential instrument to address OPEX is ***Carbon Contracts for Difference (CCfDs)***. CCfDs ***compensate the additional annual costs of operating*** a low-carbon process relative to a defined conventional reference over ***15 years***. In this way, they hedge firms against operating-cost risks, especially ***uncertainty in the EU ETS price and volatility in hydrogen and electricity prices***. The contracts also include strict emissions-reduction requirements, including a requirement eventually to ***achieve emissions 90% below those of a comparable conventional plant***.[56] The first CCfD auction round did not award support to a steel project.[57] Even so, CCfDs remain relevant to steel decarbonisation because their design addresses the OPEX risk profile that is currently delaying final investment decisions on H_2-DRI/EAF projects.

energy-intensive industries, using tariff levers to encourage the completion of pollution-control and efficiency retrofits.[62] Operating costs are further reduced through ***lower environmental protection tax rates and preferential tax treatment for energy-efficient plants***. Implementation, however, has been uneven and often insufficiently stringent at the local level.[63]

[54] (Competition-policy, 2025)
[55] (Bundesnetzagentur, 2024a)
[56] (Federal Ministry for Economic Affairs and Climate Action, 2024)
[57] (Bundesministerium für Wirtschaft und Energie, 2025a)

[62] Electricity generated by local power producers can have its tariff administered by provincial and similar level governments. Provinces retain meaningful discretion over the design of time-of-use tariffs.
[63] (China Metallurgical News (CMN), 2025)

3.4 Policies to drive demand of low carbon steel

The policy mapping covers measures targeting two major downstream users: the automotive and construction sectors.

Automotive industry

Automakers and their suppliers are increasingly signalling a willingness to use lower-carbon materials. In practice, however, uptake remains limited and is largely confined to isolated initiatives.[64] This weak demand pull is reflected in the absence of clear supply-chain targets. For example, most Chinese automotive firms have not yet established or disclosed supply-chain emissions-reduction targets. Of the 50 companies surveyed in the study, only eight have announced carbon-neutrality or emissions-reduction targets covering Scope 1 and 2 emissions, and only three have started to disclose steel-related emissions reductions or set explicit decarbonisation objectives for their upstream supply chains.[65]

Germany:

Demand signals mainly via ***EU regulations.***

Policies steering low-carbon steel uptake in ***Germany***'s automotive sector are ***not yet in place***. Current policy development is ***driven mainly at EU level***:

- ***2025 EU Automotive Package***: The package envisages a 90% reduction in tailpipe emissions by 2035, with residual emissions to be compensated through the use of EU-made low-carbon steel and/or e-fuels and biofuels. If implemented, this could strengthen demand for low-carbon steel in EU automotive value chains.[66]
- ***End-of-Life Vehicles (ELV)*** Regulation (provisional 2025): The provisional agreement foresees ***binding targets for recycled steel*** and aluminium to be introduced two years after the regulation enters into force, subject to the completion of the feasibility studies.[67]
- ***Ecodesign for Sustainable Products Regulation (ESPR): Minimum requirements for steel*** are expected to be defined in 2026 and would apply to EU-made and imported products.

China:

Early efforts to address the gap through ***guidance*** and ***standards***-oriented measures:

- Roadmap: In 2023, the government tasked industry associations and other main stakeholders with developing a ***roadmap for a green and low-carbon automotive sector***. Among others, the roadmap encourages manufacturers to adopt robust ***life-cycle carbon-emissions assessment methods*** for low carbon materials and to ***work with upstream and downstream partners*** on voluntary carbon footprint assessments.
- ***Recycled materials strategy***: in 2026, a national strategy to promote the use of recycled materials was published. It explicitly ***encourages vehicle producers*** to increase the share of recycled inputs, including recycled steel, and sets out plans for the development of supporting standards.

[64] (Transport & Environment, 2024b)
[65] (Li et al., 2024)
[66] (European Commission, 2025c)
[67] (European Parliament, 2025)

Buildings

Low-carbon steel is also indispensable to the decarbonisation of buildings and infrastructure. Construction depends on steel for structural frames and reinforcement, while emissions from steel production, alongside those from cement, account for a large share of embodied carbon in the built environment. These embodied emissions become more significant as operational emissions fall.[68] Green public procurement (GPP) can therefore play an important demand-side role in scaling up the use of low-carbon steel in this sector and narrowing the cost gap with conventional steel, because it can provide predictable, bankable offtake at scale. In 2019, for example, public procurement in the EU construction sector accounted for about 15.6 million tonnes of steel, equivalent to 11 percent of total EU steel consumption.[69]

Germany:

Project-level sustainability, limited pull for low-carbon steel.

Sustainability remains only weakly integrated into public procurement practice in Germany. In 2021, 13 percent of public contracts included sustainability considerations in their award criteria. Where such criteria are applied, project sustainability is assessed through the ***Sustainable Building Assessment System (BNB)***, which covers life-cycle costs (LCC), circularity and energy efficiency, and requires the use of a CO_2 shadow price in LCC calculations. The BNB Silver standard is ***mandatory for federal buildings***, but ***only three federal states*** apply the BNB framework. While the BNB encourages project-level sustainability performance, it does not currently define criteria for reducing ***embodied carbon or improving the circularity*** of carbon-intensive materials such as steel.[70]

China:

GPP standards for green buildings and materials exist, but no low-carbon steel requirements.

In China, GPP for construction materials is primarily guided by ***the GPP Standard for Green Buildings and Green Building Materials,*** which is updated periodically. However, the 2025 version still does ***not introduce low carbon requirements*** for key steel components including structural steel components and reinforcing steel. This limits the role of public procurement in creating demand for low-carbon steel in the construction sector.

Data and low-carbon steel-standards

High-resolution and verifiable carbon-intensity data is essential for downstream users to quantify or track upstream emissions reductions, based on which take purchase decision.

Germany:

Mature environmental product declaration (EPD) for construction, shifting from voluntary towards regulation; economy-wide

In the EU, the most operationalised carbon data infrastructure relevant to steel is found in

China:

Rapid product carbon footprint (PCF) system build-out alongside industry-led disclosure platforms.

In China, steel suppliers rarely provide high-resolution, verifiable carbon-intensity data, making it difficult for downstream users

[68] (Global Alliance for Buildings and Construction, 2025)
[69] (Ramboll, 2024)
[70] (Ramboll, 2024)

construction.

