

Making Clean Steel Competitive in International Trade

A Positive-Sum Agenda for Policy and Diplomacy

A report of the Breakthrough Agenda Policy Network



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The Breakthrough Agenda Policy Network

The Breakthrough Agenda Policy Network brings together institutes from eight countries and regions to conduct joint research and analysis on opportunities for international cooperation to overcome difficult problems in the low carbon transition. In its first year, the Network has focused on the role of trade in enabling the transition to clean steel. Members of the Network and other experts from Europe, Asia, Africa, and the Americas gathered in Baku in November 2024 and in London in June 2025 to discuss this topic. S-Curve Economics CIC coordinates the Network and acts as its secretariat.

Full references can be found in the main report at:
www.scurveeconomics.org/publications/making-clean-steel-competitive-in-international-trade/



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Executive Summary

Steel is a foundational industry and the highest emitting industrial sector in the global economy, responsible for 7% of global energy-related CO₂ emissions. It plays a crucial role in the modern economy, underpinning the buildings, industry, transport, power, and defence sectors.

In advanced economies, steel consumption is roughly constant, and the industry remains important at local and national levels. In many emerging and developing countries, demand is either growing rapidly or is expected to grow, and is critical to meeting basic needs. Steel remains vital in the global economy, and the deep decarbonisation of the sector is therefore essential to meet shared climate change goals.

The steel sector's transformation must take place in a context of competitive international trade. At present, trade acts as a barrier to the transition: high trade exposure means that steel producers cannot pass on the additional costs of clean steel production, while global excess capacity depresses prices and profits, further reducing their willingness to risk investment in new technologies. With over half the G20 countries having increased steel tariffs, safeguards or anti-dumping measures since 2024, trade diplomacy remains focused on the issue of excess capacity, while trade and climate policies are developed in isolation. Without a change in this dynamic, investments in clean steel will continue to be delayed.



Primary steelmaking is responsible for around

85–90%

of the sector's emissions.

As we discuss in **Section 1**, this does not need to be the case. With the right rules and incentives, trade could become a driver of the transition: reducing the deployment costs of clean steel technologies, strengthening signals for investment, and reorienting competition towards near-zero emission steel. The right trading arrangements could also improve the prospect that future demand growth for steel in emerging and developing economies is met with clean technologies and drives sustainable economic development, rather than locking in investment into fossil fuel-burning assets. While trade diplomacy in high emission steel is a negative-sum game, for clean steel, positive-sum cooperation is possible.

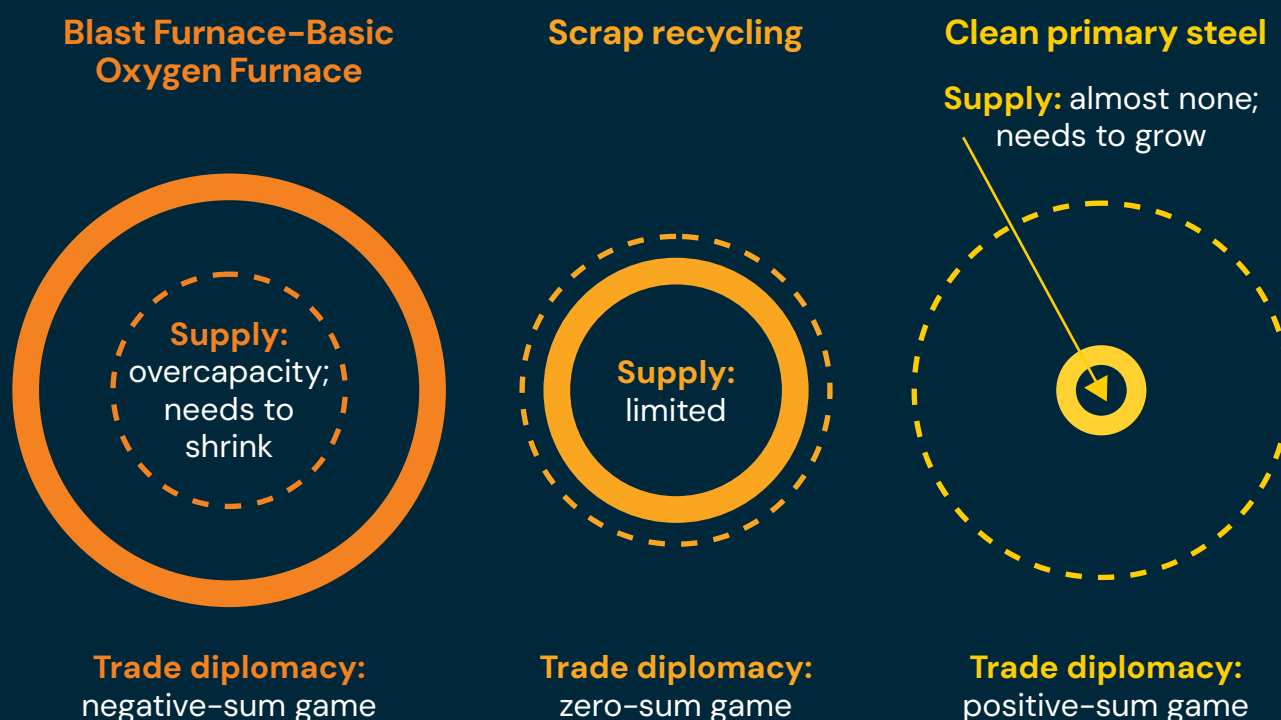
The most pressing challenge is to deploy clean primary steel production capacity. Primary steelmaking is responsible for around 85–90% of the sector's emissions. More than 100 megatonnes per annum (Mtpa) of near-zero emission primary steel capacity is estimated to be needed by 2030, and less than 1 Mtpa is currently operational. The cost of near-zero emission primary steel production is currently estimated to be 30–75% more than that of conventional steel, meaning that first-mover risks are high. In contrast, steel made from scrap recycling is already competitive or close to competitive in major markets. The supply of scrap is limited – around 80–90% of steel is already recycled, globally – so policies that increase demand for scrap in some countries can decrease its use in others. For these reasons, detailed in **Section 2**, the deployment of primary clean steel should be the top priority for policymakers in this sector.

To make clean primary steel competitive in international trade, action is needed at three complementary levels: unilateral (national) policies, bilateral partnerships, and plurilateral cooperation.



Executive Summary Figure 1:

The dynamics of steel trade diplomacy depend on its focus.



National policies (Section 3)

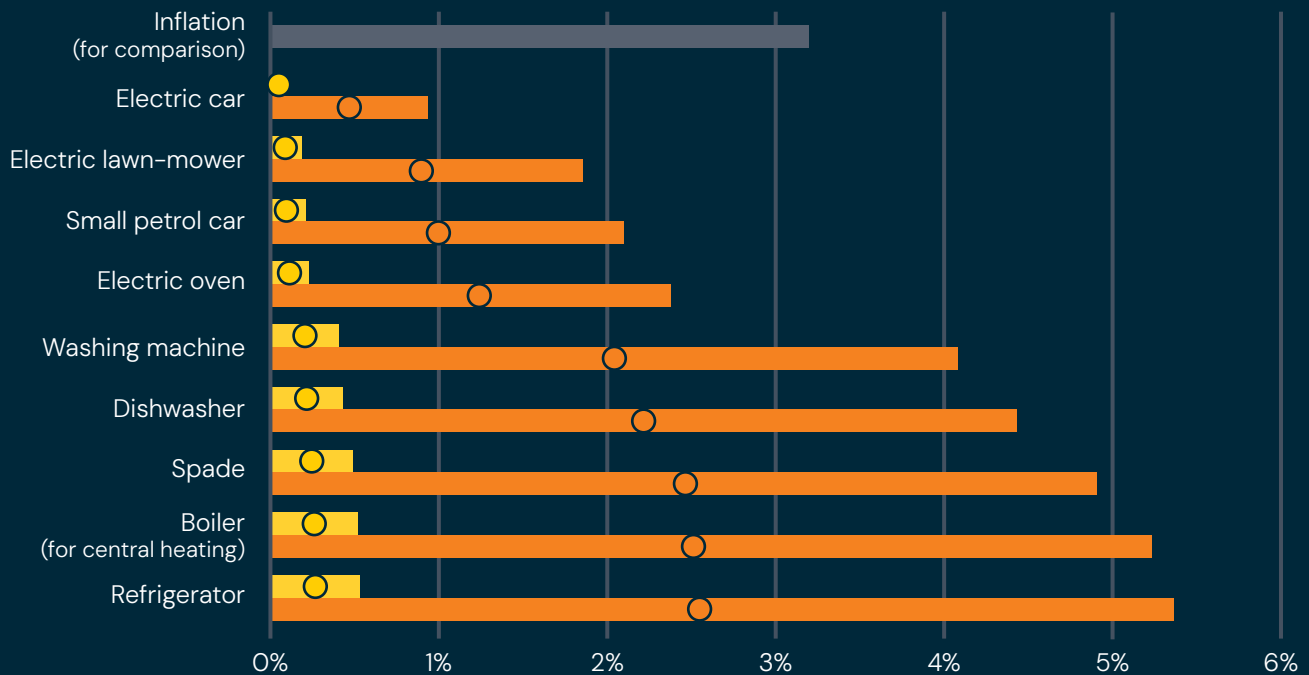
Multiple lines of evidence – including the current pipeline of clean steel projects, simulation modelling, industry consultations, and past and present experience of technology transitions in other sectors – point to targeted subsidies as likely to be needed for deploying near-zero emission primary steel plants. Almost all near-zero emission primary steel projects announced or under construction are known to have received subsidies. Public procurement or clean steel mandates could play complementary roles, increasing clean steel demand and supply respectively. By contrast, carbon pricing and emissions intensity regulations would be most likely to encourage a shift towards greater scrap recycling or technologies that only partially reduce emissions, and are unlikely, on their own, to enable the near-term deployment of near-zero emission primary steel technologies.

Clean steel subsidies (or payments for avoided carbon emissions) can be made revenue-neutral by ‘recharging’ their cost to industry, spreading the cost equally across all steel produced domestically or imported, with an exemption for steel exported. With this approach, the additional cost to consumers of deploying near-zero emission steel is lower than with carbon pricing, and can be trivially small during the early stages of the transition – adding only a fraction of one per cent to the cost of a car, dishwasher, or refrigerator. In most countries, annual inflation is considerably higher. Variations of this approach can be designed to suit a country’s political economy.



Executive Summary Figure 2:

Clean steel subsidy-and-recharge: revenue neutral for governments, and trivially low cost to consumers.



- Global average annual consumer price inflation over the past ten years
- Increase in cost using a subsidy-and-recharge policy for the first 10% market share of near-zero emission primary steel (high cost-gap assumption)
- Increase in cost using a carbon price at \$200/tCO₂ or subsidy-and-recharge at 100% clean steel market share (high-cost gap assumption)
- Increase in cost using a subsidy-and-recharge policy for the first 10% market share of near-zero emission primary steel (low cost-gap assumption)
- Increase in cost using a carbon price at \$100/tCO₂ or subsidy-and-recharge at 100% clean steel market share (low-cost gap assumption)

The subsidy-and-recharge approach creates no competitiveness risks to steel producers or downstream industries in either domestic or export markets. In contrast, carbon pricing creates substantial competitiveness risks that can only be partially mitigated with carbon border adjustment mechanisms (CBAMs). For countries that already have emissions trading systems, a hybrid approach is possible, where the balance between carbon pricing and subsidy is managed in response to external conditions, enabling near-term deployment while managing competitiveness risks.

Although a CBAM exerts some influence on the global transition through its leverage of market access, its main effect may be to increase competition for scrap steel. A subsidy-led approach could exert influence internationally by changing expectations: as clean primary steel technologies are successfully deployed, the balance of industry concerns could shift from first-mover risk to late-mover risk.

Bilateral partnerships (Section 4)

Green iron trade partnerships could accelerate the shift to near-zero emission steel by matching exporters with low-cost renewable energy and high-quality iron ore to importers seeking competitive, lower-cost decarbonisation and relief for grid-constrained power systems.

For steelmakers in countries and regions with high energy costs, such as those in Germany, Japan, and South Korea, importing green iron rather than producing it domestically could cut the costs of green iron by around 30%, and of near-zero emission primary steel production by around 15%, improving long-term competitiveness and preserving higher value jobs. Around 70–95% of jobs in the steel sector are downstream of iron production.

For countries with the most abundant iron ore and renewable energy resources, exporting

green iron could drive job-creation and growth. Australia's green iron export potential has been estimated to lie in the range of \$60–200 billion USD annually. In South Africa, 1 Mt of green iron production per annum could replace the export value of 7 Mt of coal, offsetting the losses from declining demand for fossil fuels.

Future growth in steel demand is expected to come mainly from developing countries, which have low stocks of steel embedded in their economies and consequently more constrained potential for recycling. (Many sub-Saharan African countries have in-use steel stocks of less than 0.5 tonnes of steel per capita, compared with 10–15 tonnes per capita in the USA and many European countries.) Policies that encourage value-added industrialisation through near-zero emission technologies in developing countries will have a stronger chance of ensuring that future demand will be met with low and near-zero emission steel.

Importing green iron could halve the cost gap between high emission steel and near-zero emission steel in a country with high energy costs, but is not likely to eliminate the cost gap in the near term. Subsidies, payments for avoided emissions, carbon prices, or combinations of these measures are likely to be needed to make green iron plants commercially viable. Joint investment and long-term offtake agreements could de-risk first projects.

Parties to these deals will need to agree how costs are to be shared, and how 'green iron' will be defined. Standards that are overly stringent could hold back investment. Governments in importer countries giving policy support for this approach will need to communicate clearly how it benefits jobs and competitiveness. Clean steel subsidy policies that give industry flexibility to manufacture or import iron could help to manage both political and commercial risks.



The subsidy-and-recharge approach creates no competitiveness risks to steel producers or downstream industries.

Plurilateral cooperation (Section 5)

Plurilateral cooperation among a small group of large steel producing countries could change global market conditions in the steel sector, influencing investment decisions worldwide and accelerating the transition.

The most widely discussed approach of coordination on carbon pricing (with or without CBAMs) is likely to be particularly difficult to agree among major steel producers because of its immediate, uneven effect across countries. National average emission intensities of steelmaking using the dominant blast furnace–basic oxygen furnace production route vary widely, due to differences in fuels, feedstocks, efficiency, and other factors. A common carbon price of \$200/tCO₂ would lead to differing cost increases across countries, from 100% in Canada and 110% in the EU to 140% in China and 150% in India. These differences would immediately affect countries' competitiveness in international trade.

Emissions intensity regulations applied to steel production face even greater practical and distributional competitiveness challenges, making them even less likely to be viable

as a basis for plurilateral cooperation at this stage of the transition.

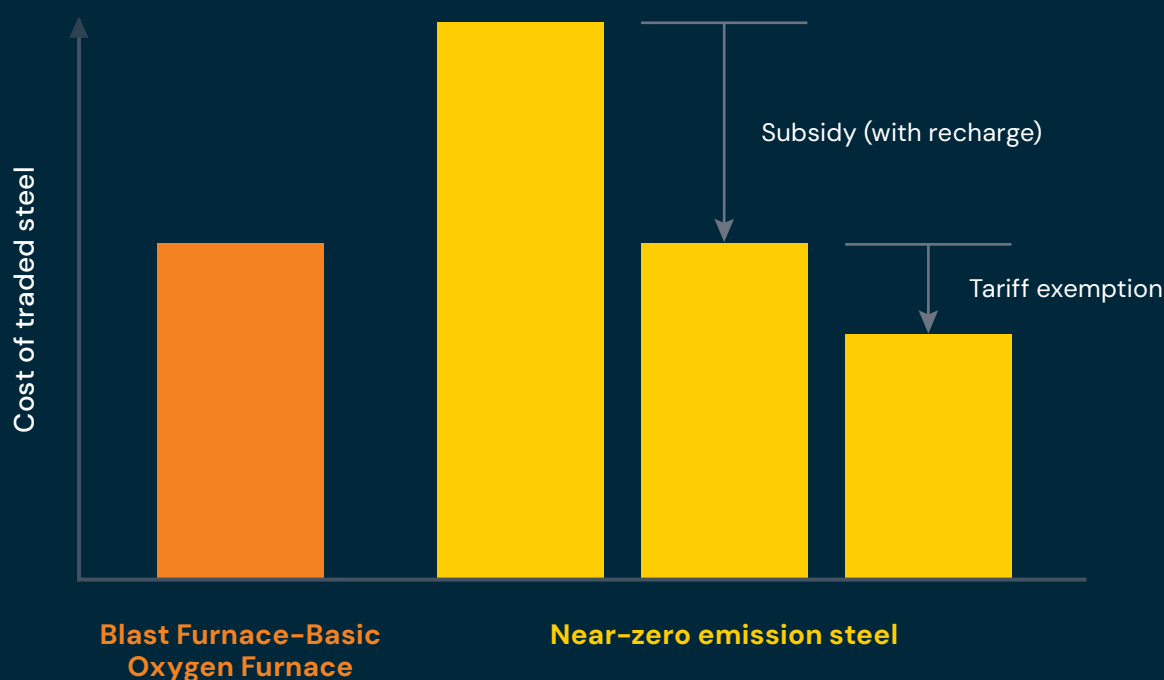
A more effective path would be to focus on positive-sum market creation for clean primary steel. A tariff exemption for near-zero emission steel would have no immediate effect on the cost of steel production or trade balance of any country, making it more feasible to agree. Instead it would reduce the risk for investments in clean steel production, both in absolute terms and relative to conventional steel production. Combined with domestic policies such as subsidy-and-recharge that closed the cost gap to conventional production, the tariff exemption would give clean steel an advantage in international trade. This could provide a powerful additional incentive for investment.

Countries that might see a plurilateral clean steel tariff exemption as being in their interests are those that have either natural resource advantages (iron ore and low-cost renewable energy), leading clean steel technological capabilities, or strong political commitments to near-term decarbonisation. Adoption of the measure by countries with large



Executive Summary Figure 3:

Together with domestic deployment policies, a tariff exemption could give clean steel an advantage in international trade.



steel imports and significant existing tariff levels would have the most effect. The EU, China, Brazil and Mexico all have relatively strong interests aligned with the transition and substantial existing steel tariffs or safeguards, and together accounted for over a quarter of global steel imports in 2024. Competitiveness risks could be managed by making the tariff exemption time-limited or quota-limited.