- ***Construction***: downstream users can draw on the voluntary Type III EPD system built around EN 15804, which standardises how the environmental impacts of construction products are calculated and reported.[71] Germany operationalises this framework for ***public procurement through ÖKOBAUDAT***, the federal LCA dataset platform, which is formally designated as the mandatory database for the above-mentioned BNB and provides datasets compliant with DIN EN 15804.[72]
- ***Shift from voluntary towards regulation***: the recast Construction Products Regulation (EU) 2024/3110 explicitly strengthens requirements for declaring the environmental sustainability performance of construction products, supporting more systematic and comparable disclosure across the single market.[73]
- ***Cross-sector data transparency***: Beyond construction, where steel is also used heavily in automotive and appliances, policy is beginning to address data fragmentation. The ***Ecodesign for Sustainable Products Regulation*** (ESPR, Regulation (EU) 2024/1781) establishes an ***economy-wide framework for mandatory product sustainability requirements*** and, through future delegated acts, enables ***Digital Product Passports*** with ***standardised, machine-readable information. Iron and steel*** are ***pre-defined*** as priority product groups in the Commission's first ESPR working plan.[74]

(including automakers) to quantify or track upstream emissions reductions.[75] Recent policy and industry initiatives aim to narrow this gap.

- ***National Product Carbon Footprints (PCF) roadmap*** (to 2030): In 2024, the government set out a roadmap to build a PCF management system by 2030. Recent national policies increasingly prioritise the PCF system, partly in response to green trade measures such as the EU's CBAM.
- ***Methodologies and standards*** (since 2022): Since 2022, national authorities have promoted sectoral ***product-level carbon accounting*** methodologies. In 2025, the Steel PCF Accounting Rules were included into the first national batch of developing technical standards for basic industrial products, establishing a unified life-cycle accounting approach.
- 2025 steel industry policies: Two major steel industry policies issued in 2025 ***call for the development of a PCF assessment system***. Leading firms are encouraged to carry out PCF assessments and disclose EPDs.

Meanwhile, both steel and automotive industries are developing ***industry-led disclosure*** *platforms*:

- ***Steel***: The China Iron and Steel Association (CISA),[76] together with Baowu and other firms, launched a steel-industry EPD platform. Eighteen listed steel companies have published product-level carbon-footprint through the platform.[77]
- ***Automotive***: The China Automotive Technology and Research Center's Carbon Footprint Publicity Platform disclosed life-cycle carbon data for more than 8,300 vehicle models across 88 enterprises by the end of 2024.[78]

However, there is no clear evidence of substantive coordination between automotive and steel EPD/PCF systems, limiting interoperability and integrated verification across the two sectors.

[71] (ECO Platform, n.d.)
[72] (ÖKOBAUDAT, n.d.)
[73] (European Union, 2024)
[74] (European Commission, 2025a)
[75] (Li et al., 2024)
[76] It is national nonprofit organisation including enterprises and research institutions from the steel industry
[77] https://www.c2fsteel.com
[78] http://en.auto-cpp.com

Standards and definitions

A further barrier to uptake is the absence of harmonised **low-carbon steel** definitions. In 2024, industrial stakeholders in both **China and Germany introduced definitions and methodologies.**

Germany:

The federal government positions lead markets as the main route to scaling demand for climate-friendly basic materials, including steel, and supported the development of low-carbon steel definitions led by the German steel industrial association, WV Stahl. The Low Emission Steel Standard (LESS) ***classifies steel products by climate-performance metrics*** and can serve as an interim tool for downstream users (notably automotive) pending an EU-level framework.[79]

China:

Together with a wide range of stakeholders, CISA developed Methods for the Assessment of China Decarbonised, Ecological, Future-Oriented Steel. This establishes a ***product-level framework for CO_2-intensity assessment and a five-tier grading system for crude and finished steel.*** The methodology is ***being developed into a national standard.***

3.5 Policies to secure access to affordable renewable hydrogen and renewable electricity

Renewable hydrogen

The scale-up of green H_2-DRI depends on secure access to renewable hydrogen at competitive and predictable cost. This requires not only an expansion of electrolysis capacity, but also parallel investment in hydrogen transport and storage infrastructure, alongside the coordinated growth of renewable power generation.[80]

Germany:

Hybrid renewable hydrogen supply and steel being a priority off-taker

Supply model and definition

Germany's policies to support industrial access to renewable hydrogen are built around a hybrid supply model and sit within the EU's broader, system-wide expansion of the renewable hydrogen economy.

Hybrid supply model: Germany and the EU face different constraints from China. The renewable electricity needed for large-scale H_2-DRI makes fully domestic hydrogen supply unlikely. Policy therefore rests on a hybrid model: ***accelerating domestic electrolysis, while enabling imports*** from countries boasting low-cost, renewable energy-based electricity and hydrogen production

China:

Rapid scale-up with an increasing focus on system building (standards, value-chain integration, and infrastructure and industrial demand)

China has already developed several hydrogen-ready DRI pilot and demonstration projects, suggesting that the route is technologically credible. However, economically viable renewable hydrogen remains scarce and unevenly distributed. As a result, most H2-ready DRI capacity continues to rely on fossil gases, mainly natural gas and coke-oven gas.[89]

China has ***expanded renewable hydrogen capacity rapidly*** under a ***broad policy framework***. A recent governmental report indicates that, by 2024, China had deployed around 125,000 t/yr of renewable hydrogen

[79] (LESS & Responsiblesteel, 2025)
[80] (Wang et al., 2025), (OECD, 2025a)

[89] (Transition Asia, 2024)

supported by new cross-border infrastructure. This is embedded in EU strategy. REPowerEU sets a 2030 target of producing 10 Mt of renewable hydrogen in the EU and importing a further 10 Mt. Germany's hydrogen strategy is consistent with this approach, anticipating that imports will meet 50-70% of hydrogen and hydrogen-derivative demand by 2030.

Definition of low carbon hydrogen at the EU level: Renewable hydrogen, or Renewable Fuels of Non-Biological Origin (RFNBOs), and low-carbon hydrogen are ***defined at EU level***. EU legislation sets detailed and legally binding requirements for renewable hydrogen production and maintains a clear distinction between renewable and low-carbon hydrogen.[81]

Measures to improve availability and affordability

Scale up domestic supply:

- Germany's updated National Hydrogen Strategy doubles the 2030 domestic electrolysis target to at least 10 GW. ***Federal flagship programmes*** aim to expand electrolyser deployment and manufacturing, advance offshore wind-to-hydrogen value chains, and develop hydrogen transport and related infrastructure.[82]
- Germany also operates within the EU framework to support the expansion of the hydrogen production market: the ***European Hydrogen Bank provides a fixed euro-per-kilogram premium to certified RFNBO hydrogen producers*** through auction.[83]

Targeted tools to de-risk import: H_2Global, which employs a ***double-auction*** model to support global trade,[84] and the PtX Development Fund, which provides ***grant-based de-risking*** for industrial-scale PtX infrastructure and value-chain projects in developing and emerging economies.[85]