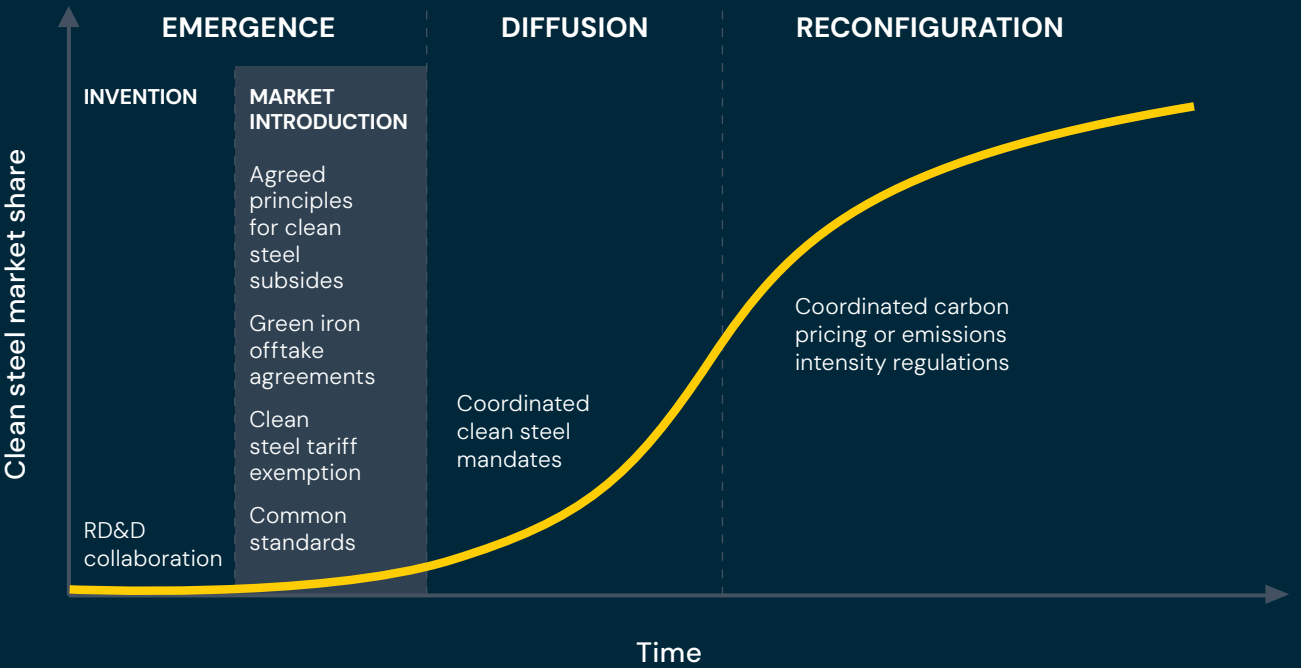
To be effective in encouraging investment in clean primary steel production, the tariff exemption would need to be based on standards that discriminate between primary and secondary steel, either using a ‘sliding scale’ as proposed by the International Energy Agency and ResponsibleSteel, or with a more binary distinction. To be compatible with World Trade Organization rules, the exemption would need to apply to steel from all countries, not only from those that agreed to implement the measure. Consultation and negotiation, flexibility in design, and transparency in implementation would all be important to minimising the risk of successful legal challenge.

An agreement on principles for clean steel subsidies could be an additional helpful measure. The governments of Germany, the USA, the UK, and Japan have already provided subsidies for clean steel or its inputs, and the EU appears to have similar plans. While careful policy design can minimise legal risks, any uncertainty around the legal status of such policies or expectation of future disputes and countermeasures could disincentivise investment. An agreement on principles could at least partially mitigate these risks, allowing industry to invest in clean steel production with more confidence. This could also be important to enable joint action on a clean steel tariff exemption.

As the transition progresses, coordination around other measures may become possible. Clean steel mandates are an alternative option for introducing clean primary steel technologies to the market and could be used to drive their further diffusion. Coordination on carbon pricing or emissions intensity regulations may become more feasible in the late stages of the transition, when the high emission technologies represent a small share of the market and have decreasing economic importance.



Executive Summary Figure 4:
Priorities for trade diplomacy change over the course of the transition.





A new strategic dialogue is needed, to explore the opportunities for cooperation on principles for clean steel subsidies, bilateral or plurilateral green iron offtake agreements, a clean steel tariff exemption, and the definitions and standards to underpin any of these measures.

Next steps for steel diplomacy

Diplomacy on the steel transition already encompasses research and innovation, standard-setting, public procurement, and financial and technical assistance, but diplomacy on the trade aspects of the transition is underdeveloped.

Since multilateral discussions are limited by the trade-off between breadth of participation and depth of potential cooperation, plurilateral diplomacy is needed. It will be most effective if it involves the world's largest steel producers, such as China, India, and the EU, and the countries that could become the largest green iron exporters, most notably Australia, Brazil, and South Africa.

As we outline in **Section 6**, no existing plurilateral forum has a focus on steel trade and the transition, and the participation of these countries. Only two of these six are members of the Climate Club. A new strategic dialogue is needed, to explore the opportunities for cooperation on principles for clean steel subsidies, bilateral or plurilateral green iron offtake agreements, a clean steel tariff exemption, and the definitions and standards to underpin any of these measures. Efforts should be focused on the core challenge of enabling deployment of near-zero emissions primary steel, while also ensuring that actions do not create barriers to expanding secondary steel production.

Trade as a barrier or driver of the transition

A large industrial steel mill with molten metal being poured, creating a bright orange glow and sparks. The scene is filled with complex machinery, pipes, and structural beams, all bathed in the intense light of the molten metal.

In Section 1, we consider the role of international trade in shaping the steel sector's transition to near-zero emissions. We argue that while the global exposure of the steel industry and the higher costs of near-zero emission production routes have so far made trade a barrier to decarbonisation, trade could become a critical driver of the transition under the right policy and market conditions. The following sections explore how unilateral, bilateral, and plurilateral approaches could contribute to achieving these conditions.

Key messages

- The international exposure of the iron and steel sector, combined with the higher costs of near-zero emission production routes, means that trade is currently a significant barrier to the transition.
- Overcapacity in the industry is making the task of transition even more difficult, by reducing steel companies' available capital and risk appetite for investment.
- Trade policies have barely begun to grapple with the challenge of deploying primary clean steel in a competitive international market. Some trade policies, such as restrictions on scrap exports, risk making the transition more difficult.
- With the right conditions in global markets, trade could become a powerful driver of the transition. First-mover risk could be replaced with late-mover risk, as companies compete for leadership in clean steel technologies.

Steel is a highly trade-exposed sector

Steel is a highly traded industrial commodity. Twenty-four per cent of all steel produced worldwide is traded across borders. Much of this trade is intra-regional, within Asia, Europe, and North America, but 15% of all steel produced is traded extra-regionally, such as from China to South America or Europe. China is the largest exporter of steel by weight. In 2024, China

contributed around 41% of global extra-regional exports; Asian countries other than China and Japan contributed 19%; Japan 11%; and the EU 8%. The largest importing regions of steel by weight are Asian countries other than China and Japan (31% of extra-regional imports); the EU (15%); and North America (14%).¹

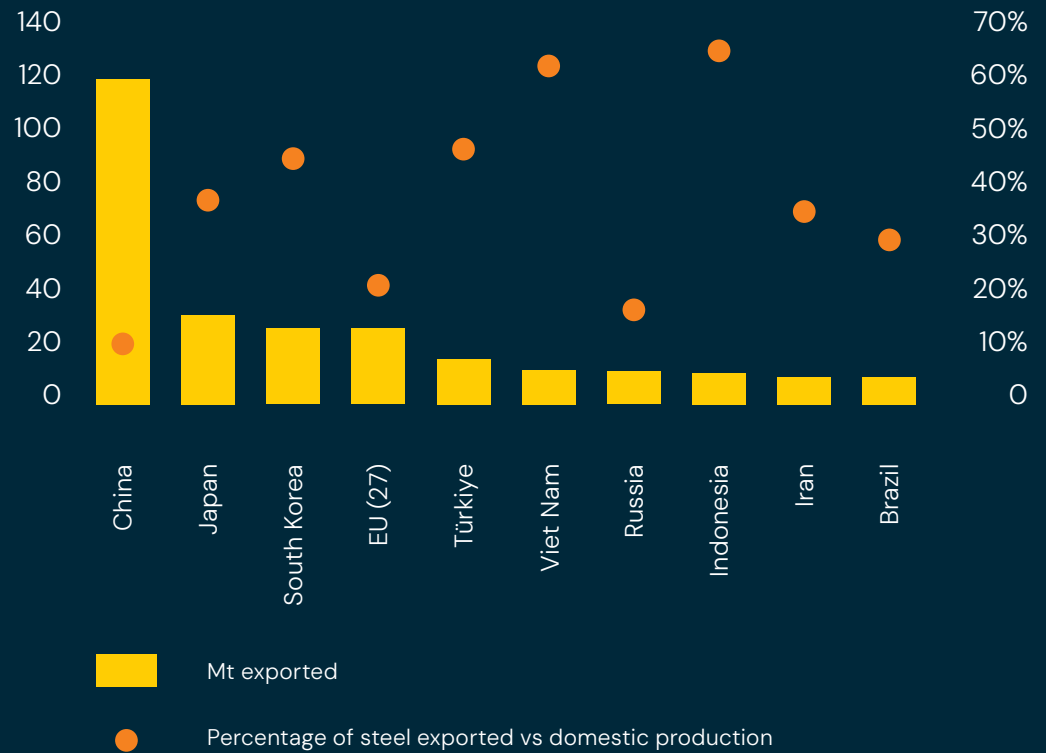
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24% of all steel produced worldwide is traded across borders.

¹World Steel (2025). *World Steel in Figures 2025*.



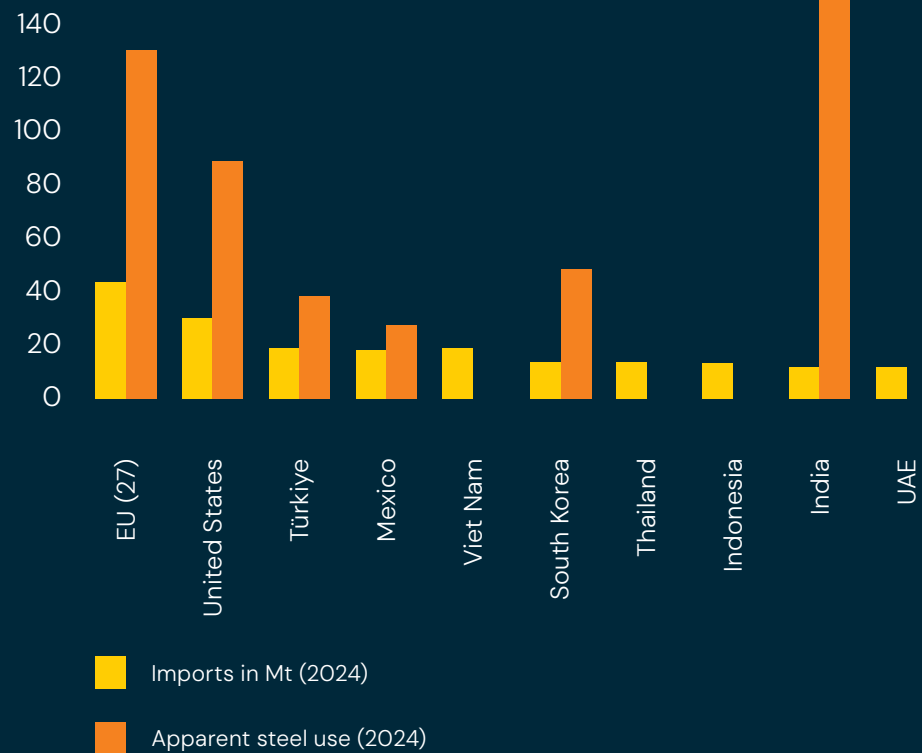
Figure 1:
Largest steel exporters by megatonnes (Mt) and as a percentage of domestic production.



Source: Authors' representation using data from World Steel (2025).



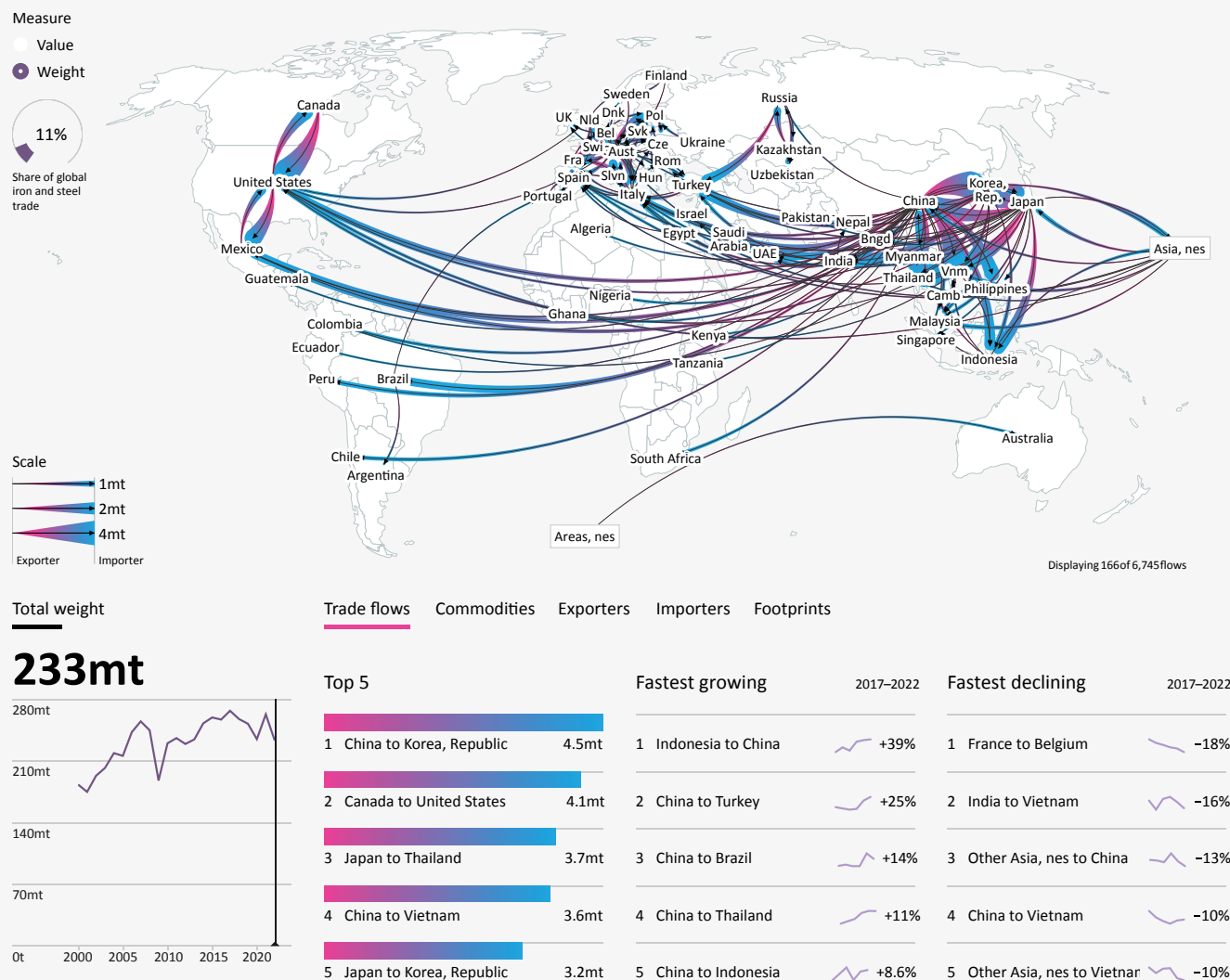
Figure 2:
Largest steel importers by Mt and apparent steel use.



Source: Authors' representation using data from World Steel (2025).



Figure 3:
Global trade
of rolled iron
and steel.



Source: Chatham House (2024). [ResourceTrade.earth](https://www.resource-trade.org/). Rolled iron and steel, 2022.

No major steel-producing country is fully insulated from trade. Even the largest producers such as China, India, the EU, and the US are exposed to international markets – as importers, exporters, or both.

Figure 1 shows the largest exporters of steel by country, and their exports as a share of their domestic production. Most countries also rely on imports of raw materials such as iron ore or increasingly scrap, and on export markets for end-use sectors such as automotive and manufactured goods. **Figure 2** shows the largest steel importers relative to their apparent steel use in 2024. This deep integration means that national steel industries are inextricably shaped by global dynamics.

Trade is currently a barrier to near-zero emission steel production

A consequence of the globalised trade in steel is that the price of steel is determined by factors outside any one country's control. Even where countries impose tariffs or quotas to shield domestic producers in their domestic markets, there usually remains some exposure to global market conditions. Near-zero emission primary steel production technologies are currently significantly more expensive than conventional high emission production routes. The additional cost of near-zero emission primary steel production has been

estimated to lie in the range of 30–75%.²

The combination of high trade exposure and higher costs creates a strong disincentive to invest in near-zero emission primary steel production. Companies cannot risk making major capital investments in new plants if they expect to be undercut in global markets. The steel sector's high capital investment costs, long asset lifetimes, and highly varying profit margins across the years make this problem particularly acute. This is in part why the sector has been typically described as 'hard-to-decarbonise'.³

In the absence of policies that either equalise the costs of high and low emission steel, or require the use of the latter, demand for low emission steel is limited to private steel-consumer businesses willing to pay a premium. Even this is difficult, as currently steel produced via lower emission routes cannot be easily distinguished from conventionally produced steel, other than by voluntary certification schemes. Moreover, low levels of demand cannot easily justify large investments in new production plants.

Overcapacity in the global industry is making the task of transition more difficult

The steel sector is currently suffering from structural excess production, where steel production capacity significantly exceeds demand.⁴

This has been a persistent problem, but has been exacerbated by a recent downturn in China's construction sector, resulting in Chinese steel exports nearly doubling since 2020.⁵ Exports from ASEAN countries, Türkiye, and India also increased in 2024 compared with 2023, while demand in developed markets in Asia, North America, and Europe weakened. These dynamics have resulted in low prices for finished steel in international markets, putting pressure on steel producers.⁶ Falling steel prices due to global overcapacity have been given as reasons for plant closures from Chile to South Africa.^{7 8}

The extent of concern about global overcapacity is visible in the intensified use by many countries of trade defence instruments – such as increased tariffs, quotas, and anti-dumping duties – to protect domestic producers from price pressures and low-cost imports.⁹ Since 2024, over half of the G20 countries have increased steel tariffs, safeguards, or anti-dumping measures (see **Table 1**). The policy justification given by governments for these measures is typically to support domestic industry against unfair international competition, an argument often supported and advanced by steel producers.

²IEA and UN Climate Change High-Level Champions (2024). *The Breakthrough Agenda Report 2024*. ³Bataille, C. (2020). Physical and policy pathways to net-zero emissions industry. *Wiley Interdisciplinary Reviews: Climate Change* 11(2): e633. ⁴OECD (2025). *OECD Steel Outlook 2025*. ⁵Shen, X. & Schäpe, B. (2025). *Urge for reform: blast furnace glut in China erodes profitability and hinders green steel transition*. CREA. ⁶Mattera, G., Pazos, R., & Takada, Y. (2025). *Steel trade and trade policy developments (Jan–Oct 2024)*. OECD. ⁷Steel Orbis (2025). *ArcelorMittal South Africa to close long-planned plants amid challenging market conditions*. ⁸Fundacion Andres Bello (2024). *Chile's largest steel plant closes due to Chinese competition*. ⁹Mattera, G., Pazos, R., & Takada, Y. (2025). *Steel trade and trade policy developments (Jan–Oct 2024)*. OECD.

**Table 1:**

Increases in tariffs amongst G20 countries since January 2024.

Month	Country	Description	Tariff Change
April 2024 May 2025	Brazil	Introduced import quotas and planned tariff increases on 11 rolled steel product categories	Increased applied tariffs from 9–11% to 25%. ¹⁰ Also applied 25% safeguard on 19 types of steel ¹¹
August 2024	Canada	Imposed a 25–50% surtax on steel imports from countries except the US and Mexico. Also imposed a 25% surtax on steel and aluminium if the steel was melted and poured in China	25%–50% surtax ¹²
April 2025	India	Imposed a safeguard duty on some steel imports to curb a surge of cheap shipments, mainly from China	12% safeguard tariff ¹³
December 2024	Indonesia	Extended anti-dumping duties on hot rolled coil imports from countries including China for another five years	Various levels; 20% maximum ^{14 15}
Beginning of 2025	Republic of Korea	Imposed temporary anti-dumping duties on Chinese imports of thick-gauge rolled steel. Decision due on further measures	Increased from 28% to 38% ¹⁶
April 2024	Mexico	Amended its tariff law by adding 72 new tariff lines for steel products, requiring Automatic Import Notices	Increased from 20% to 35% ¹⁷
June 2025	Saudi Arabia	Imposed final anti-dumping duties on imports of steel and stainless steel pipes with longitudinally-welded circular sections from China	Ranging from 6.5% to 27.3% ¹⁸
August 2024	South Africa	Raised customs duties on certain steel bars and rods from zero to 10%	10% on certain imports and a temporary 9% safeguard duty on hot-rolled steel from all countries ^{19 20 21}

¹⁰Mattera, G., Pazos, R., & Takada, Y. (2025). *Steel trade and trade policy developments (Jan–Oct 2024)*. ¹¹OECD. GMK Center (2025). *Brazil renews and expands safeguard measures on steel imports*. ¹²Department of Finance Canada (2025, July 19). *Support for the Canadian steel sector*. Government of Canada. ¹³Reuters (2025, April 21). *India imposes 12% temporary tariff on some steel imports*. ¹⁴International Trade Centre (2025). *Indonesia extends anti-dumping duties on HRC coils from seven countries*. ¹⁵Ministry of Trade of the Republic of Indonesia (2024). *Peraturan Menteri Perdagangan Republik Indonesia Nomor 36 Tahun 2024 tentang Ketentuan Ekspor dan Impor Besi dan Baja*. ¹⁶GMK Center (2025). *South Korea considers anti-dumping duties on hot-rolled steel from China and Japan*. ¹⁷Mattera, G., Pazos, R., & Takada, Y. (2025). *Steel trade and trade policy developments (Jan–Oct 2024)*. OECD. ¹⁸Saudi Press Agency (2024, December 30). *GAFT Imposes Final Anti-Dumping Duties on Steel Pipe Imports from China and Taiwan*. ¹⁹Mattera, G., Pazos, R., & Takada, Y. (2025). *Steel trade and trade policy developments (Jan–Oct 2024)*. OECD. ²⁰South African Revenue Service (2024). *Tariff amendments 2024*. ²¹Reuters (2025, August 20). *S. African trade body recommends duties to curb steel imports*.



Table 1 continued...

Month	Country	Description	Tariff Change
January 2024	Türkiye	Imposed new import tariffs on over 4,000 products, especially iron and steel, to support its domestic industry	Various level ranging from 8% to 20% ²²
July 2024	United Kingdom	Extended its steel safeguard measure to 15 product categories for another two years	25% safeguard tariff ²³
Feb–May 2024	United States	In February, the US placed 25% Section 232 tariffs on all steel imports including countries previously exempt. ²⁴ In June, the US increased tariffs to 50%, except for the UK which remains subject to 25% tariffs. ²⁵ On 13 September, the US Trade Representative announced increases in Section 301 tariffs on China from 7.5% to 25% ²⁶	Section 232 tariffs increased from 25% to 50% for most countries Section 301 tariff increased from 7.5% to 25% on China (additional to 232 tariffs)
April 2025	European Union	Extended its steel safeguard to mid-2026 and tightened liberalisation and quota carry-overs to limit tariff-free steel imports. Agreed on a suspended package targeting €21 billion of US goods in response to U.S. steel and aluminium tariffs	Steel safeguards of 25% on imports above tariff-rate quotas. ²⁷ Plus additional countermeasures to US tariffs ²⁸



Since 2024, over half of the G20 have increased steel trade defences.

²² YIEH Corp. (2024). *Turkey imposes duties on various steel products*. ²³ Department for Business and Trade (2024). *Statement by the Department for Business and Trade on the future of the UK's steel safeguard measure*. Government of the United Kingdom. ²⁴ Federal Register (2024, February 10). *Adjusting imports of steel into the United States*. Government of the United States. ²⁵ Federal Register (2024, July 15). *Adjusting imports of steel into the United States*. Government of the United States. ²⁶ White & Case (2025). *United States finalises Section 301 tariff rates on imports from China*. ²⁷ Directorate-General for Trade (2024). *EU prolongs steel safeguard measure until June 2026*. European Union. ²⁸ Reuters (2025, July 23). *What's in the EU's countermeasures to US tariffs?*

These conditions make the task of transition more difficult, in two ways. Steel companies whose margins are compressed and profitability threatened by low prices have less capital to invest in new clean steel production plants, and less appetite for risk. When steel plants are closing and jobs are being lost, governments face pressure to protect existing assets, which can make it more difficult to focus political attention and resources on transition policies. In some cases, governments have to fight the narrative that the job losses are caused by their decarbonisation policies.²⁹

Tariffs and other trade defences are not a straightforward solution to these problems. Some of their effects can be counterproductive. For example, in 2018, the United States applied 25% tariffs to steel imports from a wide range of countries. These measures were seen to

temporarily increase domestic prices and production, and were associated with higher capacity utilisation and employment in steel production.³⁰ However, rising steel prices affected the construction and automotive industries,³¹ with some estimates that for 1,000 jobs gained in steel production, there were 75,000 fewer jobs in manufacturing.³² This period also saw falling steel demand, as well as retaliation from countries that deemed the tariffs to be unfairly applied.³³

Tariffs may be a protection for steel production in one country, but they can also worsen the conditions for the transition in others. A reduction in market access for exporters, along with supply chain disruption, can create an uncertain environment for investment in new technologies. This can be particularly harmful for developing countries. Exporters in developing

countries tend to face higher tariffs on finished goods than on raw materials, and so escalating tariffs can further discourage value addition and industrialisation.³⁴

Trade policies have barely begun to grapple with the transition

While trade policies for the steel sector have focused strongly on protecting domestic steel producers, they have barely begun to address the challenge of enabling the transition to low or near-zero emission steel. Tariffs and trade defences currently make no distinction between high or low emissions steel.

Some combined trade and climate policies have recently begun to emerge. The most prominent attempt is the EU's adoption of a carbon border adjustment mechanism (CBAM) to complement its emissions trading system (ETS). The CBAM imposes a charge

Tariffs and other trade defences are not a straightforward solution. After the Section 232 tariffs in the United States in 2018, rising steel prices affected the construction and automotive industries, with some estimates that for:



²⁹Horton, H. (2025). *Rightwing media falsely blame Ed Miliband for UK steel crisis, experts say*, The Guardian. ³⁰US International Trade Commission (2023). *Economic Impact of Section 232 and 301 Tariffs on U.S. Industries*. ³¹Flaen, A. & Pierce, J. (2019). *Disentangling the effects of the 2018-2019 tariffs on a globally connected U.S. manufacturing sector*, Federal Reserve Board. ³²Russ, K. & Cox, L. (2020). *Steel Tariffs and U.S. Jobs Revisited*, Econofact. ³³US International Trade Commission (2023). *Economic Impact of Section 232 and 301 Tariffs on U.S. Industries*. ³⁴UNCTAD (2025). *Global trade update: policy insights. The role of tariffs in international trade*.

on embedded emissions in imported materials that is equivalent to the difference between what EU producers would pay under the ETS, and the carbon price paid in the country where the materials were produced. A CBAM has also been implemented by the UK, and CBAMs are now under consideration in Canada, Japan, and Australia.³⁵

The EU's CBAM was introduced in 2023 as the bloc's leading trade-related decarbonisation policy, with the stated aim of putting a fair price on carbon emitted in the production of carbon-intensive goods that are entering the EU, and encouraging cleaner production in non-EU countries.³⁶ Subsequent research has identified that different EU actors saw the CBAM as a means to meet different objectives, including preventing 'carbon leakage' (industrial production moving to areas with weaker

decarbonisation policies); encouraging stronger climate change policies globally; making cleaner products more competitive; and raising new revenues by enabling an end to free allowances under the EU's emissions trading scheme.³⁷

It may be too early to say whether the EU's CBAM, or similar policies being developed by other countries, can achieve any of these effects. However, in Section 3 of this report, we argue that carbon pricing and CBAMs are most likely to be effective at incentivising an uptake in recycling of scrap steel, rather than enabling near-zero emission primary steel production. We also find that CBAMs offer incomplete protection of clean steel production against undercutting by high emission producers, and alternative approaches may be more effective.

CBAMs could, in principle, provide a foundation for plurilateral cooperation. But implementation has already triggered strong pushback from emerging and developing countries concerned about the costs to their economies and perceived inequity. For this reason, the role of CBAMs as a cooperative instrument for enabling global trade in near-zero emission steel remains highly uncertain.³⁸ In Section 5, we compare the potential of coordinated carbon pricing and CBAMs against other options for changing conditions in the global market.

³⁵GMK Center (2025). *How countries around the world are responding to the EU CBAM (June 2025)*.

³⁶Directorate-General for Taxation and Customs Union (2025). *Carbon Border Adjustment Mechanism*.

³⁷Assous, A., Burns, T., Tsang, B., Vangenechten, D., & Schäpe, B. (2021). *A storm in a teacup. Impacts and geopolitical risks of the European carbon border adjustment mechanism*. E3G. ³⁸Mohan, V. (2025). *Brics reject EU's unilateral carbon border tax proposal*. The Times of India.



Restrictions on scrap exports risk increasing difficulty and inequity in the transition

Recycling of scrap steel in electric arc furnaces is a way to produce low emission steel that is already commercially viable. But as demand for scrap exceeds supply, countries are increasingly restricting their scrap exports. As of March 2025, as many as 48 countries had put in place policies to restrict the export of ferrous scrap. Of those countries, 54% are in Africa, 24% in Asia, 9% in the Middle East, 8% in South America, and 4% in Europe. China, the largest steel producer, imposes substantial export restrictions on scrap.³⁹ The main reasons given by governments for these scrap trade restrictions include: to secure supply for domestic decarbonisation needs; to manage stocks and flows; to manage scrap prices and ensure competitiveness of domestic 'green' steel industry; to increase the recycled content in domestic goods; and to level the playing field in trade by responding to other countries who have implemented similar approaches.⁴⁰

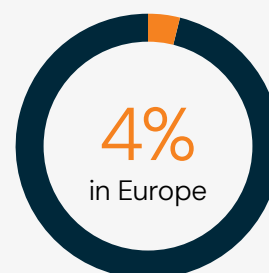
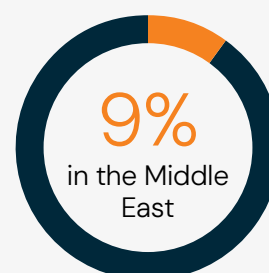
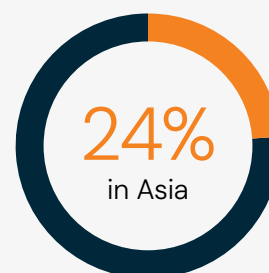
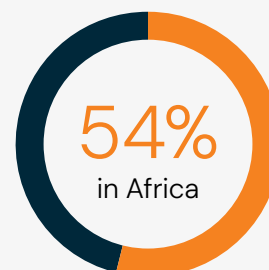
The widespread adoption of such restrictions, particularly if the practice spreads to advanced economies, risks inequity in the steel transition globally. Advanced economies with historically high steel use per capita have more scrap embedded in their economies. In contrast, many developing

and emerging economies, where per capita steel stocks are significantly lower, have limited domestic scrap stocks. In-use steel stocks per capita remain relatively constant at around 10–15 t/capita in the United States and many European countries. In contrast, many sub-Saharan African countries have less than 0.5 t/capita.⁴¹ If both stock and supply of scrap steel to emerging and developing countries are constrained, this is likely to raise the cost of secondary steel production or limit its growth in these countries, leaving conventional high-emission production as the default option while clean primary steel remains higher-cost and more difficult. As well as being inequitable, this could slow the global transition to clean steel, since growth in demand for steel is expected to be driven by emerging economies over the coming decades as they build up their in-use stock of steel towards levels seen in advanced economies today.⁴²

In summary, trade-exposure and high costs disincentivise investment in clean primary steel. Global overcapacity in steel production makes this even more difficult. Trade policies in the sector are mainly focused on insulating steel industries from perceived unfair competition, and have barely begun to address the challenges of the transition. Meanwhile, restrictions on scrap exports threaten developing countries' access to low-cost decarbonisation.

As of March 2025, as many as 48 countries had put in place policies to restrict the export of ferrous scrap.

Of those countries:



³⁹Corneille, A. et al. (2024). *Unlocking potential in the global scrap steel market: opportunities and challenges*. OECD, Paris. ⁴⁰GMK Center (2025). *Global scrap exports restrictions 2025*. ⁴¹IEA (2025). *Iron and Steel Technology Roadmap*. ⁴²IEA (2025). *Iron and Steel Technology Roadmap*.



Trade could be a driver of the transition

While trade currently acts as a barrier to the steel transition, under the right conditions it could become a driver of the transition. In fact, trade is likely to be essential to achieving a globally extensive, cost-efficient, and sufficiently rapid (to meet internationally agreed climate change goals) transition. A well-designed trade system could support the cost-efficient deployment of decarbonisation technologies, reduce costs through specialisation, reorient competition towards clean steel technologies, and help to distribute the benefits of the transition more equitably across countries.

Enabling cost-efficient production

The natural resources required for new forms of near-zero emission steelmaking – such as low-cost renewable energy and high-quality iron ore – are not evenly distributed globally. While countries with steel industries are likely to want to preserve them, international trade can allow iron production to be located where conditions are most favourable and costs are lowest, with the output traded to steelmakers elsewhere. This creates opportunities for specialisation, cost reduction, and accelerated deployment of near-commercial technologies, while allowing countries to contribute to the transition in different ways depending on their comparative advantages. We discuss this further in Section 4.

Increasing incentives for investment

As demand for low emission steel increases, driven by policy as well as early adoption in downstream industries such as automotive, construction, and appliances, an open trading system can enable steelmakers in different countries to access those markets – provided that carbon content is measurable and verifiable. This could to some extent aggregate the effects of policies in different countries, increasing the incentives for investment in clean steel production.

Reorienting competition towards the new technologies

Most importantly, if the conditions can be created such that near-zero emission primary steel is at least on a level footing with conventional steel in global markets, then competitive international trade is more likely to become a powerful driver of the transition, instead of holding it back. With the first-mover risk removed, the risk of being a late-mover to the new

technologies will be more substantial, and the incentives for companies worldwide to invest in the transition will be increased. If the transition to a near-zero emission steel sector, as envisaged in countries' net zero targets and agreed global climate change goals, is ever to be completed, then, whether by technological progress or by regulatory enforcement, there must be a moment at which this shift in industry expectations occurs.

Driving sustainable economic development

Future demand for steel is likely to come overwhelmingly from countries that currently have low in-use steel stocks. This is because steel consumption generally plateaus in advanced economies after a certain point of accumulation. In contrast, in countries with expanding needs for infrastructure and construction, consumption grows strongly after a certain point of industrialisation.⁴³ The EU and North America, for example, had an apparent steel use in 2024 (inferred from domestic production

and import data) of 290 kg and 220 kg per capita respectively, compared with 924 kg in South Korea and 601 kg in China. In many countries, however, consumption remains low and insufficient to meet basic needs. For example, South Africa has an average per capita use of 71 kg, whereas consumption in Africa as a whole stands at only 25 kg per capita.⁴⁴

The trade and deployment policies that countries use will have a bearing on where future steel is produced, relative to demand patterns, and whether investments are in low, near-zero, or conventional production technologies. Policies that encourage value-added industrialisation through near-zero emission technologies in developing countries will have a stronger chance of ensuring that future demand will be met with low and near-zero emission steel. In contrast, policies that make the transition harder for developing countries could result in an expansion of high-emitting production capacity.



If clean primary steel can be put on a level footing with conventional steel in global markets, then trade could become a powerful driver of the transition.

⁴³Yang, X. et al. (2024). Multinational dynamic steel cycle analysis reveals sequential decoupling between material use and economic growth. *Ecological Economics* 217; 108092.

⁴⁴World Steel Association (2025). *World Steel in Figures 2025*.



The dynamics of trade diplomacy in the sector will be different depending on its focus.

Differing dynamics of trade diplomacy

A conclusion from this review of the role of trade in the steel transition is that the dynamics of trade diplomacy in the sector will be different depending on its focus. Trade diplomacy focused on tackling overcapacity in high emissions steel production, or on the further reductions necessary to meet climate change goals, can only be a negative-sum game. While these discussions are necessary, they are likely to be most difficult diplomatically. When the focus is on secondary steel, trade diplomacy is close to being a zero-sum game, since the global supply of scrap is limited at any one time. Nonetheless, diplomacy to ensure that scrap export restrictions do not slow the global transition may be useful. There may also be other ways that countries can usefully cooperate to expand the supply of scrap to global markets over time, such as by sharing best practice on measures to encourage scrap collection. In relation to clean primary steel, the supply of which must expand rapidly to meet climate goals, there is potential for positive-sum cooperation. **Figure 4** illustrates this contrast.