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capacity, close to half of the global total of about 250,000 t/yr.[90,91]

This acceleration is aligned with top-level strategy and policy:

- The ***Hydrogen Energy Industry Medium- and Long-Term Development Plan*** (2021–2035) sets a near-term target of 100,000–200,000 t/yr of renewable hydrogen by 2025 and signals ***a larger role for hydrogen in final energy consumption*** by 2035.
- ***Standard development:*** policies aim to reduce regulatory uncertainty through standardisation. More than 30 hydrogen standards were scheduled for development or revision by 2025. The recently issued Clean and Low-Carbon Hydrogen Assessment Standard introduces a lifecycle carbon-footprint accounting framework, strengthe-ning the basis for certification, procurement and future conditional support.[92]

Policy emphasis is also ***shifting from capacity additions to value-chain integration***:

- 2025 ***pilot programmes***: the central government launched pilot programmes to support ***coordinated development across the hydrogen value chain***, including production, storage, transport and end-use, combining national and provincial incentives with preferential lending for selected projects.
- Hydrogen ***transportation***: the West-to-East Hydrogen Pipeline described as the first interprovincial, long-distance, large-scale renewable hydrogen transport project, starts in the renewable-rich western provinces and is intended to reduce spatial mismatches between supply and demand.[93]
- ***Clearer demand-side steering***: recent policies give greater priority to low-carbon hydrogen uptake in energy-intensive sectors, including steel and chemicals, with the aim of moving from pilot projects to larger-scale deployment by 2027.

[80] (Wang et al., 2025), (OECD, 2025a)
[81] (Bruch & Knodt, 2025)
[82] https://www.wasserstoff-leitprojekte.de/home
[83] https://energy.ec.europa.eu/topics/eus-energy-system/hydrogen/european-hydrogen-bank_en
[84] https://h2-global.org/
[85] https://www.ptx-fund.com/

[89] (Transition Asia, 2024)
[90] (National Energy Administration, 2025)
[91] (Yin, 2025)
[92] (Guohua investment, 2026)
[93] (Xinhua, 2023)

Infrastructure as a precondition for scale:

- The ***European Hydrogen Backbone (EHB)*** vision is centred on ***repurposing existing gas assets*** into a dedicated hydrogen network, with a 2040 mix of around 60 percent repurposed and 40 percent new pipelines, and on ***developing import corridors and storage*** to connect demand centres to lower-cost renewable supply regions.[86]
- Germany's Hydrogen Core Network: in parallel and as a complement, the Commission approved an estimated €3 billion German scheme to support the construction of the Hydrogen Core Network. The national plan foresees 9,040 km of pipelines being brought online in stages through to 2032, around 60 percent of them converted from existing gas pipelines. The national backbone is designed to connect ports, industrial clusters and production sites, and to make imported and domestic hydrogen physically usable for steel decarbonisation.[87]

Important Projects of Common European Interest (IPCEIs) provide an ***EU state-aid framework*** through which member states jointly structure integrated and cross-border value-chain projects and finance them primarily through national public funds. For Germany, IPCEIs have become a ***central de-risking channel*** for both scaling domestic hydrogen supply and building enabling infrastructure (Hy_2Tech and Hy_2Use waves).[88]

Demand-pull measures: industry

- At the ***EU*** level the ***Renewable Energy Directive (RED) III*** introduces ***binding targets for RFNBO use in industry***, including the 2030 and 2035 milestones.
- At the ***national level***, and particularly for steel decarbonisation, the federal government's ***hydrogen import*** strategy explicitly identifies ***steel as a key offtake sector*** because hydrogen demand rises with the progressive conversion to DRI.

Constraints on renewable hydrogen availability for steel are nevertheless likely to persist, at least in the near term. China's existing industrial hydrogen demand remains heavily concentrated in the chemical sector,[94] and early renewable hydrogen output, especially from renewable-rich western regions, has often been directed towards green ammonia and green methanol projects, which also benefit from targeted public support. Without clearer prioritisation, steel could continue to face tight renewable hydrogen availability even as overall supply expands.

[86] (European Hydrogen Backbone, n.d.)
[87] (Bundesnetzagentur, 2024b)
[88] (European Commission, n.d.-a)

[94] (Zhang et al., 2024)

Renewable electricity

Because the EAF route is central to steel decarbonisation in both China and Germany, this section compares how the policy framework shapes steelmakers' access to affordable renewable electricity in the two countries. To keep the analysis focused, it considers two policy bundles: (i) measures that directly promote renewable electricity use in the steel industry, including incentives, conditional support and compliance requirements; and (ii) measures that enable either physical connection to renewables or the contractual purchase of renewable electricity. Direct physical connection can reduce exposure to congestion and connection constraints and may also lower regulated grid charges. Corporate power purchase agreements (PPAs) can provide renewable electricity claims with multi-year price stability. Both can improve the bankability of EAF expansion and broader electrification.

Germany:

Access primarily via PPAs and direct lines; no industrial-specific demand mandate

In Germany, aside from wholesale electricity purchases backed by Guarantees of Origin, access to affordable renewable electricity for steel rests on the following two channels:

- ***Corporate PPAs:*** The EU's 2024 electricity market design reform explicitly promotes long-term contracts, such as PPA, to reduce exposure to short-term price volatility, and invites member states to broaden their uptake, including through guarantee schemes.[95]
- Direct line: physical procurement through "direct lines" is ***legally enabled***. EU Article 7 of Directive (EU) 2019/944 requires member states to allow supply through direct lines on the basis of objective and non-discriminatory criteria. Germany implements this through the EnWG definition of a Direktleitung, which is legally distinct from regulated public networks. In suitable site configurations, this can ***reduce average delivered electricity costs*** and lower the operating cost of renewable-based EAF production. The framework underpins early industrial applications such as thyssenkrupp Hohenlimburg, where a nearby wind park supplies the steel site through a dedicated cable, largely bypassing the public grid.[96]

China:

Rising policy pressure for industry to consume renewables, backed by green power access frameworks

In China, policies have ***increasingly steered energy intensive industries***, including steel, ***towards higher renewable electricity use***, while simultaneously putting in place the ***framework required for green power access***.

Demand pulls from industrial users:

- The 2024 Guiding Opinions on Vigorously Implementing Renewable Energy Substitution (to fossil fuel) calls for raising the ***share of EAF steelmaking***.
- This is complemented by the 2025 renewable electricity consumption responsibility framework, which introduces a ***green electricity consumption target for steel***, alongside other energy-intensive industries, but specifies that the steel sector's progress will only be monitored, rather than formally assessed, in 2025. Compliance relies heavily on ***Green Electricity Certificates (GECs)*** as proof of renewable electricity consumption, rather than on physical delivery alone.