In Sections 3 to 5 of this report, we outline how the shift in the role of trade, from barrier to driver of the steel transition, could be brought about through unilateral policies, bilateral cooperation, and plurilateral trade diplomacy. First, though, we review the technology options and consider the relative priority of policies to deploy primary and secondary clean steel production.





Figure 4:

The dynamics of steel trade diplomacy depend on its focus.

**Blast Furnace–Basic
Oxygen Furnace**



Trade diplomacy:
negative–sum game

Scrap recycling



Trade diplomacy:
zero–sum game

Clean primary steel

Supply: almost none;
needs to grow



Trade diplomacy:
positive–sum game

Prioritising deployment of primary near-zero emission steel

2

In Section 2, we examine the technological pathways for decarbonising steel production. It is widely recognised that while scaling up recycling of scrap steel in electric arc furnaces (EAFs) powered by clean electricity is a proven and cost-effective solution, achieving deep decarbonisation of the sector will require the development and deployment of new, near-zero emission primary production routes starting with iron ore.

Of these, hydrogen-based direct reduced iron (H_2 -DRI) combined with EAFs is emerging as the leading option at least in the near term, while biomass may play a complementary role in certain contexts, and molten oxide electrolysis is an example of an early-stage technology that could

emerge as an alternative option in future. At present, all near-zero emission primary steel technologies remain significantly more expensive than conventional production, meaning that without strong policy action to close cost gaps, investment will be too slow to align with global climate goals.

Key messages

- Deploying near-zero emission primary steelmaking technologies (where production starts with iron ore) should be a high priority, since this is essential for the decarbonisation of the global steel sector and is much more difficult than increasing steel recycling. Continuing to increase the rate of recycling remains important in parallel.
- Of existing primary near-zero emission technologies, H₂-DRI-EAF production is the leading option for deployment in the near-term. Biomass may prove important for some countries (e.g. Brazil), and molten oxide electrolysis may become important in future decades.
- The costs of near-zero emission primary production remain significantly higher than those of conventional production. Without policy action to address these cost gaps, it is inconceivable that investment will flow into near-zero emission production in the timeframes needed to meet global climate targets.

Steel production today

The steel sector is one of the most emissions-intensive industries in the world, responsible for approximately 7% of global direct energy-related carbon dioxide (CO₂) emissions. As a foundational material underpinning many other sectors (power, buildings and infrastructure, transport), and essential in the process of countries' industrialisation, steel demand is expected to grow in coming decades.⁴⁵ Steel production must undergo rapid and deep decarbonisation if countries are to meet their shared climate change goals.

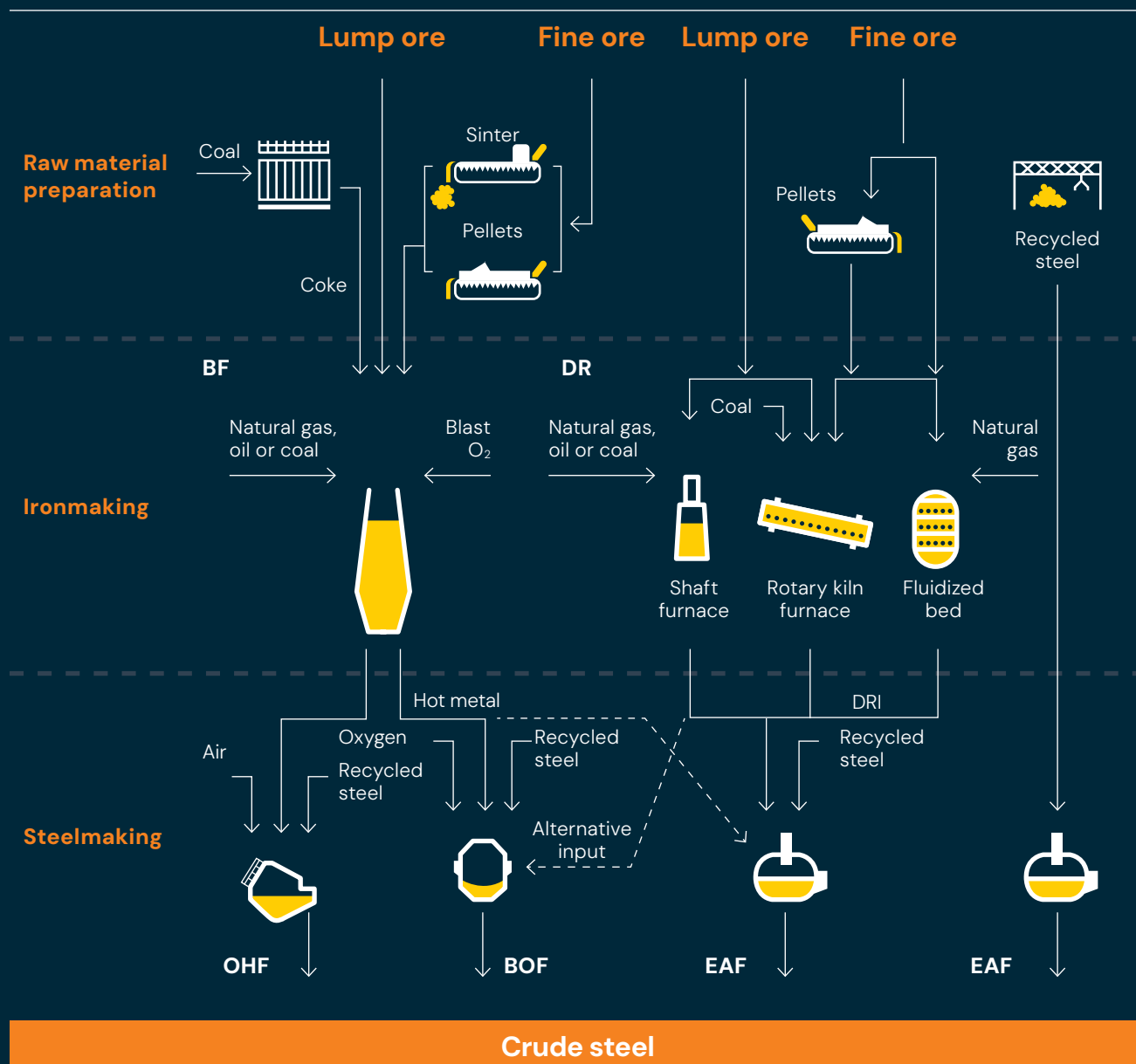
Globally, steel is produced in several main ways:

- Blast furnace–basic oxygen furnace (BF-BOF): The most emissions-intensive production route, where iron ore is reduced in a coal-fired blast furnace before being oxidised in a basic oxygen furnace to make primary steel. This route accounts for over 70% of global production.⁴⁶
- Scrap recycling–electric arc furnace (scrap-EAF): A substantially lower emission route when producing secondary steel by melting scrap steel using electricity and recycling it into new products. The scrap-EAF route in total accounts for 20% of global production.⁴⁷
- Direct reduced iron–electric arc furnace (DRI-EAF): An alternative to coal-fired blast furnaces, where natural gas is used in direct reduction furnaces to produce iron which is then smelted in an EAF. This route is more emissions-intensive than scrap-EAF, but less so than BF-BOFs.⁴⁸ DRI-EAF production accounts for around 5% of global steel production.⁴⁹

⁴⁵ IEA (2020). *Iron and Steel Technology Roadmap*. ⁴⁶ Agora Industry, Wuppertal Institute, and Lund University (2024). *Low-carbon technologies for the global steel transformation. A guide to the most effective ways to cut emissions in steelmaking*. ⁴⁷ Agora Industry, Wuppertal Institute, and Lund University (2024). *Low-carbon technologies for the global steel transformation. A guide to the most effective ways to cut emissions in steelmaking*. ⁴⁸ The average CO₂ intensity of existing steel plants using the BF-BOF route globally was 2.33 tonnes of CO₂ per tonne of crude steel in 2022, versus 1.37 tonnes of CO₂ for DRI-EAF and 0.68 tonnes of CO₂ for scrap-EAF. Source: World Steel (2024). *World Steel in Figures*. ⁴⁹ Agora Industry, Wuppertal Institute, and Lund University (2024). *Low-carbon technologies for the global steel transformation. A guide to the most effective ways to cut emissions in steelmaking*.



Figure 5:
Simplified iron and
steelmaking routes.



Source: Dayal, S. et al. (2025). *Towards near-zero emissions steel: modelling-based policy insights for major producers*. Originally from: Kim, J. et al. (2022). Decarbonising the iron and steel industry: a systematic review of sociotechnical systems, technological innovations, and policy options. *Energy Research & Social Science*, 89: 102565. Notes: BF, blast furnace; DR, direct reduction; OHF, open hearth furnace; BOF, basic oxygen furnace; EAF, electric arc furnace.

Primary near-zero emission steel production is essential in the global transition

To achieve the deep decarbonisation of the steel sector globally, there is a need both for the deployment of new *primary* near-zero emission production technologies – those starting predominantly with iron ore – and for the increased use of *secondary* steel production technologies – those starting predominantly with scrap. This strategy has been described as ‘dual decarbonisation’.⁵⁰

‘Dual decarbonisation’ is necessary because the global supply of steel scrap is not expected to fully meet global steel demand in coming decades. Around 80–90% of steel is already recycled, globally.⁵¹ The International Energy Agency (IEA) projects that the supply of scrap steel will only be enough for recycling to meet 46% of global demand for new steel in 2050, even in a scenario where demand is limited by improvements in material efficiency.⁵² A modelling study anticipates that with existing

policies, and enhanced efforts to improve scrap sorting and recycling, scrap-EAF production could increase globally from 25% now to 58% by 2050.⁵³ These estimates suggest around half of global steel production in a fully decarbonised steel sector will need to come from primary near-zero emission production.⁵⁴

The large majority of emissions in primary steel production come from the reduction of iron ore, so developing and deploying very low emissions technologies for this purpose will be critically important. For example, in the BF-BOF process, 68–87% of the emissions come from the ironmaking stage.⁵⁵ The IEA estimates that over 100 Mt of primary near-zero emission steel production should be operating by 2050 for the sector to make a transition in line with the 1.5°C target.⁵⁶ Less than 1 Mt of such capacity is operational at present. Since the construction of a new steel plant typically takes 2 to 5 years at best, and often longer from planning stages through to testing, investment in these projects is needed now.⁵⁷

The challenge of deploying more EAFs for recycling scrap

and the challenge of deploying technologies for primary near-zero emission steel production are not of equal difficulty. EAFs using 100% scrap inputs and zero emission electricity are already capable of producing steel with near-zero emissions. EAFs are commercially well established, with a technology readiness level (TRL) of 9,⁵⁸ and already widespread in many countries such as the United States, Italy, and Türkiye. In several regions, EAFs are already cost-competitive with BF-BOFs, either generally or in certain product segments.⁵⁹

In contrast, primary near-zero emission steel technologies are still in development and have significantly higher costs than BF-BOFs and EAF-scrap routes. Nonetheless, several routes have emerged as viable to produce near-zero emission steel, and deep decarbonisation of the global industry by mid-century is considered technically possible.⁶⁰

Table 2 summarises key difference between primary and secondary steel technologies, demonstrating why the deployment of clean primary steel must be an urgent priority for governments.

⁵⁰ The Institution of Structural Engineers (2025). *The role of scrap in steel decarbonisation*. ⁵¹ IEA (2020). *Iron and Steel Technology Roadmap*. ⁵² IEA (2021). *Net zero by 2050: a roadmap for the global energy sector*. ⁵³ Bataille, C., Stiebert, S., & Li, F. (2024). *Facility level global net-zero pathways under varying trade and geopolitical scenarios*. ⁵⁴ The Institution of Structural Engineers (2025). *The role of scrap in steel decarbonisation*. ⁵⁵ Fan, Z. & Friedmann, J. (2021). Low-carbon production of iron and steel: technology options, economic assessment, and policy. *Joule* 5(4): 829–862. ⁵⁶ IEA and UN Climate Change High-Level Champions (2024). *The Breakthrough Agenda Report 2024*. ⁵⁷ Laith Kumar, B. V. K. (2023). *Steel Plant Layout: Civil Engineering perspective*. *International Research Journal of Engineering and Technology* 10: 567–571. ⁵⁸ Bataille, C., Stiebert, S., & Li, F. (2024). *Facility level global net-zero pathways under varying trade and geopolitical scenarios*. ⁵⁹ Medarac, H., Moya, J. A., & Somers, J. (2020). *Production costs from iron and steel industry in the EU and third countries*. European Commission JRC. ⁶⁰ Bataille, C. et al. (2018). A review of technology and policy deep decarbonization pathway options for making energy-intensive industry production consistent with the Paris Agreement. *Journal of Cleaner Production* 187 (2018): 960–973.



Table 2:

Key differences between primary and secondary steel technologies

	Secondary steel	Primary steel
Current share of global steel sector emissions ¹	~3–7%	~85–90%
Cost-competitiveness of clean technology	Already competitive with BF-BOF in some markets, slightly more costly in others	Costs around 30–75% more than BF-BOF
Maturity of clean technology	Already commercial	Not yet deployed at commercial scale
Required growth in clean production capacity	~ 3x scale-up in capacity estimated in next 25 years , ² as scrap availability increases	> 100x scale-up in operating capacity required in next 5 years ³
Location of levers for decarbonisation of the production route	Mainly outside the steel sector (power sector decarbonisation)	Mainly inside the steel sector (technology change in ironmaking), although also likely to require expansion of electricity grids and generation capacity

Notes: (1) Estimates based on IEA data (2020) and World Steel data (2025) for global average emissions intensity of BF-BOF and scrap-EAF production routes, and current shares of global production. (2) The IEA projects global demand for steel to increase by more than a third by 2050, compared with 2020, while the scrap-EAF share of global production could increase from 25% now to 58% in 2050. The rate of increase is constrained by scrap availability. (3) Over 100Mtpa of primary near-zero emission steelmaking production is required by 2030 in the IEA's Net Zero Emissions by 2050 Scenario. Less than 1Mtpa is currently being produced at commercial scale.

Steelmaking technologies differ in their levels of readiness and emissions reduction potential

Hydrogen Direct Reduced Iron (H_2 -DRI): the front runner

The H_2 -DRI-EAF route is one of the most advanced routes for clean primary steel production, at TRL7.⁶¹ This production process involves switching from natural gas to hydrogen in a DRI furnace to produce iron pellets, which can then be used in an EAF (with or without scrap as an additional input) to make steel.⁶² When hydrogen is used as the reducing agent rather than coking coal or natural gas, H_2O is produced, rather than CO_2 , meaning that emissions from this process can be almost entirely eliminated.⁶³ Green hydrogen is produced from renewable electricity powering electrolysis, resulting in few if any emissions. 'Blue hydrogen' (produced from natural gas using steam methane reforming, together with carbon capture and storage) could also be used, but it is unclear whether this or other hydrogen production routes can be near-zero emission because of the fugitive emissions they may create during the production process.⁶⁴

Hydrogen has so far taken the lead as the preeminent primary near-zero emission technology. The first industrial-scale hydrogen-ready DRI-EAF plant came online in China in 2023. By the late 2020s and early 2030s, commercial-scale DRI plants running on 100% green hydrogen are expected in several countries, including Spain, Sweden, and Germany (see Section 3). In addition, many hydrogen-ready plants have been announced, which will run on natural gas initially but can be transitioned to hydrogen when it is available.⁶⁵

Carbon Capture and Storage (CCS): lagging behind

Carbon Capture and Storage (CCS) is a prospective technology for decarbonising steel production, but has not yet been demonstrated at a commercial scale, with very few steel-CCS projects existing globally. It has previously been assumed that BF-BOFs could be built with CCS to achieve 90% emissions reductions, but this technology remains in the development stage (TRL5).⁶⁶ More recent estimates have suggested that the emissions reduction potential of BF-BOF-CCS routes may be lower, at 70–75% of on-site emissions, due to the number of diffuse sources of emissions, with only the Hlsarna-BOF-CCS technology (a form of blast furnace that produces more concentrated exhaust gases) in theory capable of reducing

emissions by 93%.⁶⁷ Retrofitting CCS to existing coal-based BF-BOFs is only expected to capture up to 50% of a plant's emissions, while adding significant costs.⁶⁸ For this reason, some experts have argued CCS is not likely to play an important role in the transition.⁶⁹

There has been little evidence of progress or investment in BF-BOF-CCS projects in recent years, beyond the small-scale COURSE 30 and COURSE 50 projects in Japan.⁷⁰ While the 2030 project pipeline of hydrogen-ready plants has grown to 84 Mt globally, the pipeline of commercial-scale CCS on the BF-BOF routes by 2030 amounts to only 1 Mt.⁷¹ To date there has been no example of retrofitting an existing BF-BOF for CCS.⁷²