Policy mix to improve physical access to renewables

Detailed ***national guidelines*** issued in 2024–2025 have strengthened ***support for nearby and on-site renewable generation and dedicated connections.*** In parallel, the ***national Zero-***

[95] (Council of the European Union, 2024)
[96] (NRW.Energy4Climate, n.d.)

In Germany, there are ***no steel-specific or industry-wide policies*** that ***mandate or preferentially reward the consumption of renewable electricity***.

Carbon Industrial Parks programme, launched in 2025, provides ***targeted financial support*** to selected pilot projects and ***gives explicit priority to direct physical access to green electricity supply***. It stipulates that, in principle, at least 50 percent of electricity consumption should be met through nearby and on-site renewable generation or dedicated connections.

Institutionalising bilateral green power trading

Beyond physical connection models, China has also ***institutionalised bilateral trading of renewable electricity***, broadly ***comparable to PPAs***. Since 2021, national authorities have ***progressively defined its rules***, clarifying trading procedures, contract models and pricing mechanisms. In practice, commercial and industrial consumers contract bilaterally with renewable generators or licensed power retailers, while grid companies retain responsibility for metering, settlement and system balancing. ***Contract durations*** have traditionally ranged from ***several days to one year***, though recent policy guidance explicitly ***encourages multi-year contracts*** to enhance price stability and investment certainty. Trading remains ***predominantly intra-provincial, complemented by cross-provincial*** green power transactions.[97]

[97] (Greenpeace, 2025)

4. Comparing policy landscapes in Germany and China and implications for mutual learning

Germany and China are entering a critical phase in steel decarbonisation, moving beyond incremental efficiency gains towards the large-scale deployment of near-zero production routes. Transition is constrained by a mix of shared bottlenecks and country-specific binding constraints:

- **Diverging production structures:** China's steel industry remains overwhelmingly based on BF–BOF. Germany, despite a higher EAF share, still relies on a small number of integrated BF–BOF sites for primary steel production.
- **A bankability gap for near-zero routes is real:** In both countries, deep decarbonisation means a structural shift away from coal-based BF–BOF. Yet near-zero routes, for example, H_2-DRI (typically paired with EAF), face a major bankability gap because of high upfront capital needs and exposure to operating costs, especially electricity and renewable hydrogen prices.
- **Margin pressure reinforces incumbent lock-in:** Persistently weak margins favour continued reliance on incumbent routes and delay investment in breakthrough technologies. In Germany, profitability is under pressure from war-related demand disruption, high energy and production costs, tariff uncertainty, weak demand and import pressure linked to global excess capacity. In China, weak demand, structural overcapacity, and a growing use of trade remedies similarly weigh on profitability and weaken incentives for early transition investment.
- **Reinvestment cycles are key decision points:** Germany faces near-term choices between relining and replacement at integrated sites, with implications for emissions profiles over decades. China's younger BF-BOF fleet will also require substantial reinvestment before 2030, making the 2020s a decisive period for avoiding long-term carbon lock-in.
- **Energy-system and scrap constraints are binding:** In both countries, access to affordable renewable electricity and renewable hydrogen limits scaling hydrogen-based steelmaking. In China, scrap supply is fragmented and pro-cyclical. Periods of weak steel prices compress EAF margins, reduce scrap collection incentives, and further destabilise supply.
- **Demand for low-carbon steel remains weak:** In both jurisdictions, demand for low carbon steel in the automotive sector is still limited and fragmented, while in buildings and infrastructure it remains largely confined to a small number of flagship projects.

These structural factors have shaped policy design and their priority in the two jurisdictions.

>>> Set direction for decarbonisation

- In both countries, clear technology pathways can be identified in directionality policies.

CHINA	GERMANY
Centrally coordinated and consistent policy mix integrating climate and sustainable development strategies, industrial strategy, funding and financing instruments, plant capacity governance, and air-pollution control.	National directionality policies that combine climate targets with funding and innovation support, hydrogen strategy, and enabling infrastructure planning, anchored in EU climate governance.
Technology pathways: strong emphasis on energy efficiency upgrades as near-term action; scrap-based EAF as a near- to mid-term lever; pursue broader hydrogen applications, including hydrogen applications in BF–BOF, H_2-DRI/EAF, and hydrogen-rich smelting reduction.	Technology pathway: scrap-based EAF as a near- to mid-term lever; treat renewable hydrogen DRI/EAF as fundamental option for primary steelmaking.
Capacity governance as a dual lever: curbing overcapacity while steering steel's technological transition.	EU ETS: mature development and phasing-out of free allocation is reshaping investment decisions.
ETS China: deliberately low stringency in the first phase.	Policies combatting air pollution do not play a significant role in steering the sector's decarbonisation trajectory

>>> Support knowledge creation and development (TRL 1-6)

- In both countries, clear strategic R&D directions for steel decarbonisation innovation were defined, which is consistent with the signalised technology pathways.

CHINA	GERMANY
R&D effort remains below targets; soft incentives recently introduced.	A layered TRL pipeline links early R&D towards demonstrations combining national and EU instruments.
National guidance is strong, with defined technical priorities.	National instruments support early and mid-TRL industrial decarbonisation R&D, but have not yet funded breakthrough steel decarbonisation technologies.
Absence of a dedicated, centrally funded programme for steel R&D and demonstration. Innovation activities largely driven by major SOEs and leading private steel firms.	EU instruments extend support into FOAK-ready demonstration, and coordination mechanisms align priorities across governance levels.
Next step: a national innovation centre with dedicated funding.	

Financial support for mainstreaming low carbon steel production

- Both support steel decarbonisation through deploying CAPEX and OPEX instruments, aligned with their technology pathways.

CHINA	GERMANY
CAPEX support: • Subsidies prioritise energy efficiency upgrades and air-pollution control retrofits rather than a dedicated push for breakthrough deep-decarbonisation routes • Use transition finance as a policy lever to facilitate capital access for steel decarbonisation.	CAPEX support for H_2-DRI/EAF is largely delivered through EU state-aid-cleared FOAK conversions, national programs, and EU de-risking instruments.
OPEX support: • Performance-linked electricity pricing; • Tax incentives linked to air pollution control and energy efficiency measures; • Subsidies for renewable electricity procurement fragment at the local level.	OPEX, particularly electricity prices, are a major constraint on the EAF route. Existing support focuses mainly on electricity cost relief. In addition, operating-cost hedging instruments such as CCfDs remain relevant for underwriting the cost gap faced by near-zero steel.

Drive demand for low carbon steel

- The current buildings procurement frameworks of both countries do not translate into a clear, enforceable preference for low-carbon materials.
- Industrial stakeholders in both countries introduced definitions and methodologies for low-carbon steel.

CHINA	GERMANY
Automotive: policies focus primarily on strategic roadmaps, guidance and the gradual development of standards.	Automotive: forthcoming EU regulations could potentially create a lead market of low carbon steel in this sector through binding emission and recycled targets.
Buildings: GPP standards for green buildings and materials exist, but no low carbon steel component requirements.	Buildings: GPP incentivises project-level sustainability performance, rather than shifting procurement towards low-carbon building materials.
Data transparency: rapid Product Carbon Footprints (PCF) system build-out alongside industry-led EPD platforms from both steel and automotive industries.	Data transparency: construction sector-mature EPD, shifting from voluntary towards mandatory requirements; economy-wide mandatory information framework emerging.

>>> Secure affordable renewable hydrogen and renewable electricity

CHINA	GERMANY
Renewable hydrogen access: rapid scale-up with growing emphasis on system-building (standards, value-chain integration, infrastructure, and industrial demand).	Renewable hydrogen access: within the EU framework, a hybrid approach to renewable hydrogen access, i.e., scaling of domestic supply while using specialised instruments to de-risk imports and build infrastructure. Steel is identified among priority industrial application sectors.
Renewable electricity: mandatory industrial renewable use. Longer-term bilateral contracting is still developing. Increasing support for nearby and on-site renewable generation and dedicated connections.	Renewable electricity: securing cost-competitive green electricity for steel producers: long-term corporate PPAs, plus direct-wire connections supported by legislation, but not yet mainstream.

The mapping suggests both China and Germany already deploy a broad mix of instruments to steer steel decarbonisation. The following point to ***policy gaps*** and outline ***opportunities for mutual learning and cooperation.***

Setting direction for steel decarbonisation

1. **Coordinate directionality through a policy stack.** China's policy framework is characterised by strong central coordination. Climate and sustainable-development planning, industrial strategy and air-pollution control are mutually reinforcing: together, they provide clear direction for steel decarbonisation pathways and align compliance expectations with investment signals and infrastructure decisions. However, China's current transition pathway is bounded by the starting point: a production base still dominated by BF–BOF routes, with decarbonisation efforts concentrated on incremental efficiency gains and BF-BOF retrofits rather than a decisive shift towards near-zero routes.
2. **Avoid lock-in: make support conditional and time-bound.** China's BF–BOF-heavy starting point continues to favour efficiency upgrades and a broad hydrogen portfolio, including blast-furnace hydrogen injection. The risk lies not in transitional measures as such, but in the absence of explicit phase-down and retirement schedules, together with clear reinvestment rules. Without these guardrails, high-emissions assets may operate longer than intended, delaying investment in near-zero alternatives.[98]
3. **Make the ETS a stronger investment signal.** The EU ETS already covers iron and steel and, as it tightens, raises expected carbon-cost exposure for incumbent BF–BOF routes, strengthening the incentive to avoid long-lived high-emissions reinvestment. In China, extending the national ETS to steel introduces an initial signal, but with limited early stringency. Whether it influences investment decisions will depend on tighter benchmarks, allocation rules and a rising carbon price over time.[99] A credible, pre-committed tightening path would enhance its effectiveness as an investment-grade instrument.

Support R&D for breakthrough technologies

4. **Build a staged innovation pipeline (TRL 1–6).** To accelerate learning on breakthrough routes, China could draw on German/EU practice by establishing dedicated R&D support that combines steel-specific and industry-wide programmes, structured along TRL stages through a predictable funding pipeline. Preparations to establish a National Low-Carbon Steel Technology Innovation Centre are a credible first

[98] (OECD, 2025a)
[99] (Transition Asia, 2025)

step if matched with dedicated funding and clear decarbonisation criteria.

Financial support to mainstream low-carbon production

5. **Tie OPEX relief to delivery conditions and to the binding risk.** China's performance-linked electricity pricing shows how OPEX support can be conditional and scalable. Germany's electricity cost relief would only support decarbonisation if it is designed with sharper conditionality tied to verifiable transition actions.[100] Germany's project-level hedging instruments, based on CCfD logic, more directly address operating-risk gaps. In this area, China could draw lessons from CCfD-type instruments to mitigate the high cost of renewable hydrogen and narrow the cost gap between hydrogen-based and conventional steel production.
6. **Recycle ETS value into investment discipline.** The EU Innovation Fund converts EU ETS auction value into competitively allocated support. As China's ETS expands and matures, revenue recycling could be used to build a predictable and rules-based funding channel for breakthrough CAPEX.

Drive demand for low-carbon steel

7. **Build verifiable carbon product database.** Most measures intended to create lead markets for low-carbon steel depend on high-resolution, verifiable carbon-intensity data based on sound and harmonised methodologies. China's product-level carbon accounting framework remains under development, but is advancing quickly, including for steel and related products. In the EU and Germany, the most developed steel-relevant framework is currently found in the construction sector, where verified EPDs, life-cycle assessment practice and established databases already support product-level disclosure. This is increasingly complemented by the EU's broader shift towards mandatory sustainability information and digital product-data systems. These developments create scope for mutual learning: the EU and Germany can share practical experience in methodology design, data governance and verification, while China's rapid implementation offers lessons in scaling product-level systems across emissions-intensive industries.
8. **Use procurement to create repeatable volume.** Despite the strong decarbonisation potential of public spending in the construction sector, both countries still lack an adequate GPP framework capable of generating reliable demand for low-carbon steel. The priority is to require embodied carbon disclosure for key structural materials (starting with steel) in China and to translate such disclosure through procurement rules in both countries.

Secure affordable renewable hydrogen and renewable electricity

9. **Take a systematic approach to affordable renewable hydrogen.** Although Germany/the EU and China are taking different routes to secure access to affordable renewable hydrogen, both are applying more systematic policy approaches that strengthen the credibility of future hydrogen availability for industry. This offers a transferable lesson for other countries.
10. **Prevent allocation bottlenecks for renewable hydrogen in China.** A key near-term risk for steel decarbonisation in China is allocation. Affordable renewable hydrogen will be scarce in the early years, while policy-backed demand in adjacent value chains, especially chemicals such as green ammonia and green methanol, could absorb a disproportionate share of initial supply. To avoid crowding out steel decarbonisation, policy should both signal priority off-take where warranted and, more importantly, enable delivery at scale: faster connections to supply infrastructure for steel plants, aggregated off-take arrangements to reduce volume and counterparty risk, and regional clustering that co-locates renewable generation, hydrogen production and industrial demand.[101]

[100] (Agora Energiewende, 2025)
[101] (International Renewable Energy Agency, n.d.))