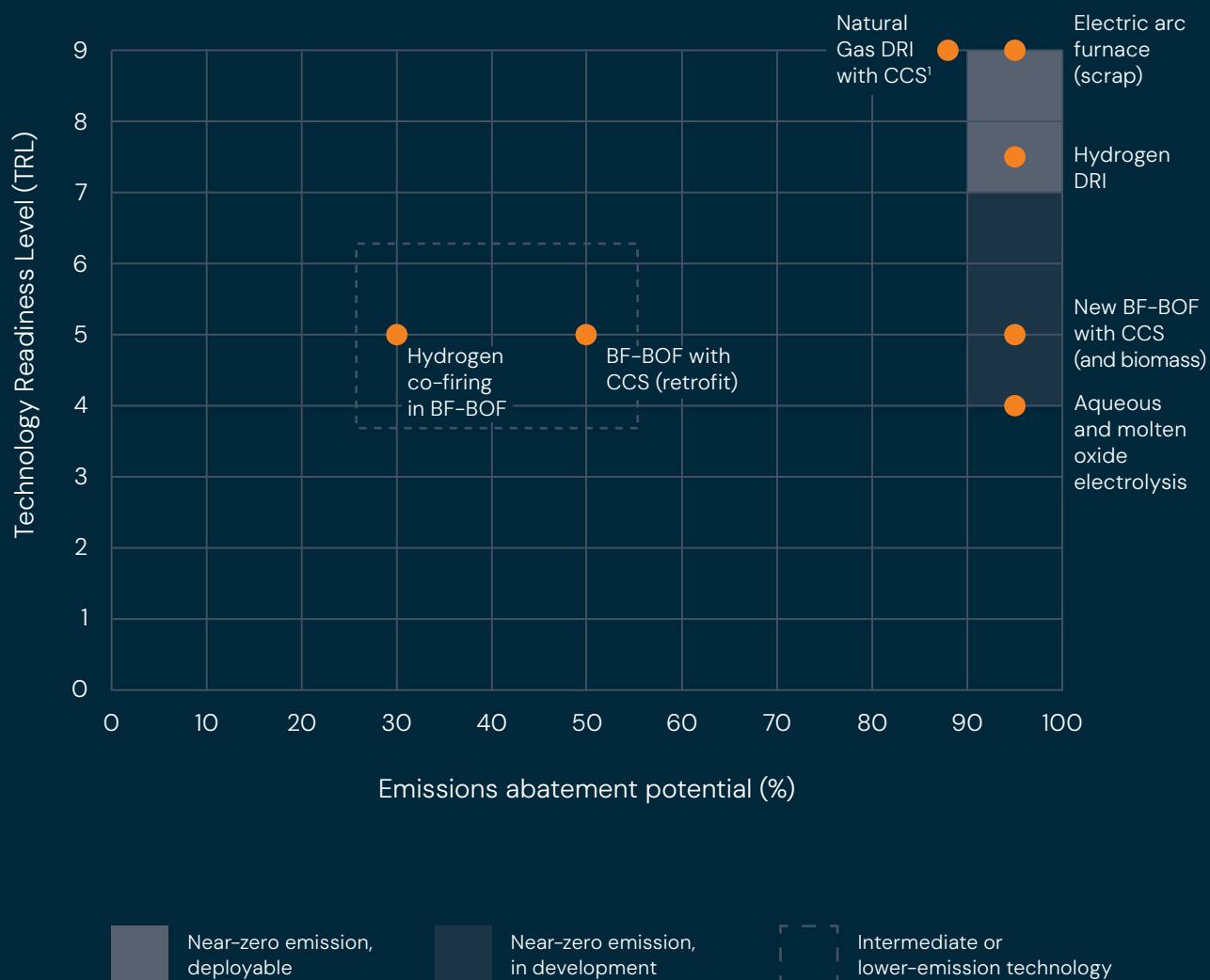
One application of CCS that has been demonstrated is *natural gas DRI with CCS*, where syngas (a mixture of hydrogen and carbon monoxide) is produced from the steam reforming of methane and used as a reductant, and the waste gases are captured by carbon capture technologies. In theory, captured carbon can then be stored in geological storage sites. This has been partially demonstrated at a commercial scale at the Al Reyadah project in Abu Dhabi and is considered to have a TRL of 9.⁷³ However, this project has not captured and stored carbon at a level

⁶¹ Bataille, C., Stiebert, S., & Li, F. (2024). *Facility level global net-zero pathways under varying trade and geopolitical scenarios*. ⁶² Vogl, V., Åhman, M., & Nilsson, N. J. (2018). *Assessment of hydrogen direct reduction for fossil-free steelmaking*. *Journal of Cleaner Production* 203: 736–745. ⁶³ Agora Industry, Wuppertal Institute, and Lund University (2024). *Low-carbon technologies for the global steel transformation. A guide to the most effective ways to cut emissions in steelmaking*. ⁶⁴ Howarth, R. W. & Jacobson, M. Z. (2021). *How green is blue hydrogen?* *Energy Science & Engineering*, 9: 1676–1687. ⁶⁵ Agora Industry, Wuppertal Institute, and Lund University (2024). *Low-carbon technologies for the global steel transformation. A guide to the most effective ways to cut emissions in steelmaking*. ⁶⁶ Bataille, C., Stiebert, S., & Li, F. (2024). *Facility level global net-zero pathways under varying trade and geopolitical scenarios*. ⁶⁷ Agora Industry, Wuppertal Institute, and Lund University (2024). *Low-carbon technologies for the global steel transformation. A guide to the most effective ways to cut emissions in steelmaking*. ⁶⁸ Fan, Z. & Friedmann, J. (2021). Low-carbon production of iron and steel: technology options, economic assessment, and policy. *Joule* 5(4): 829–862. Note: Range depends on whether you include the coke production, sintering, and pelletising along with the blast furnace stage. ⁶⁹ Witecka, W. K. et al. (2023). *15 insights on the global steel transformation*. Agora Industry and Wuppertal Institute. ⁷⁰ Bataille, C., Stiebert, S., & Li, F. (2024). *Facility level global net-zero pathways under varying trade and geopolitical scenarios*. ⁷¹ Witecka, W. K. et al. (2023). *15 insights on the global steel transformation*. Agora Industry and Wuppertal Institute. ⁷² Fan, Z. & Friedmann, J. (2021). Low-carbon production of iron and steel: technology options, economic assessment, and policy. *Joule* 5(4): 829–862. ⁷³ Bataille, C., Stiebert, S., & Li, F. (2024). *Facility level global net-zero pathways under varying trade and geopolitical scenarios*. ⁷⁴ Nicholas, S., & Basirat, S. (2024). *Carbon Capture for Steel*. Institute for Energy Economics and Financial Analysis.



Figure 6:

Technology options for the deep decarbonisation of iron and steel production



Notes: Authors' interpretation of data originally sourced from: Chris Bataille, Seton Stiebert, and Francis Li (2024) 'Facility level global net-zero pathways under varying trade and geopolitical scenarios'. 'Natural-gas-CCS emissions abatement estimates from: Agora Industry (2024) 'Low-carbon technologies for the global steel transformation'.

that is consistent with deep decarbonisation.⁷⁴

Biomass: a niche option for some countries

BF-BOFs could also in theory use *biomass* as a fuel reductant with CCS to achieve near-zero or even negative emissions.⁷⁵ Biomass could be used even more efficiently in DRI or other smelting routes equipped with CCS. This could be near-zero emission, or not, depending on the source of the biomass and how it is gathered.⁷⁶ However, as previously noted, investment in CCS is far behind that of alternative options.

Biomass used without CCS is also a route to reduce emissions. Approximately 10% of Brazilian steel is produced using charcoal with BF-BOFs.⁷⁷ This practice has significant potential for expansion in Brazil, and potentially some other countries, if coupled with sustainable supply chains and strong governance. When

produced sustainably, biochar can not only reduce direct process emissions but also contribute to carbon removal through soil applications or long-term storage. Moreover, biogas and biomethane could replace natural gas as a feedstock in the production of DRI.⁷⁸ However, scalability depends heavily on land-use governance, supply chain organisation, and the development of monitoring systems that can credibly account for the carbon balance. Estimates around the extent of emission reductions achievable in this way compared with a conventional coal-based BF-BOF plant vary from 25 to 58%, depending on assumptions around the source and emissions of the biomass.⁷⁹

The potential for this route to be used globally in the steel transition is severely limited by the supply of sustainable biomass. Given the relative scarcity of sustainable biomass in most regions, experts have

suggested that its use globally should be prioritised for those sectors where no scalable alternatives have yet been proven, such as aviation or plastics.⁸⁰

Molten oxide electrolysis: a possible future disrupter

Innovative approaches such as *aqueous or molten oxide electrolysis* (MOE) may prove useful as options for near-zero emission primary steel production in future. These routes are potentially significant because of their modularity and efficiency, as they do not require clean electricity to be converted into hydrogen (which involves significant energy losses). However, these routes require further research and demonstration, and remain uncertain until demonstrated at a commercial scale.⁸¹ Boston Metals aims to establish a commercial-scale MOE plant by 2026, but generally the technology appears likely



The H₂-DRI-EAF route is the leading option for deployment of near-zero emission primary steel in the near-term.

⁷⁵ Fan, Z. & Friedmann, J. (2021). Low-carbon production of iron and steel: technology options, economic assessment, and policy. *Joule* 5(4): 829–862. ⁷⁶ Witecka, W. K. et al. (2023). *15 insights on the global steel transformation*. Agora Industry and Wuppertal Institute. ⁷⁷ E+ Energy Transition Institute (2022). *Scoping paper on the Brazilian Steel Industry Decarbonization*. ⁷⁸ IEA (2025). *Outlook for biogas and biomethane: a global geospatial assessment*. ⁷⁹ Fan, Z. & Friedmann, J. (2021). Low-carbon production of iron and steel: technology options, economic assessment, and policy. *Joule* 5(4): 829–862. ⁸⁰ Energy Transitions Commission (2021). *Bioresources within a Net-Zero Emissions Economy: Making a Sustainable Approach Possible*. Mission Possible Partnership series. ⁸¹ Bashmakov I. A. et al. (2022). *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Chapter 11. ⁸² Agora Industry, Wuppertal Institute, and Lund University (2024). *Low-carbon technologies for the global steel transformation. A guide to the most effective ways to cut emissions in steelmaking*.

only to reach commercial use in the 2030s, given its current readiness level.⁸²

No primary near-zero emission steel technology is currently cost-competitive

All near-zero emission primary production routes currently involve significant additional costs compared with conventional production:

- The production costs of early commercial-scale 100% green H_2 -DRI-EAF plants that could be operational in 2030 could be approximately 30–75% more on average than those of BF-BOF plants, according to IEA estimates.⁸³ A detailed academic study estimates the cost difference to be around the bottom end of this range.⁸⁴ Up to 50% of the costs of near-zero emission steel in the H_2 -DRI route come from the green hydrogen production.⁸⁵ Cost estimates therefore depend strongly on the assumed cost of hydrogen, which is expected to come down over time with deployment.
- The costs of CCS applications can vary greatly depending on how dilute the carbon emissions sources are.⁸⁶ The median cost gap between DRI-gas-CCS-EAF

and BF-BOF production in 2025 has been estimated at around \$140–200 per tonne of crude steel for G20 countries (an additional cost of around 30–50%).⁸⁷

Primary near-zero emission steel production may remain necessary for quality purposes

A final consideration is that different production routes are generally associated with their potential to produce different-quality steel products. Whilst BF-BOFs have typically made *flat products*, associated with higher quality and value and used in aerospace and automotive sectors, EAFs have typically made *long products*, used in infrastructure and construction. This is because scrap steel often contains contaminants – particularly copper and tin – which reduce the quality of steel produced, and explains why primary steelmaking is still dominant in automotive and aerospace applications.⁸⁹

This distinction, however, does not always hold. EAFs can use a mix of scrap and other ferrous inputs (such as sponge iron and hot briquetted iron) in the steelmaking process to produce high-quality flat products, and some BF-BOFs

produce long products. Furthermore, innovation has improved the quality of steel production in EAFs over time. Traditionally, the BF-BOF route was seen as the only viable option for high-quality flat products, but technological progress and improved scrap quality mean that EAFs are increasingly able to compete in this segment.⁹⁰ Decades of incremental improvements in EAF design – such as better burners, more efficient heat transfer, and reduced contamination – means that some steel produced in a modern EAF can in many cases be indistinguishable in quality from that produced in integrated BF-BOF plants.⁹¹ This trend is visible globally, including in Japan where the latest EAF technologies are now being deployed to produce grades previously only achievable through BF-BOF.⁹² The increasing ability of EAF plants to compete with BF-BOF plants for the same segments of the market has implications for policy to advance the transition, which we consider in Section 3.

⁸³ IEA and UN Climate Change High Level Champions (2024). *The Breakthrough Agenda Report 2024*. ⁸⁴ Richstein, J. C. & Neuhoff, K. (2022). Richstein, J. C. & Neuhoff, K. (2022). Carbon contracts-for-difference: How to de-risk innovative investments for a low-carbon industry? *IScience*, 25(8). ⁸⁵ Wilmoth R. et al. (2024). *Green Iron Corridors: Transforming the Steel Supply Chains for a Sustainable Future*. RMI. ⁸⁶ Baylis-Stern, A. & Berghout, N. (2021). *Is carbon capture too expensive?* IEA. ⁸⁷ Li, F. & Bataille, C. (2025). Research conducted for the Breakthrough Agenda Policy Network. ⁸⁸ Transport & Environment (2025). *Boosting the use of recycled steel in the EU automotive industry*. ⁸⁹ IEA (2020). *Iron and Steel Technology Roadmap*. ⁹⁰ Clean Air Task Force (2025, April 14). *Decarbonization pathways and policy recommendations for the United States steel sector*. ⁹¹ Pistorius, P. C. (2017, April). *Electric arc furnace steelmaking: advancing technology and quality*, Industrial Heating. Carnegie Mellon University. ⁹² Transition Asia (2025). *Japanese electric arc furnace steel: a market ready for low-carbon growth*.



Conclusion

Deployment of near-zero emission primary steel technologies should be a high priority for policymakers, since they are essential for the transition and face much greater barriers than the increased use of scrap steel recycling. The H₂-DRI-EAF production route appears to be the frontrunning option for deployment at scale globally in the near term, given its potential for near-zero emission production, technological readiness, and dominant share of the clean primary steel investment pipeline. Biomass could be useful in particular regions. There is high uncertainty over the role of CCS, and over the potential emergence of more disruptive technologies such as MOE.

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Deployment of near-zero emission primary steel technologies should be a high priority for policymakers.

Unilateral policies to accelerate clean steel deployment in a context of competitive trade

3

The steel sector is a globally interconnected system, and the actions that countries take individually will influence the success of the transition not only in their own countries, but also more widely.

In this section, we consider which of the policies that a country can adopt unilaterally are most likely to be effective in deploying near-zero emission primary steel production in the context of competitive international trade. We compare policy options in terms of their effectiveness in driving technology deployment, distribution

of costs, competitiveness risks, and effect on the global transition. We argue that targeted subsidies are likely to be essential, supported by demand-side measures and clear standards, and that subsidy-and-recharge policies can fund the transition at minimal cost to consumers while better managing competitiveness risks.

Key messages

- Targeted subsidies are likely to be essential to enable the deployment of near-zero emission technologies for primary steel production. Other demand-creating policies, such as public procurement and potentially clean steel mandates, can play a complementary role. Provision of the necessary infrastructure and clarity on standards and definitions will also be needed.
- Carbon pricing and carbon intensity regulations are likely to be useful in prompting a shift from high emission blast furnace–basic oxygen furnace (BF–BOF) production towards low emission scrap–electric arc furnace (scrap–EAF) production. These policies alone are unlikely to enable deployment of near-zero emission primary steel technologies, at least in the near term.
- The additional costs of clean steel production will ultimately be paid by consumers or taxpayers, whichever policies are used. A subsidy-and-recharge policy can be revenue-neutral for governments and would increase the cost of steel much less than carbon pricing of equivalent stringency. The cost increase of steel for consumers of household goods would be very low, especially in the early stages of the transition.
- A subsidy-and-recharge policy for near-zero emission steel can avoid risks to the international competitiveness of a country's steel industry or downstream industries in either domestic or foreign markets. With carbon pricing and a carbon border adjustment mechanism (CBAM), these risks are relatively high.
- For countries that have an emissions trading system, a hybrid approach is possible (the Clean Industry Contribution, with carbon contracts for difference) that could allow policy to adapt in response to global conditions, enabling the deployment of clean primary steel technologies while effectively managing international competitiveness risks.
- Any of these approaches can exert some positive influence on the steel transition internationally. A CBAM's international effect is most likely to be an increase in steel recycling. A subsidy-and-recharge policy or a Clean Industry Contribution could have a positive effect on international adoption of clean primary steel technologies.



Subsidies and demand creation measures are likely to be necessary in most countries for the deployment of primary near-zero emission steel technologies.

Policies to deploy near-zero emission steel production

Policy experience in the steel sector to date

The Intergovernmental Panel on Climate Change has reported that in the first 30 years since countries agreed to stabilise atmospheric concentrations of greenhouse gases, requiring complete elimination of net anthropogenic emissions, policies for the decarbonisation of energy-intensive industries have focused largely on (a) improving efficiency; and (b) researching and developing new technical solutions.⁹³ Although these policies have supported the emergence of new near-zero emission primary steel technologies, they have not led to the commercial deployment of those technologies, which have a global market share of approximately zero.

The policy to decarbonise the steel sector that has been more widely advocated than any other over the past two decades has been carbon pricing. The European Union has operated its Emissions Trading System (ETS) since 2005. Steel has been covered by the scheme since its inception. The direct financial effect of the EU ETS on industry so far, however, has been limited. The carbon prices generated by the system have been far lower than the cost gap between conventional and near-zero emission production for most of the scheme's history. In the past few years, prices have been higher, but to avoid harming the industry's competitiveness in

international trade, most emissions permits are allocated without cost. These 'free allocations' currently apply to around three-quarters of steel emissions, making the effective carbon price even lower.⁹⁴ The policy has reportedly led to increased industry interest in exploring low-carbon options, including increased use of scrap recycling, but it has not on its own led to the deployment of any near-zero emission primary steel production technologies – although it may have contributed to success in cases where targeted subsidies were also used.

Nearly all near-zero emission primary steel projects announced or under construction have received subsidies

To date, only a handful of iron and steel facilities using technologies that are capable of near-zero emissions at demonstration or full scale are currently operating anywhere in the world:

- In Sweden, HYBRIT's pilot project in Luleå became operational in 2020, delivering hydrogen-reduced sponge iron to its first customer in 2021.⁹⁵ Gällivare has been selected as the site for its demonstration plant using hydrogen–direct reduced iron (H₂–DRI) technology to produce 1.3 Mt of sponge iron per year, but it is not yet operational. HYBRIT has received a grant of €143m from the EU⁹⁶ and a

grant of \$300m from the Swedish government.⁹⁷

- In China, both HBIS Group and China Baowu Steel are operating full-scale DRI projects using a mix of hydrogen with other gases. The Baowu Zhanjian project uses a mix of natural gas, coke-oven gas, and hydrogen. The HBIS Group project uses coke-oven gas and externally sourced hydrogen. These are therefore not near-zero emission, but could be capable of being so with sufficient low-carbon hydrogen supply.⁹⁸ The financing arrangements of these projects are unclear, but both HBIS Group and Baowu are state-owned enterprises and therefore may have benefited from favourable financing arrangements.
- In Namibia, HyIron has begun operating at demonstration scale this year (2025) using green hydrogen–DRI. The project received a grant of €13m from the German government.⁹⁹ The project has also signed an offtake agreement with the German metals firm Benteler for 200,000 tonnes; however, the first phase of the project will produce 15,000 tonnes per year.¹⁰⁰

Beyond these existing projects, a number of other full-scale near-zero emission (H₂–DRI) projects either are under construction or have been announced (see **Table 3**).

⁹³ Bashmakov I. A. et al., (2022). *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Chapter 11. ⁹⁴ Eurofer (2025). *EU ETS revision: benchmarks and CBAM free allocation phase out*. ⁹⁵ Hybrit (n.d.) *Hybrit: Facts and milestones*, Hybrit.

⁹⁶ Directorate-General for Climate Action (2023). *The HYBRIT story: unlocking the secret of green steel production*. European Commission. ⁹⁷ Hybrit (2023). *Positive decision on support for LKAB and HYBRIT*. ⁹⁸ Agora Industry, Wuppertal Institute and Lund University (2024). *Low-carbon technologies for the global steel transformation. A guide to the most effective ways to cut emissions in steelmaking*. ⁹⁹ Clean Energy Wire (2023). *Germany funds Africa's first green ironworks in Namibia*. ¹⁰⁰ Hydrogen Insight (2024). *Africa's first green hydrogen-based ironworks signs offtake deal as it receives electrolyzers*.



Table 3:

H₂-DRI projects by location, project, and disclosed subsidy.

Location	Project ¹⁰¹	Disclosed subsidy
Sweden, Boden	Stegra's Boden facility is a green electricity electrolysis project under construction for 2026.	Stegra has received substantial public support, including €250m from the EU Innovation Fund ¹⁰² and €100m from the Swedish Energy Agency, ¹⁰³ as well as €1bn green credit guarantee from the Swedish National Debt Office. ¹⁰⁴
The Netherlands, IJmuiden	Tata Steel's Heracleus facility is a H ₂ -DRI project using 'energiron' technology announced for 2030.	The Government of the Netherlands has approved €2bn in subsidies, and Tata Steel is applying for €0.3bn from the EU's innovation fund. ¹⁰⁵
France, Fos sur Mer	GravitHy is a green electricity electrolysis DRI project under construction for 2028 by the company GravitHy.	€60m has been raised from public funding through France's 'Première Usine' programme. ¹⁰⁶
South Korea, Pohang	POSCO Holding's HyREX facility is a H ₂ -DRI project using fluidised bed reactors and electrical smelting expected for 2028.	No direct subsidies have been disclosed. The South Korean Government has committed to actively supporting POSCO's 2030 spending plans. ¹⁰⁷
Germany, Salzgitter	Salzgitter Group's SALCOS facility is a green electricity electrolysis DRI project announced for 2033, but with some phases now delayed by approximately three years.	Salzgitter has received €1bn from the German Government. ^{108 109}
Finland, Inkoo	The Blastr Green Steel Project is a midrex H ₂ -DRI project and EAF announced for 2027.	No direct subsidies have been disclosed. In its last round of strategic partner financing, Tesi, Finland's state-owned venture capital, increased its stakes in the company. ¹¹⁰
Spain, Puertollano	Hydnum Steel is a green electricity electrolysis and EAF project under construction for 2026.	The project has been awarded €60m in funding under the government's PERTE programme for Industrial Decarbonisation. ¹¹¹
China, Naiman, Inner Mongolia	HBIS Naiman is a green electricity electrolysis project under construction for 2025 by the HBIS Group.	No direct subsidies have been explicitly disclosed. The project's location in Inner Mongolia suggests it may benefit from preferential policies, financial and resource prioritisation, and infrastructure support introduced by the local government to foster the green hydrogen industry. It is also likely that this project would fall within the scope of national support schemes (see next page).

¹⁰¹ LEADIT (2025), *Green Steel Tracker*. Notes: authors representation of data from the steel tracker. ¹⁰² Stegra (2025, April 10), *Stegra supported by the EU Innovation Fund*.

¹⁰³ Stegra (2024, September 19), *Stegra granted state aid from the Industrial Leap and the Swedish Energy Agency*. ¹⁰⁴ Stegra (2024, October 24), *Leading European financial institutions support H2 Green Steel's €3.5 billion debt financing*. ¹⁰⁵ Reuters (2025, September 29), *India's Tata Steel signs pact with Dutch government to lower carbon emissions*. ¹⁰⁶ Renewables Now (2025), *GravitHy raises EUR 60m to advance low-carbon iron project in France*. ¹⁰⁷ FCW (2024), *South Korea Boosts POSCO's hydrogen reduction steelmaking with significant investment support*. ¹⁰⁸ BankTrack, (2025), *EU state aid at a crossroads: green steel projects are stalling despite public subsidies worth billions*. ¹⁰⁹ GMK Centre (2025) *European countries increased steel decarbonization subsidies to €15.1 bln*. ¹¹⁰ EuroMetal (2025), *Blastr Green Steel secures partner finance round for Finnish low-carbon steel plant*. ¹¹¹ Hydnum Steel (2025, April 23), *Government grants €60 million to Hydnum Steel*.

Additionally, a number of 'hydrogen-ready' DRI plants have been announced or are under construction globally. These are plants that will operate as natural gas-DRI at first, but in which the gas can be replaced with hydrogen when this is available and commercially viable. Around half of these are in Europe.

A common feature across projects is that, of those for which data is disclosed, most have received sizeable capital expenditure grants. In the EU, 15 subsidy decisions have been taken to support these projects totalling €14.6bn as of December 2024.¹¹² Other estimates put figures at €9.3bn across 10 projects, noting that transparency around these decisions is limited.

Subsidies in China are harder to quantify, but the Chinese Government has publicly indicated a willingness to support clean steel projects. The National Development and Reform Commission has issued the Special Management Measures for Central Budget Investment in Energy Conservation and Carbon Reduction (2024), which provides capital investment

subsidies and interest support, and has published a 'List of Green and Low-Carbon Advanced Technology Demonstration Projects'.¹¹³ The State Council's 2024–2025 Energy Conservation and Carbon Reduction Action Plan calls for expanding electric arc furnace capacity and accelerating hydrogen-based production processes.^{114 115} In addition, the People's Bank of China has extended its Carbon Emission Reduction Facility to 2027, offering low-cost re-lending for eligible green projects.¹¹⁶

Despite these large capital expenditure subsidies, several projects in the EU face implementation delays and are at risk of not meeting the conditions set out in state aid contracts.¹¹⁷ In November 2024, ArcelorMittal announced that it was freezing all investment in decarbonisation projects, despite receiving subsidies for five projects. ArcelorMittal chairman Lakshmi Mittal cited the lack of hydrogen supply, threats of foreign steel imports, and lack of demand for near-zero emission steel.¹¹⁸ The German steelmaker Thyssenkrupp has announced that it will continue with its

€3bn facility in Duisburg, but has called for new conditions included expanding relevant infrastructure and energy prices,¹¹⁹ warning that without a supply of cheap renewable hydrogen, it risks becoming a stranded asset.¹²⁰

Although each project is context-specific, some conclusions can be drawn. Leading clean steel projects that have made progress in the past year have typically benefited from targeted government incentives. Specifically, for those projects where data is available, subsidies in the form of direct grants for capital expenditure have been influential in supporting the announcement of projects. However, despite being offered subsidies for capital costs, some companies have stalled projects and are waiting for clarity on policy support for the operational cost of production, in the face of high prices for hydrogen. Capital subsidies alone are insufficient to cover the long-term cost differences in production; and for this, operating subsidies may be necessary.



A common feature across projects is that, of those for which data is disclosed, most have received sizeable capital expenditure grants.

¹¹² GMK Center (2024). *European countries granted 14.6bn EUR for decarbonisation of the steel sector*. ¹¹³ Transition Asia (2024). *Blog: Key Policy Highlights for the Steel industry in China (Q1 2024)*. ¹¹⁴ National Development and Reform Commission (2024, April 8). 国务院关于印发《碳达峰碳中和标准体系建设方案》的通知 [The State Council's notice on issuing the plan for establishing the carbon peak and carbon neutrality standard system]. ¹¹⁵ State Council of the People's Republic of China (2024, May 29). 国务院关于印发《推动大规模设备更新和消费品以旧换新行动方案》的通知 [The State Council's notice on issuing the action plan for promoting large-scale equipment upgrades and trade-ins of consumer goods].

¹¹⁶ Green Central Banking (2024, August 22). *China's central bank extends green lending scheme until 2027*. ¹¹⁷ BankTrack (2025). *EU State Aid at a Crossroads: Green Steel Projects are Stalling Despite Public Subsidies Worth Billions*. ¹¹⁸ BankTrack (2025). *EU State Aid at a Crossroads: Green Steel Projects are Stalling Despite Public Subsidies Worth Billions*.

¹¹⁹ Reuters (2025). *Thyssenkrupp sticks with green steel plant, but calls for 'adjusted' conditions*. ¹²⁰ Hydrogen Insight (2025). *Thyssenkrupp's green steel plant not viable if supply of cheap renewable hydrogen never arrives*.

Governments are moving to provide operating subsidies and use public procurement to support clean steel

There are signs that governments are beginning to see operating subsidies as necessary to enable the deployment of primary clean steel technologies. In some cases these are complemented with public procurement policies. Examples include:

- **The US** Inflation Reduction Act under the Biden administration provided investment and production tax credits for low-carbon electricity, clean hydrogen production, CCS and manufacturing of clean technologies such as electrolyzers. The US also implemented large public procurement targets (Buy Clean Initiative) and provided loans and grants through the Department of Energy for low emission steel.^{121, 122} However, many of these schemes have now been reversed.
- **Germany** has launched carbon contracts for difference (CCfDs) for energy-intensive industries including steel, which provides subsidies that vary with the carbon price, enabling firms to switch production processes from fossil fuels to electricity and hydrogen. Steel is within scope of the policy, although no contract was awarded for

steel production in the first round of allocations. The government's intention is to expand support to CCS and carbon capture and utilisation (CCU) projects in future rounds. The CCfDs are awarded over a 15-year period and were estimated in 2023 to have a potential cost of around €50bn in total, although whether this is the actual budget is not clear.¹²³ The first round had a budget of €2.8bn.¹²⁴

- **The UK** is implementing a similar approach, providing production subsidies through CCfDs for low-carbon hydrogen (under the Hydrogen Production Business Model) and CCS. Three contracts have been signed and eight more are expected in 2025.¹²⁵ Revenue support is provided to selected projects over a 15-year period, to overcome the operating gap between low-carbon hydrogen and competing high-carbon fuels. In 2024, 11 projects were granted support under round 1 which consisted of £90m in capital grant support and £2bn of revenue support.¹²⁶
- **The Japanese government** is supporting the industry's transition with a price-difference support scheme to bridge the cost between low emission hydrogen and conventional fuels, modelled on the UK's system, worth \$21bn over 15 years.

A demand-side subsidy scheme for purchasing electric vehicles that use green steel has also been introduced (worth \$345 per vehicle to the consumer). Capital investment subsidies are also available for conversion of BF-BOF steel plants to EAFs. Nippon steel has been awarded \$1.7bn for three large-scale EAFs, and JFE steel \$0.7bn for one large-scale EAF. Corporation tax deductions are also available for the production of green steel, at a rate of \$139 per tonne.¹²⁷

- **The EU** has indicated that it aims to provide €100bn of financial support through its Clean Industrial Deal and Industrial Decarbonisation Bank. This is based on funds from the EU's Innovation Fund and ETS revenues, as well as InvestEU. The Commission will launch a pilot auction of contracts worth a total of €1bn across sectors including steel.^{128, 129}

In most of these countries where operating subsidies are being considered or implemented, carbon pricing or emissions trading systems already exist. This suggests a growing recognition amongst industry and policymakers of the need for policies to provide additional long-term support for operating expenditure, to reduce the risks of investing in lower and near-zero emission steel production.

¹²¹ Galluci, M. (2024). *US pledges up to \$1bn for two pioneering 'green steel' projects*. ¹²² Bistline, J. et al., "Emissions and energy impacts of the Inflation Reduction Act." Science 380, no. 6652 (2023): 1324-1327. ¹²³ Euractiv (2023). *Berlin launches 50bn EUR 'climate contracts' for industry*. ¹²⁴ Clean Energy Wire (2024). *Germany awards first companies with pioneering 'climate contract' scheme to slash industry emissions*. ¹²⁵ Hydrogen Insight (2024). *First subsidised green hydrogen production contracts in UK signed, guaranteeing \$12 per kg for 15 years*. ¹²⁶ Department for Energy Security and Net Zero (n.d.) *Hydrogen Allocation Rounds*. ¹²⁷ Written contribution from Kentaro Tamura, IGES. ¹²⁸ European Commission (2025). *Clean Industrial Deal*. ¹²⁹ European Commission (2025). *A clean steel and metals action plan*.



Only

7%

of steel industry leaders were confident that the sector would achieve the goal of near-zero emission steel being the preferred choice in global markets by 2030.



Industry calls for demand creation, financial support and standards

Surveys indicate that industry leaders believe stronger policy support for the transition is needed. A 2025 World Business Council on Sustainable Development survey found that only 7% of steel industry leaders were confident that the sector would achieve the goal of near-zero emission steel being the preferred choice in global markets by 2030. Most doubted that currently announced clean steel projects would reach final investment decision before the end of this decade. They pointed to a deceleration in project development, with major companies cancelling or delaying projects because of high energy prices, limited hydrogen availability and uncertainty about ETS allowance timelines, as well as concerns about competitiveness.¹³⁰

Industry perspectives highlight a divergence. Investment in near-term, incremental emissions reductions is progressing. This includes increasing use of scrap steel in EAF production, improvements in efficiency, and the use of higher-grade iron ore. In contrast, investment in technologies for the decarbonisation of ironmaking, such as H₂-DRI and CCS, remains delayed. These projects remain in the pilot phase and are broadly viewed by industry as post-2030 solutions.

Almost all businesses (90%) highlighted the importance of policy for driving investment in low emission steel. They noted that some voluntary demand for low-carbon steel exists, but not enough to enable large-scale investment. Most steel-buying businesses are unwilling to pay the additional cost. Firms identified financial support as critical to close the cost differential between low and high emission steel, and to reduce investment risks. Support could be in the form of CapEx and/or OpEx subsidies, or included within double-sided auctions between steel producers and consumers. Businesses also called for measures such as public procurement, mandates, and carbon prices, to help to create demand for low emission steel.

Businesses also stated the need for simplified and internationally aligned taxonomies for clean steel based on whole lifecycle emissions assessments, and certifications for near-zero emissions steel. Access to low-cost renewable electricity was also identified as essential.

Lessons from other sectors: subsidies and demand creation are effective early in the transition

While each sector is unique, the experience of other sectors also shows that early deployment of low-carbon technologies typically depends less on carbon pricing and more on policies such as subsidies, mandates, and public procurement.

¹³⁰ WBCSD (2025, June 23). *Business Breakthrough Barometer 2025*.

The two sectors in which low carbon transitions have made the most progress globally are the power sector and road transport. In the power sector, the initial deployment of the zero emission technologies of solar and wind power was driven primarily by two forms of policy: subsidies (including feed-in tariffs), and regulatory mandates (such as clean power portfolio standards). Public procurement also played a role in the early stages.¹³¹ In road transport, purchase incentives have played a central role in driving the initial deployment of electric vehicles (EVs), while zero emission vehicle mandates and increasingly stringent carbon intensity regulations have proven powerful levers for increasing EVs' market share.^{132, 133}

A systematic review of academic studies of the effects of existing carbon pricing policies found that where these have reduced emissions, it has been mainly through efficiency increases or switching to lower emission fossil fuels. The review found 'no evidence that carbon pricing systems have triggered zero-carbon investments, and scarce but consistent evidence that they have not.'¹³⁴

The low carbon transition is not unusual in this respect. In historical technology transitions, government support for investment in new technologies and systems has often been important to enable their deployment. Taxes on the old technologies have been

less important, although they have in some cases played a complementary role at later stages of the transition.^{135, 136, 137}

Policy insights from modelling: subsidies and demand creation are essential for deployment of primary near-zero emission technologies

Simulation modelling is another source of evidence for the likely role of different policies early in the steel transition, complementing industry surveys and academic literature. A study from the Economics of Energy Innovation and System Transition project used a dynamic technology diffusion model to test policy options and examine their impact on the mix of technologies used in steel production.¹³⁸

The Future Technology Transformations-Steel (FTT-Steel) model¹³⁹ simulates technology choices by steel producers across 26 different competing technologies in 71 countries and regions. The model simulates innovation through Wright's Law (also referred to as learning by doing), where technology costs fall in proportion to cumulative global production, and diffusion is subject to the 'imitator effect' where the more a technology is used, the more likely it is to be adopted. The model includes country-specific limits on the availability of scrap steel, but places no restrictions on the use of biomass, green hydrogen, or land use for CCS facilities.

One significant limitation of the model is that it does not represent international trade in steel, meaning that it does not consider how policy effectiveness is influenced by first-mover risks. Another limitation is that the model does not differentiate between different qualities of steel produced.

The study tested the effects of four policies across China, India, Japan, and the USA:

- a capacity cap on blast furnaces;
- carbon pricing (following trajectories set by the IEA's Announced Pledges scenario, which is designed to be consistent with countries' net zero or carbon neutrality goals);
- subsidies for clean primary steel (set to achieve cost-parity with BF-BOF); and
- a clean steel mandate.