11. **Strengthen policies to secure affordable renewable energy supply.** The Chinese government is pushing heavy industry towards higher renewable electricity uptake by setting province-level renewable power consumption ratios for key energy-intensive industries. This could accelerate electrification, especially when combined with direct renewable power connections and the continued expansion of green electricity trading and longer-term contracting arrangements. On dedicated connections, China could draw on Germany's experience, where comparable models rest on firmer legislative foundations, thereby reducing regulatory discretion and improving bankability.[102] In China, multi-year and cross-provincial green power procurement is still developing and new direct-connection rules are opening additional pathways for industrial buyers. Germany provides a useful practical reference because long-term PPA is embedded in a more mature regulatory environment. For both jurisdictions, exchange could also cover how industrial users can provide flexibility to increasingly renewable-based power systems, and how the resulting revenues and cost savings might strengthen the business case for electrification investment.

Steel decarbonisation is a shared challenge for Germany/the EU and China: emissions must fall, the sector must remain investable and competitive, and the transition must be socially manageable. In the current context of trade tensions and geopolitical strain, this strengthens the case for more structured dialogue, mutual understanding and targeted cooperation. Such engagement will not remove underlying trade frictions, but it can reduce misperceptions, limit escalation around trade instruments, and support a clearer investment runway for near-zero steel.

[102] (Guo, 2025)

Bibliography

Agora Energiewende. (2021). Global steel at a crossroads: Why the global steel sector needs to invest in climate-neutral technologies in the 2020s. Agora Energiewende. https://www.agora-energiewende.org/fileadmin/Projekte/2021/2021-06_IND_INT_GlobalSteel/A-EW_236_Global-Steel-at-a-Crossroads_WEB_V2.pdf

Agora Energiewende. (2025). Industriestrompreis mit Perspektive: Mehr Erneuerbare, mehr Flexibilität und geringere Kosten. Agora Energiewende. https://www.agora-energiewende.de/aktuelles/industriestrompreis-mit-perspektive-mehr-erneuerbare-mehr-flexibilitaet-und-geringere-kosten

Agora Industry. (2024). Achieving climate-neutral steel by 2050. Agora Industry. https://www.agora-industry.org/fileadmin/Projekte/2024/2024-28_IND_Green_Iron/A-IND_382_Achieving_climate-neutral_steel_by_2050_WEB.pdf

Bruch, N., & Knodt, M. (2025). Low carbon hydrogen in the European Union: A coherent regulatory framework. Ariadne. https://ariadneprojekt.de/en/publication/analysis-low-carbon-hydrogen-in-the-european-union-a-coherent-regulatory-framework/

Bundesministerium für Wirtschaft und Energie. (n.d.). Bundesförderung Industrie und Klimaschutz (BIK)—Förderung zur Dekarbonisierung der Industrie. Förderdatenbank. Retrieved https://www.foerderdatenbank.de/FDB/Content/DE/Foerderprogramm/Bund/BMWi/bik-modul1-2.html

Bundesministerium für Wirtschaft und Energie. (2025a). Project profiles. Bundesministerium für Wirtschaft und Energie. https://www.klimaschutzvertraege.info/lw_resource/datapool/systemfiles/agent/ewbpublications/16f1fca8-3afa-11f0-88d6-fa163e7d9971/live/document/BMWE_A4-Template_Projektsteckbriefe_bf_final.pdf

Bundesministerium für Wirtschaft und Energie. (2025b). Übersicht BIK Projekte Förderwettbewerb 2025. Bundesministerium für Wirtschaft und Energie. https://www.bundeswirtschaftsministerium.de/Redaktion/DE/Downloads/B/uebersicht-bik-projekte-foerderwettbewerb-2025.pdf?__blob=publicationFile&v=4

Bundesministerium für Wirtschaft und Klimaschutz (BMWK). (2024). Importstrategie für Wasserstoff und Wasserstoffderivate.

Bundesnetzagentur. (2024a, July 24). Federal Network Agency plans reform of grid charges for industry. https://www.bundesnetzagentur.de/SharedDocs/Pressemitteilungen/DE/2024/20240724_IndustrieNE.html

Bundesnetzagentur. (2024b, October 22). Bundesnetzagentur approves hydrogen core network. https://www.bundesnetzagentur.de/SharedDocs/Pressemitteilungen/EN/2024/20241022_H2.html

C Steel News. (2025, March 13). 2024 R&D Progress on Key Emission Reduction Technologies in the Steel Industry (Chinese). http://www.csteelnews.com/xwzx/aqhb/202503/t20250313_97927.html

CBCSD. (2023, November 7). 2023 guidelines for projects under the China Baowu low-carbon metallurgy innovation fund released. http://www.cbcsd.org.cn/xws/hydt/20231107/104374.shtml

CEIC Data. (n.d.). China: Steel: Capacity utilization, production, and demand [Data set]. Retrieved https://www.ceicdata.com/zh-hans/china/steel-capacity-utilization-rate-production--demand

China Metallurgical News (CMN). (2025, June 25). Leading the steel energy-efficiency revolution through ultimate energy efficiency innovation. https://www.csm.org.cn/col/col6371/art/2025/art_1984370748.html

Choksey, Y. (2025). The State of the European Steel Transition. E3G. https://www.e3g.org/wp-content/uploads/The-State-of-the-European-Steel-Transition-Report.pdf

Climate Bonds Initiative. (2025). Financing the decarbonisation of China's steel sector: Pilot transition-finance initiatives and market developments. Climate Bonds Initiative. https://www.climatebonds.net/files/reports/cbi_china_steel_report_24_cn_01b.pdf

Competition-policy. (2025). Clean Industrial Deal State aid Framework: Overview of Support Measures. https://competition-policy.ec.europa.eu/about/contribution-clean-just-and-competitive-transition/clean-industrial-deal-state-aid-framework-cisaf_en

Council of the European Union. (2024, May 21). Electricity market reform: Council signs off on updated rules. https://www.consilium.europa.eu/en/press/press-releases/2024/05/21/electricity-market-reform-council-signs-off-on-updated-rules

CSTEELNEWS. (2024, October 24). China's steel industry is becoming a driver of global steel technological progress and a contributor to green transition. http://www.csteelnews.com/xwzx/djbd/202410/t20241024_93800.html

CSTEELNEWS. (2025, July 1). Shortlisted projects for the 2024 Baowu low-carbon metallurgy innovation fund announced. http://www.csteelnews.com/qypd/qydt/202507/t20250701_101582.html

Deutsch Bahn. (2025, November 5). German Railway started pilot project of green steel with Saarstahl. https://www.deutschebahn.com/de/presse/pressestart_zentrales_uebersicht/Deutsche-Bahn-startet-Pilotprojekt-zu-gruenem-Stahl-mit-Saarstahl-13601048