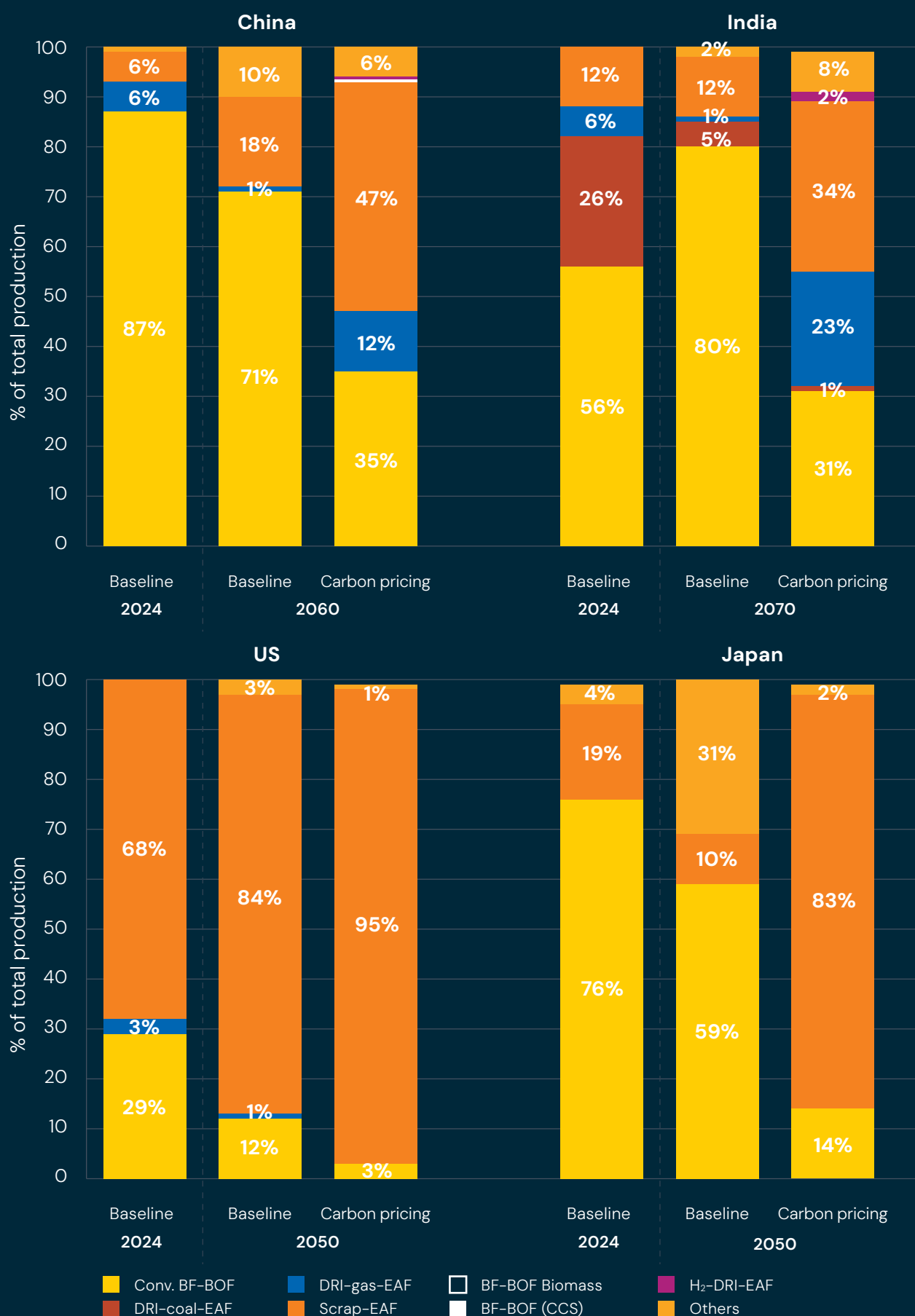
The results showed that the policies had widely differing effects. Carbon pricing and the BF-BOF capacity cap policies each drove a shift from conventional high emission BF-BOF production towards scrap-EAF production in all four countries, and to a more limited extent led to the adoption of some intermediate-emissions technologies. In the carbon pricing scenario, high carbon prices in later years combined with limited scrap availability led to the emergence of some gas-DRI-EAF production in China and India (see **Figure 7**).

¹³⁰ WBCSD (2025, June 23). *Business Breakthrough Barometer 2025*.¹³¹ Nemet, G. F. (2019). *How solar energy became cheap: A model for low-carbon innovation*. Routledge.

¹³² ICCT (2018). *The role of standards in reducing CO2 emissions of passenger cars in the EU*.¹³³ Vergis, S., & Mehta, V. K. (2012). *Technology Innovation and Policy: A Case Study of the California ZEV Mandate. Paving the Road to Sustainable Transport: Governance and Innovation in Low-Carbon Vehicles*, Chapter 8. Routledge.¹³⁴ Lilliestam, J., Patt, A., & Bersalli, G. (2022). On the quality of emission reductions: observed effects of carbon pricing on investments, innovation, and operational shifts. A response to van den Bergh and Savin (2021). *Environmental Resource Economics* 83, 733–758 (2022).¹³⁵ Kanger, L., Sovacool, B.K.S., & Noorköiv, M. (2020). Six policy intervention points for sustainability transitions: A conceptual framework and a systematic literature review. *Research Policy*, 49, 104072.¹³⁶ Meadowcroft, J. & Rosenbloom, D. (2023). Governing the net zero transition: Strategy, policy, and politics. *Proceedings of the National Academy of Sciences*, 120(47), e2207727120.¹³⁷ Rosenbloom, D., Markard, J., Geels, F.W., and Fuenfschilling, L. (2020). Why carbon pricing is not sufficient –and how a “sustainability transition policy” can help mitigate climate change. *Proceedings of the National Academy of Sciences*, 117(16), 8664–8668.¹³⁸ Dayal, S. et al. (2025). *Towards near-zero emissions steel: modelling-based policy insights for major producers*.¹³⁹ Vercoolen, P., Lee, S., Han, X., Zhang, W., Cho, Y., & Pang, J. (2023). Carbon-neutral steel production and its impact on the economies of China, Japan, and Korea: A simulation with E3ME-FTT: Steel. *Energies*, 16(11), 4498.



Figure 7:
Technology mix by country under the baseline and carbon pricing scenarios.

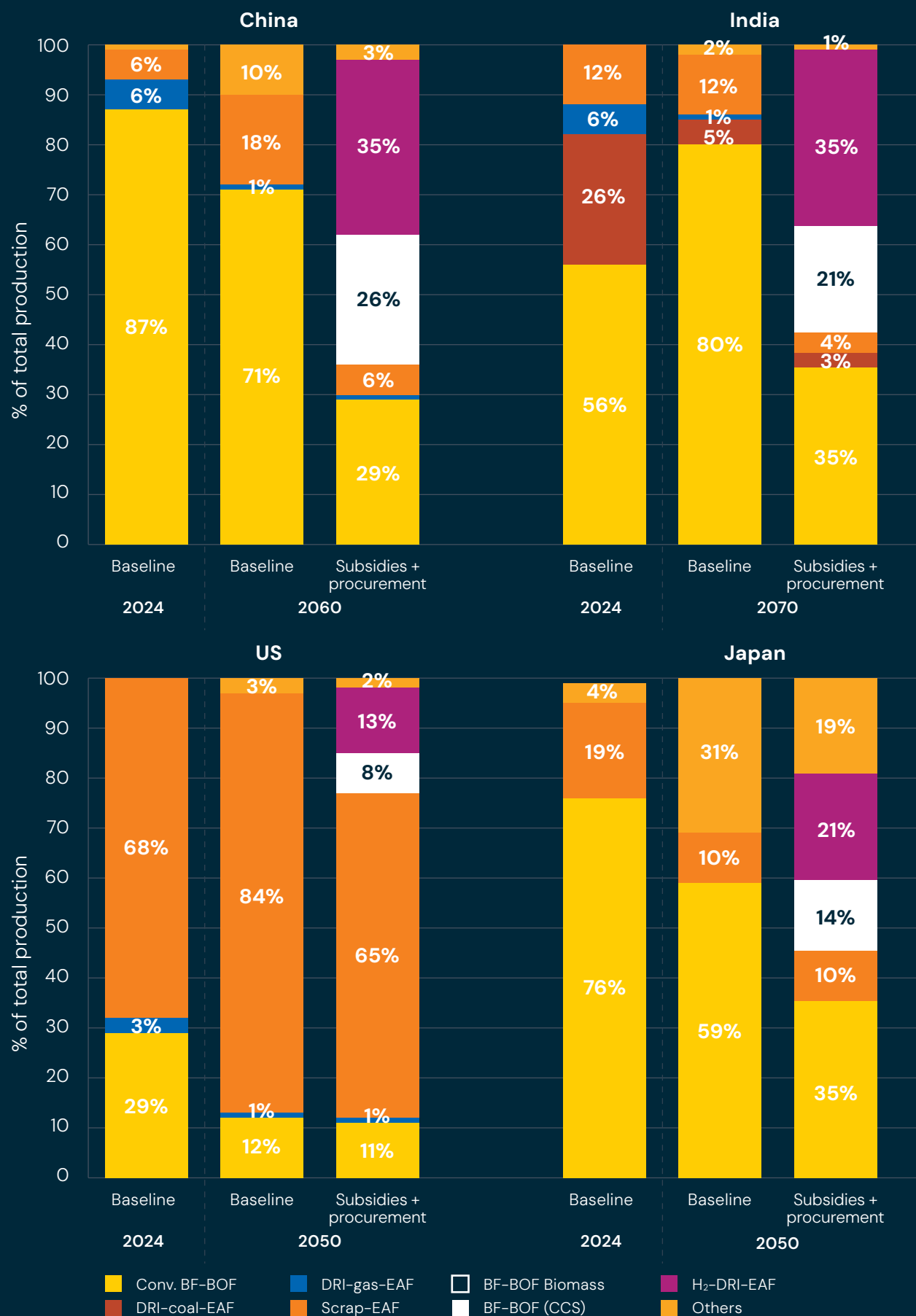


Notes: Dayal, S. et al. (2025). *Towards near-zero emissions steel: modelling-based policy insights for major producers*.
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Figure 8:

Technology mix by country in the baseline and under a scenario with clean primary steel subsidies and procurement.



Notes: Dayal, S. et al. (2025). *Towards near-zero emissions steel: modelling-based policy insights for major producers*. License: CC BY 4.0. Adapted by authors.

With the capacity cap, there was some use of the gas-DRI-EAF, smelt reduction-BOF, and blast furnace with top gas recovery production routes. Neither of these policies resulted in any significant deployment of near-zero emission primary steel production technologies.

In contrast, the subsidy and public procurement policy combination led to substantial deployment of near-zero emission primary production technologies – BF-BOF-CCS and H₂-DRI-EAF – in all four countries (see **Figure 8**). This displaced high emission BF-BOF production in China, India, and Japan (but did not eliminate it). The clean steel mandates policy also led to substantially increased deployment of near-zero emission primary steel technologies.

The combined policies scenario led to the largest technological change and deepest emissions reductions, with rapid growth of both primary clean steel technologies and scrap-EAF production, and with high emission BF-BOF production being almost entirely eliminated.

The results should be interpreted with several caveats in mind. Any of the policies could be adopted with

different stringencies, which could alter their relative effects. The absence of competitive trade from the model means that the effectiveness of any of the policy options that increase the costs of production – the carbon price, capacity cap, and clean steel mandate – could be overstated. Scrap availability could differ from the model's assumptions. The cost of green hydrogen, which was fixed in this study at US\$2.2/kg, will vary by location and is likely to fall over time (estimates range from \$2–4/kg in 2030, and from \$1.5–3/kg in 2050).¹⁴⁰ The adoption of the H₂-DRI-EAF route could be accelerated by this cost reduction, although it could also be held back by electricity infrastructure constraints. The deployment of CCS could also be limited by countries' geology.

In summary, evidence from across a range of sources suggests that carbon pricing alone cannot deliver the scale or pace of investment needed in near-zero emission primary steel. While it can create incentives at the margin, it is unlikely to overcome the significant upfront costs and technology risks involved. Experience in the steel sector, the history of transitions in other sectors, industry surveys, and simulation modelling all

point to targeted subsidies as being necessary at this point in the transition.

Options for distributing the additional costs of clean steel

For any government, the question of how costs are allocated is central to comparing policy options for the low carbon transition. This is particularly true for the steel sector.

The additional costs of using near-zero emission technologies for primary steel production, compared with using high emission BF-BOF technology, may fall over time through technological improvement and efficiency, but cannot be wished away. There is a limited range of options by which they can be managed. Assuming that companies generally pass through costs to their customers in order to remain profitable, whatever policies are chosen, the additional costs of decarbonisation will ultimately be borne by either (a) consumers of steel products, or (b) taxpayers (see **Figure 9**). Here, we consider how different policies distribute the costs of decarbonisation.



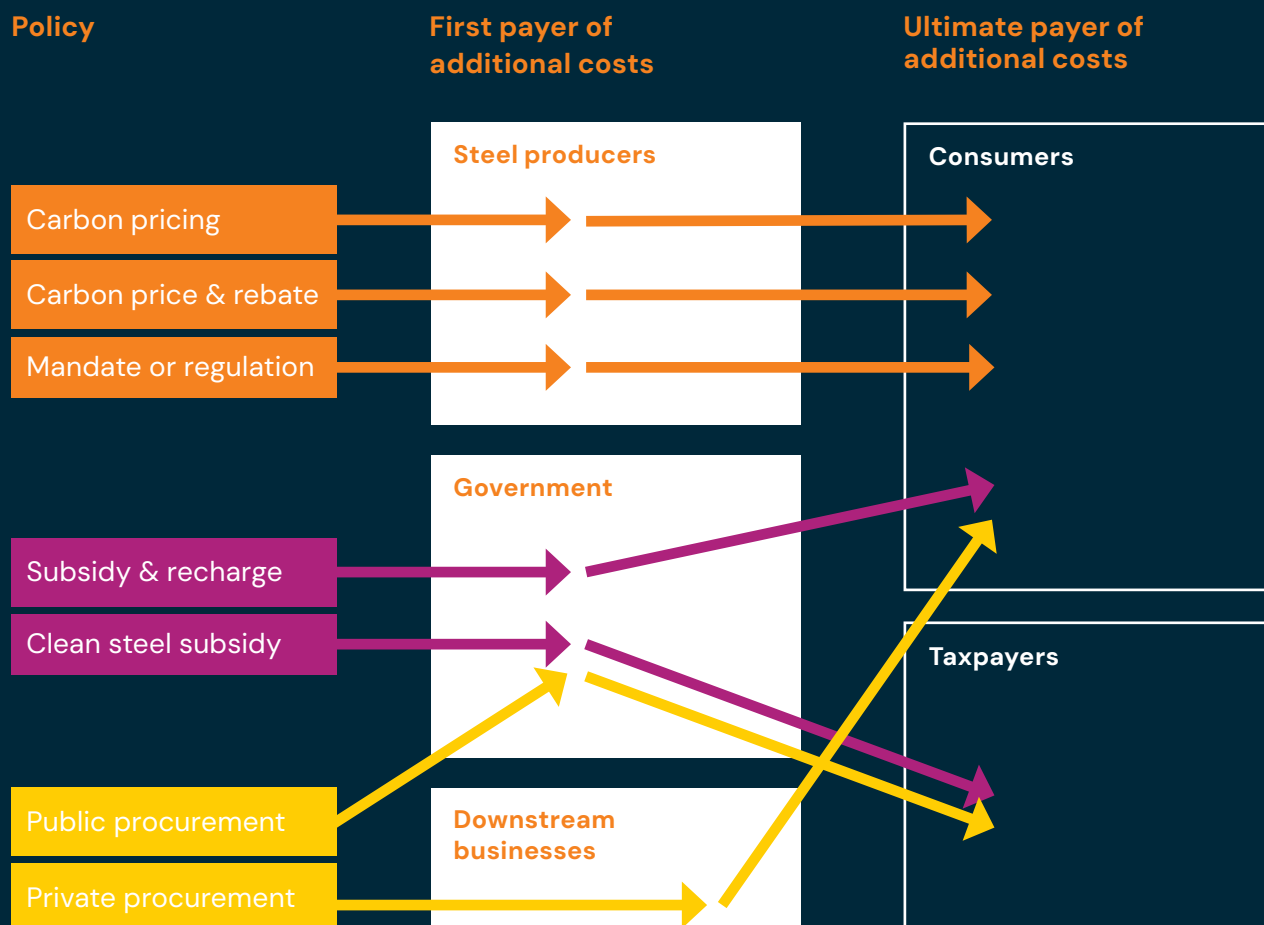
The additional costs of clean steel cannot be wished away. They will ultimately be paid by consumers or taxpayers, whichever decarbonisation policies are used.

¹⁴⁰ Baker, D. R. (2024). Green hydrogen prices will remain stubbornly high for decades. BNN Bloomberg.



Figure 9:

Who pays the additional cost of clean steel?



Note: 'Rebate' means that all the revenue from carbon pricing is returned to steel producers, distributed equally (per tonne of steel) across all production from all technologies. 'Recharge' means that all the cost of clean steel subsidies is recharged to steel producers, distributed equally (per tonne of steel) across all production from all technologies.

A subsidy-and-recharge policy to support near-zero emission steel could increase the cost of steel much less than carbon pricing, early in the transition

Regardless of whether the additional costs of near-zero emission production are paid by taxpayers or by consumers of steel-containing products, they are likely to be small in relative terms at the end of the value chain. For example, an early estimate was that an additional cost of 20% in steel production would translate into an increase of around 1% in the cost of a car.¹⁴¹ A larger difference in price can often be experienced by buying the same model from one car dealer instead of another.

The cost imposed on steel producers, and therefore the increase in steel prices faced by consumers, varies by policy. A simple comparison can be made between two policy options:

- a. **A carbon price:** Set at a level that achieves cost-parity between BF-BOF and near-zero emission primary steel production.
- b. **A 'subsidy-and-recharge':** A subsidy for near-zero emission primary steel production set at a level to achieve cost-parity with BF-BOF production, with the costs of this subsidy being recharged to industry through a levy on all steel produced or imported, at an equal value per tonne of steel.¹⁴²

While both policies would close the cost gap between BF-BOF production and near-zero emission production, the subsidy-and-recharge policy will have a much lower impact than the equivalent carbon pricing policy on the overall cost of steel production, early in the transition. This is because the subsidy only has to make production cheap for a small share of the market, whereas the carbon price has

to make production more expensive for a large share of the market, to achieve the same effect on the relative costs of different technologies.

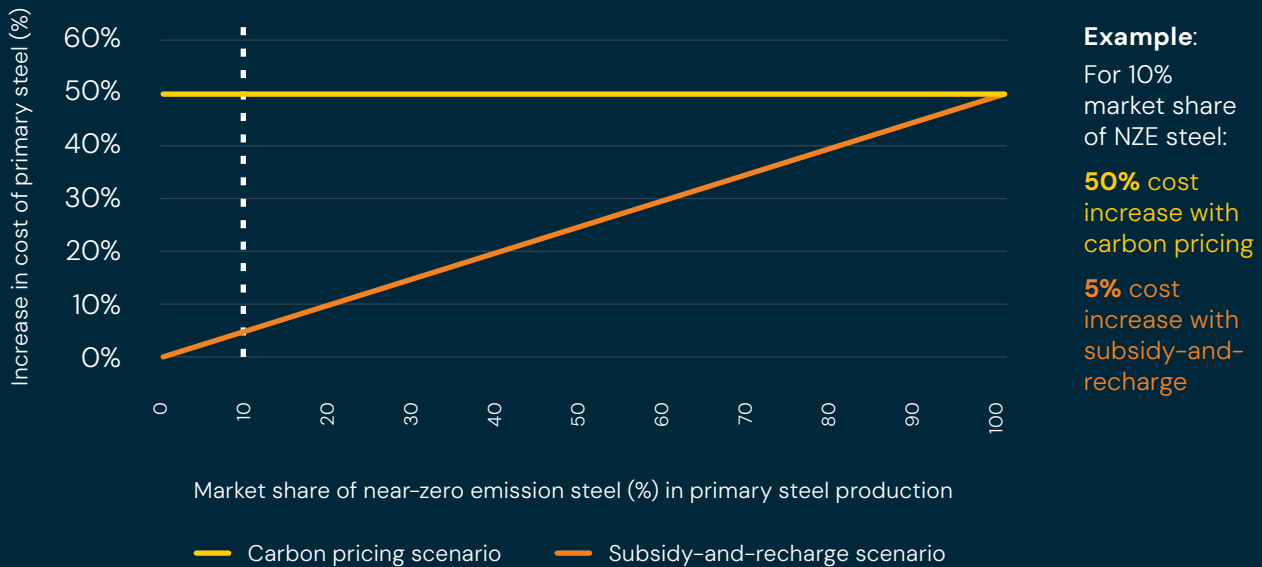
In a highly simplified example with no technological progress, switching 10% of production from BF-BOF to near-zero emission primary steel (such as H₂-DRI-EAF) using the subsidy-and-recharge policy would increase the country's weighted average levelised cost of steel production by 5%. Achieving the same effect with carbon pricing would raise the cost of steel production by 50%.¹⁴³ The subsidy-and-recharge will only increase costs by as much as the carbon price at the very end of the transition (see **Figure 10**).