Devlin, A., Kossen, J., Goldie-Jones, H., & Yang, A. (2023). Global green hydrogen-based steel opportunities surrounding high quality renewable energy and iron ore deposits. Nature Communications, 14, 2578. https://doi.org/10.1038/s41467-023-38123-2

ECO Platform. (n.d.). About EPD. Retrieved https://www.eco-platform.org/eco-epd-40.html

Economic Daily. (2024, July 24). Remarkable results achieved in ultra-low-emission retrofits in the steel industry. http://www.news.cn/energy/20240724/78b9205ab9bd47f6bff14d026cd9b023/c.html

EUROFER. (2025). European Steel in Action 2025. EUROFER. https://www.eurofer.eu/assets/publications/reports-or-studies/european-steel-in-action-2025/European-Steel-In-Action-2025.pdf

European Commission. (n.d.-a). Hydrogen value chain. Retrieved https://competition-policy.ec.europa.eu/state-aid/ipcei/approved-ipceis/hydrogen-value-chain_en

European Commission. (n.d.-b). Projects selected for grant preparation. European Commission. Retrieved https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund/calls-proposals/large-scale-calls/projects-selected-grant-preparation_en

European Commission. (2023a). State aid: Commission approves German €550 million direct grant and conditional payment mechanism of up to €1.45 billion to support ThyssenKrupp Steel Europe in decarbonising its steel production and accelerating renewable hydrogen uptake. https://ec.europa.eu/commission/presscorner/api/files/document/print/es/ip_23_3928/IP_23_3928_EN.pdf

European Commission. (2023b). State Aid SA.105337 (2023/N) – Germany: Aid to AG der Dillinger Hüttenwerke, Saarstahl AG and ROGESA Roheisengesellschaft Saar mbH for project Power4Steel – Phase 1 in Völklingen and Dillingen. European Commission. https://ec.europa.eu/competition/state_aid/cases1/202442/SA_105337_152.pdf

European Commission. (2024, February 22). €1.3 billion German State aid measure funded under Recovery and Resilience Facility to support ArcelorMittal decarbonise its steel production. European Commission. https://ec.europa.eu/commission/presscorner/detail/de/ip_24_1009

European Commission. (2025a). Ecodesign for Sustainable Products and Energy Labelling Working Plan 2025-2030. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX%3A52025DC0187

European Commission. (2025b). EU Grants: Call document (RFCS): RFCS Annual Call 2025. European Commission. https://new.regione.vda.it/Media/Regione/BandiAvvisi/call-fiche_rfcs-2025_en.pdf

European Commission. (2025c, December 15). Commission takes action for clean and competitive automotive sector. https://ec.europa.eu/commission/presscorner/detail/en/ip_25_3051

European Health and Digital Executive Agency. (2024, January 24). European clean steel: Discover HaDEA's projects towards low carbon steelmaking. https://hadea.ec.europa.eu/news/european-clean-steel-discover-hadeas-projects-towards-low-carbon-steelmaking-2024-01-24_en

European Hydrogen Backbone. (n.d.). European Hydrogen Backbone grows to meet REPowerEU's 2030 hydrogen targets. Retrieved https://ehb.eu/newsitem/european-hydrogen-backbone-grows-to-meet-repowereu-s-2030-hydrogen-targets

European Parliament. (2025, December 12). Circular economy: Deal on new EU rules for the automotive sector. European Parliament. https://www.europarl.europa.eu/news/de/press-room/20251209IPR32114/circular-economy-deal-on-new-eu-rules-for-the-automotive-sector

European Union. (2024, November 27). Regulation (EU) 2024/3110 of the European Parliament and of the Council of 27 November 2024 laying down harmonised rules for the marketing of construction products and repealing Regulation (EU) No 305/2011. https://www.eota.eu/sites/default/files/files/OJ_L_202403110_EN_TXT.pdf

Federal Ministry for Economic Affairs and Climate Action. (2024). Funding programme for carbon contracts for difference. Federal Ministry for Economic Affairs and Climate Action.

https://www.klimaschutzvertraege.info/lw_resource/datapool/systemfiles/agent/ewbpublications/fe0f6dc4-f70e-11ee-8b39-a0369fe1b6c9/live/document/0276-24_EN_Lav_Pressepapier_F%C3%B6rderprogramm_Klimaschutzvertr%C3%A4ge.pdf

German Emissions Trading Authority. (n.d.). Electricity price compensation (SPK). Retrieved https://www.dehst.de/EN/Topics/SPK/spk_node.htm

Global Alliance for Buildings and Construction. (2025). Global status report for buildings and construction 2024/2025: Not just another brick in the wall. Global Alliance for Buildings and Construction. https://globalabc.org/sites/default/files/2025-03/Global-Status-Report-2024_2025.pdf

Greenpeace. (2025). Progress, challenges, and recommendations for green electricity consumption in China's steel industry. Greenpeace. https://www.greenpeace.org.cn/wp-content/uploads/2025/11/green-power-consumption-in-china-steel-industry-report-2025.pdf

Guo, X. (2025, July 28). Analysis of Germany's green electricity direct-supply model and its implications. https://www.cpnn.com.cn/news/baogao2023/202507/t20250728_1819345.html

Guohua investment. (2026, January 8). China's first industry standard for evaluating the low-carbon attributes of hydrogen energy, led by Guohua Investment, released. https://www.ceic.com/gjnyjtww/newCE0302/202601/0414b515c1bc4009abdd62d9fbc6b7c9.shtml

Haffner, J. (2025, July 9). Low Carbon Emissions Steel Procurement in Real Estate. https://worldsteel.org/wp-content/uploads/Low-carbon-steel-procurement-in-construction.pdf

Handelsblatt. (2025, September 19). Stahlkonzern Salzgitter verzögert Investitionen in grünen Umbau.

International Energy Agency. (2023). Emissions Measurement and Data Collection for a Net-Zero Steel Industry: Executive Summary. International Energy Agency. https://www.iea.org/reports/emissions-measurement-and-data-collection-for-a-net-zero-steel-industry/executive-summary

International Energy Agency. (2025a). Estimated final electricity price for large industrial customers in energy-intensive industries, 2019-2024. International Energy Agency. https://www.iea.org/data-and-statistics/charts/estimated-final-electricity-price-for-large-industrial-customers-in-energy-intensive-industries-2019-2024

International Energy Agency. (2025b). Scaling Up Transition Finance. https://www.iea.org/reports/scaling-up-transition-finance

LESS, & Responsiblesteel. (2025). RS-LESS: The Steel Decarbonisation Scale. LESS. https://lowemissionsteelstandard.org/files/less/home/insights/RS-LESS_The%20Steel%20Decarbonisation%20Scale_final.pdf

Li, M., Zhu, Z., Ding, S., Ma, J., Xu, X., Zhang, H., & Li, Y. T. (2024). Automotive–steel and aluminium supply-chain collaborative decarbonisation evaluation report. http://oaallfile.oss-cn-qingdao.aliyuncs.com/20250314/20250314010000027515c76b535550d4196b481ef2a18dedfd3.pdf

Matthes, D. F. C., & Brauer, D. J. (2025). Hydrogen production costs.

Mendelevitch, R., Hermann, H., Graichen, V., Bibu, T., Lettow, F., & Nissen, C. (with Umweltbundesamt). (2024). Development of the iron and steelmaking sector under the EU ETS (p. 162). German Environment Agency. https://doi.org/10.60810/OPENUMWELT-7626

National Energy Administration. (2025). China hydrogen energy development report (2025). https://www.nea.gov.cn/20250430/96022785b3a747248288ad1c57d3a025/83d863317f2f44edb605348e4de40993.pdf

NRW.Energy4Climate. (n.d.). Direktbelieferung in Hohenlimburg. Retrieved https://www.energy4climate.nrw/praxisbeispiele/direktbelieferung-in-hohenlimburg

Oda, Y. (2025). Recent Developments in Nonoriented Electrical Steel Sheets. In Handbook of Magnetic Material for Motor Drive Systems (pp. 895–916). Springer, Singapore. https://doi.org/10.1007/978-981-96-5701-8_61

OECD. (2025a). Hydrogen in steel: Addressing emissions and dealing with overcapacity (OECD Science, Technology and Industry Policy Papers, Issue 174). OECD Publishing. https://doi.org/10.1787/7e2edc69-en

OECD. (2025b). OECD Steel Outlook 2025. OECD Publishing. https://doi.org/10.1787/28b61a5e-en

ÖKOBAUDAT. (n.d.). ÖKOBAUDAT. Retrieved https://www.oekobaudat.de/en.html

Oxford Institute for Energy Studies. (2024). Decarbonising China's steel sector. Oxford Institute for Energy Studies. https://www.oxfordenergy.org/wpcms/wp-content/uploads/2024/07/Insight-155-dacarbonising-Chinas-steel-sector.pdf

People's Bank of China. (n.d.). Guidelines on financial supporting for green and low-carbon development. Retrieved https://www.pbc.gov.cn/en/3688006/3995557/2025112114583978353/2024050714051271744.pdf

Ramboll. (2024). Green public procurement in construction: Driving public purchase towards truly green construction products and materials. Environmental Coalition on Standards (ECOS). https://ecostandard.org/wp-content/uploads/2024/10/Driving-GPP-in-construction-Ramboll-November-2024.pdf

ReInvent. (n.d.). KLIMPRO-Projekte. Retrieved https://reinvent-klimpro.de/projekte.html

Reuters. (2025, September 16). China steel exports poised for record high, risking further tariff backlash. https://www.reuters.com/world/china/china-steel-exports-poised-record-high-risking-further-tariff-backlash-2025-09-16/

Salzgitter AG. (2023, April 18). Salzgitter AG receives approval for state funding for the SALCOS® programme for low-CO2 steel production. https://www.salzgitter-ag.com/de/newsroom/pressemeldungen/details/salzgitter-ag-erhaelt-bescheid-fuer-staatliche-foerderung-des-salcosr-programms-zur-co2-armen-stahlproduktion-20702.html

Shi, S., Li, H., Tang, H., & Liu, Y. (2023). A study of the impact of de-capacity policies on industry capacity utilization paths: Evidence from the Chinese steel industry. PLOS ONE, 18(12), e0295613. https://doi.org/10.1371/journal.pone.0295613 thyssenkrupp. (2022, February 15). Real-world laboratory of the energy transition “H2Stahl” launches at thyssenkrupp Steel’s Duisburg site. thyssenkrupp. https://www.thyssenkrupp-steel.com/de/newsroom/pressemitteilungen/reallabor-der-energiewende-h2stahl-startet-am-standort-duisburg-von-thyssenkrupp-steel.html

Transition Asia. (2025). Will China win the green steel race? Transition Asia. https://transitionasia.org/wp-

Transport & Environment. (2024). Cleaning up steel in cars: Why and how? Transport & Environment. https://www.transportenvironment.org/uploads/files/Green-steel-in-cars-briefing_July-2024.docx.pdf

Wang, Y., Chen, C., Tao, Y., & Wen, Z. (2025). Uneven renewable energy supply constrains the decarbonization effects of excessively deployed hydrogen-based DRI technology. Nature Communications, 16, 4916. https://doi.org/10.1038/s41467-025-59730-1

Wasserstoff-Leitprojekte. (n.d.). Federal Ministry of Research, Technology and Space. Federal Ministry of Research, Technology and Space. Retrieved https://www.wasserstoff-leitprojekte.de/home

Wei, C., Zhang, X., Zhang, J., Xu, L., Li, G., & Jiang, T. (2024). Development of direct reduced iron in China: Challenges and pathways. Engineering, 41(10), 93–109. https://doi.org/10.1016/j.eng.2024.04.025

Wirtschaftsvereinigung Stahl. (n.d.). Wege der Stahlproduktion. Retrieved https://www.wvstahl.de/stahlstandort-deutschland/

Wirtschaftsvereinigung Stahl. (2025). Daten und Fakten zur Stahlindustrie in Deutschland. https://www.wvstahl.de/wp-content/uploads/WV-Stahl_Daten-und-Fakten-2025_Web.pdf

World Steel Association. (2025). World Steel in Figures 2025. World Steel Association. https://worldsteel.org/data/world-steel-in-figures/world-steel-in-figures-2025/

Xinhua. (2023, April 10). China’s first West-to-East hydrogen pipeline is incorporated into the national plan. https://www.gov.cn/yaowen/2023-04/10/content_5750685.htm

Yin, I. (2025). China has established 125,000 mt/year of green hydrogen production capacity. S&P Global Commodity Insights. https://www.spglobal.com/commodity-insights/en/news-research/latest-news/energy-transition/043025-china-has-established-125000-mtyear-of-green-hydrogen-production-capacity-nea

Zhang, Q.-Z., Wang, L.-N., Chen, W.-Y., Zhang, C.-L., Xiang, K.-L., & Chen, J.-Y. (2024). Analysis of hydrogen supply and demand in China’s energy transition towards carbon neutrality. Advances in Climate Change Research, 15(5), 924–935. https://doi.org/10.1016/j.accre.2024.07.013

Zhou, W. (2025). Achievements of China’s steel industry development during the 14th Five-Year Plan and suggestions for high-quality development during the 15th Five-Year Plan. http://gjs.cssn.cn/kydt/kydt_kycg/202506/t20250613_5879070.shtml