¹⁴¹ Energy Transitions Commission (2018). *Mission Possible: Reaching net-zero carbon emissions from harder-to-abate sectors*. ¹⁴² Note: The recharge is applied to all steel produced domestically or imported, at an equal charge per tonne of steel regardless of the technology used in its production. The subsidy's effect of closing the cost gap between near-zero emission steel and high emission steel would be unaffected by the recharge. Further note: Since both these options achieve cost-parity between high emission and near-zero emission production routes, they can be considered to be of equal stringency, to a first approximation (in reality, for reasons discussed above, their effectiveness is likely to differ). We use the 'subsidy-and-recharge' option for this comparison rather than a pure subsidy funded by taxation because, like the carbon price, this option involves no government spending. This may be considered more feasible by governments facing fiscal constraints. ¹⁴³ Assumptions: the subsidy level is set to achieve cost-parity between BF-BOF and H₂-DRI-EAF. The carbon price level is set to achieve the same effect. Scrap-EAF production has the same costs as BF-BOF production. Production with H₂-DRI-EAF costs 50% more than BF-BOF, and this does not change over time (no technological progress). Note: In reality, the difference between these two policy approaches is likely to be larger than suggested by this idealised example. The presence of intermediate-emission technologies means the carbon price alone may fail to drive the deployment of near-zero emission primary steel technologies, as discussed in the section above. A carbon price that ramps up slowly would only delay the deployment of clean primary steel technologies, not reduce the costs of that deployment. The presence of any technological innovation and learning would increase the value of early subsidies, and reduce their later costs.



Figure 10:

Increases in steel costs under carbon pricing and subsidy-and-recharge scenarios.



Notes: Idealised comparison of the increase in cost of steel production under carbon pricing and subsidy-and-recharge policy scenarios. Assumptions: Subsidy and carbon price are each set to achieve cost-parity between BF-BOF and near-zero emission primary production. The BF-BOF share of primary steel production starts at 100%. Near-zero emission primary steel costs 50% more to produce than steel made with a BF-BOF, and this does not change over time (there is no technological progress).



With a subsidy-and-recharge policy, the cost of deploying near-zero emission primary steel can be zero for government, and trivially small for consumers during the early stages of the transition.

In reality, the difference between these policy approaches is likely to be larger, and the overall costs are likely to be lower than in this idealised example. Allowing technological progress to be made reduces the work to be done by either the subsidy or the carbon price. A modelling study of the steel transition in India found that subsidies to deploy the first five, ten and twenty near-zero emission primary steel plants could be funded by a recharge equivalent to around 1.2%, 2.4%, and 4.3% of the cost of conventional BF-BOF production respectively, with these levels of deployment expected to be reached around the years 2030, 2034, and 2039 respectively. In comparison, a carbon price set at less than the level required for cost parity could raise the cost of BF-BOF production by 47% in 2040.¹⁴⁴ In this simulation, even the subsidies required to enable a 50% market share of near-zero emission production, modelled as happening in the early 2060s, can be funded by a charge equivalent to only 10% of the cost of BF-BOF production.

In addition, this highly simplified comparison ignores ways in which the policies may be qualitatively different in their effects. As discussed above, the subsidy-led approach may be more likely

to lead to the deployment of clean primary steel, while the carbon pricing approach may be more likely to encourage recycling, could also incentivise greater efficiency in material use, and would generate tax revenues that could be put to a variety of uses.

Early in the transition, the costs to consumers can be trivially small

The fractional increase in the cost of consumer goods is far lower than the fractional increase in the cost of steel production. Using data on products in the EU, we show how a carbon price of \$100/tCO₂ or \$200/tCO₂ – representing alternative estimates of the level required to achieve cost-parity between BF-BOF and H₂-DRI-EAF steel production – could affect the cost of some of the more expensive steel-containing household goods.^{145, 146}

We compare this with the effect of a subsidy-and-recharge policy at the point where near-zero emission primary steel has a 10% share of the market by assuming the same 10:1 cost ratio as in the idealised example described above. The effects of subsidies at the levels required to close the two alternative estimates of the cost gap between BF-BOF and H₂-DRI-EAF production are shown. With reference to **Figure 10** above,

the effect of the carbon price on the cost of steel products at the start of the transition can be understood to be the same as the effect of either policy on costs at the end of the transition, when the whole sector is fully decarbonised (with the same simplifying assumptions as before).

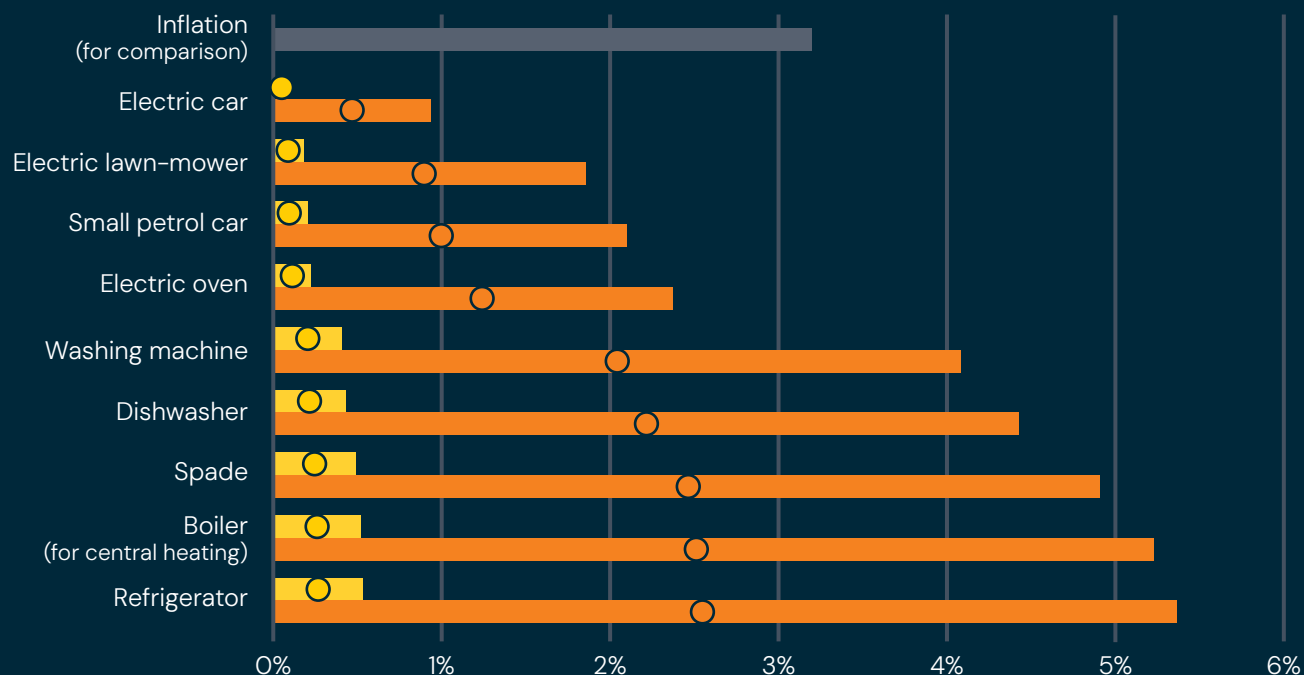
The results show that even for full decarbonisation of the steel sector, the effect on the cost of these products is in the region of 1–5% if the higher cost gap between conventional and clean steel is assumed, comparable to the global average 3% consumer price inflation – except that the cost of decarbonisation would be a one-off increase, whereas inflation happens every year (see **Figure 11**). This effect falls to around 0.5–2.7% if the lower cost gap is assumed. If the subsidy-and-recharge policy is used, then a 10% market share for near-zero emission primary steel – a share that would represent great progress in the transition compared with the present day – could be achieved with one-off cost increases in the range of 0.1–0.5% if the higher cost gap is assumed. This falls to 0.05–0.3% if the lower cost gap is assumed (still with zero technological progress over time). These cost increases are trivially small – likely to be smaller than the effect of choosing between different brands, or buying from different shops.

¹⁴⁴ Dayal, S. et al. (2025). *Towards near-zero emissions steel: modelling-based policy insights for major producers*. ¹⁴⁵ Stede, J., Pauliuk, S., Hardadi, G., & Neuhoﬀ, K. (2021). Carbon pricing of basic materials: Incentives and risks for the value chain and consumers. *Ecological Economics*, 189, 107168. ¹⁴⁶ A \$100/tCO₂ break-even carbon price is slightly more than the minimum estimated to be necessary in Richstein, J.C. and Neuhoﬀ, K. (2022). *Carbon contracts-for-difference: How to de-risk innovative investments for a low-carbon industry?* A \$200/tCO₂ break-even carbon price is roughly consistent with the cost gap between BF-BOF and H₂-DRI-EAF steel production of around \$350USD/tonne steel estimated by Francis Li and Chris Bataille for the BA network, with a carbon intensity of a BF-BOF steel plant being around 1.8tCO₂/t-steel.



Figure 11:

Comparison of the effect of steel transition policies on the cost of consumer products.



- Global average annual consumer price inflation over the past ten years
- Increase in cost using a subsidy-and-recharge policy for the first 10% market share of near-zero emission primary steel (high cost-gap assumption)
- Increase in cost using a carbon price at \$200/tCO₂ or subsidy-and-recharge at 100% clean steel market share (high-cost gap assumption)
- Increase in cost using a subsidy-and-recharge policy for the first 10% market share of near-zero emission primary steel (low cost-gap assumption)
- Increase in cost using a carbon price at \$100/tCO₂ or subsidy-and-recharge at 100% clean steel market share (low-cost gap assumption)

Approaches to a subsidy-and-recharge policy will vary by country context

In practice, there are many possible ways to finance the deployment of near-zero emission steel plants, overcoming the cost difference compared with conventional production. The most appropriate method to use is likely to depend on the political economy of each country. A recharge of clean steel subsidies to the steel industry itself may be less

appropriate if the majority of production is for export (and so exempt from the recharge), and would not be an option in a country aiming to develop a steel industry for the first time.

In the UK the Government's Hydrogen Production Business Model and auction approach is based on previous experience from CfDs in the power sector. The subsidies provided under the model will be funded by a levy on gas to be paid by gas shippers who buy gas from producers, trade gas on

wholesale markets, and sell it on to gas suppliers.¹⁴⁷

In Brazil, one potential financing avenue for industrial decarbonisation is the use of oil and gas royalties. These royalties, which currently represent a significant share of fiscal revenues in oil-producing states and municipalities, could be channelled into policies to support the deployment of industry decarbonisation technologies such as CCS, H₂-DRI, or the use of sustainable charcoal.

¹⁴⁷ Department for Energy Security and Net Zero (2025). Funding mechanism for the Hydrogen Production Business Model.



India's experience with the Clean Energy Cess, however, shows both the potential and difficulties of attempts to link specific taxes with specific clean energy uses. Introduced in 2010, the 'cess' levied a duty on coal, lignite, and peat as a means to price emissions at their source and fund clean energy initiatives and research via the National Clean Energy and Environment Fund (NCEEF). However, official data reveals a gap between the revenue collected and its use. Between 2010 and 2018, of the \$7.5bn collected, only \$3.4bn was transferred to the NCEEF, and just \$1.8bn was ultimately used for approved projects.¹⁴⁸ The cess was eventually abolished in place of other taxes. While the experience of the cess demonstrated how pricing fossil fuels could raise significant resources for the energy transition, it also revealed the vulnerability of earmarked funds to diversion under fiscal pressure. The key lesson is that future carbon taxes earmarked for specific use should be backed by credible governance and safeguards on revenue use.¹⁴⁹

A broader set of policies can further reduce the costs and difficulty of the transition

While our focus in this section is on the core policies that could close the cost gap between conventional and near-zero emission steel, a wider range of policy levers can be used to further reduce the costs and difficulty of the transition. Policies that encourage circularity and efficiency in

material use, such as lifecycle emissions regulations in downstream sectors, can reduce the overall need for steel production capacity, easing the burden on electricity systems. Policies that increase the availability of scrap steel, for example by requiring products to be designed so as to be more easily disassembled at end of life, can help to maximise the use of secondary steel, reducing the need for primary steel to the extent that these are substitutable. Reducing the share of primary steel in the market reduces the overall costs of decarbonising the sector.

Policies in other sectors will also influence the steel transition. Power sector policies will affect the availability and cost of electricity used in both primary and secondary steel production. Measures to increase the use of green hydrogen in sectors such as fertilisers, methanol and refining could contribute significantly to bringing down the cost of electrolyzers, reducing the cost of hydrogen-based steelmaking.¹⁵⁰

Options for managing the competitiveness risks of the transition

If the ultimate costs of steel decarbonisation can be managed, then it is the competitiveness effects that are overwhelmingly important.

These depend mainly on who is the first payer of the additional costs of clean steel production (with the options being as illustrated in **Figure 9**).

Generally, competitiveness risks are low or zero when the government is the first payer of the additional costs. Subsidies for near-zero emission steel production, if set at a level that achieves cost-parity with high emission production, create no competitive disadvantage domestically or internationally, since they impose no additional costs on industry. Public procurement of near-zero emissions steel does not create any competitive disadvantage for steel producers either.

When the steel industry is the first payer of additional costs, there is a high risk of the industry being put at a disadvantage in international trade compared with competitors not subject to such policies, unless effective defences are established. Carbon pricing and regulatory policies (clean steel mandates, carbon intensity regulations, and blast furnace capacity caps) fall into this category.

When downstream businesses voluntarily procure clean steel at higher cost, they may also face competitiveness risks. Equally, they may be motivated by a perception of competitive advantage flowing from the ability to sell a product containing clean steel to a niche market where this is valued by consumers.

¹⁴⁸ Shekhar, Swapnil, Bhagirath Behera, Narayan Sethi. 2023. Decarbonizing energy system in India: a critical assessment of the performance of national clean energy and environment fund (NCEEF). Eindhoven University of Technology, IIT Kharagpur, NIT Rourkela, Asian Development Bank. [Link](#). ¹⁴⁹ Contribution by Elango, S. Council of Environment, Energy and Water. ¹⁵⁰ Meldrum, M. et al. (2023). *The Breakthrough Effect: how tipping points can accelerate net zero*. Systemiq.



Unlike a carbon border adjustment mechanism, a subsidy-and-recharge policy avoids creating risks to industrial competitiveness.

In the subsection that follows, we consider three different approaches to managing competitiveness risks while also avoiding the need for public spending. These are:

1

Carbon pricing with a carbon border adjustment mechanism

2

Subsidy-and-recharge

3

A Clean Industry Contribution together with carbon contracts for difference

Other approaches are possible in principle. Regulatory policies could be applied to imports as well as to domestic production, or accompanied by a CBAM. Carbon pricing could be applied together with a rebate, as the mirror image of the subsidy-and-recharge policy.¹⁵¹ However, these options could face large practical difficulties in the early stages of the transition. To keep the comparison reasonably simple, they are not discussed further here.

Throughout this section, we only consider changes in industrial competitiveness that result from policies for the transition, and how these can be managed. In Section 4 we consider how the transition could fundamentally change countries' comparative advantage, and the implications this could have for policy.

¹⁵¹ A 'rebate' in this sense would mean all the revenue from carbon pricing being returned to steel producers, distributed equally (per tonne of steel) across all production from all technologies. This would maintain the cost difference between high and low emission steel created by the carbon price, while avoiding a net financial flow out of the sector.

Option 1: Carbon pricing with a carbon border adjustment mechanism

The competitiveness risks of carbon pricing can be moderated to some extent by a CBAM. A CBAM applies a carbon price to imported steel at a level reflecting the difference between the carbon price in the importing country and any carbon price paid by the steel producer in the steel's country of origin.

Even with a CBAM, the competitiveness risks of carbon pricing are likely to remain significant.

There are three main risks:¹⁵²

- **Export competitiveness:** WTO rules do not allow the costs of carbon pricing to be refunded to steel exporters, and this leaves them at a disadvantage in foreign markets. In addition, unsubsidised clean steel would be produced at high cost, making it uncompetitive in foreign markets.
- **Resource shuffling:** Steel companies in other countries can sell their lowest emission steel to the country with the carbon price and CBAM, undercutting its high emission domestic producers, while selling their own high emission steel elsewhere.¹⁵³ This can include imported steel produced through the EAF-scrap route (as used for 20% of current global production) undercutting domestic BF-BOF production, to the extent that these compete in the same market segments.¹⁵⁴
- **Downstream industries:** Industries that use steel in their products face significantly higher costs, whether they buy steel domestically or import it. This puts them at a competitive disadvantage in both domestic and foreign markets.¹⁵⁵

Together, these factors mean that the risk to international competitiveness from the policy combination of carbon pricing and a CBAM remains high. This is increasingly a source of concern within the EU.¹⁵⁶

To mitigate these concerns, the European Commission is working on a package of proposals that aims to address the competitiveness risks that the CBAM currently fails to manage. This includes proposing a solution later this year to address the risks of carbon leakage for goods produced in the EU for export,^{157, 158} an anti-circumvention strategy to manage the risks of resource shuffling,¹⁵⁹ and extending the CBAM to downstream products (on which the EU is currently consulting).¹⁶⁰ Whether these policies will be effective remains to be seen, but they are likely to increase the technical complexity of applying the CBAM for the EU and for other countries.



The 'Clean Industry Contribution' offers a way to combine an emissions trading system with clean steel subsidies, enabling the deployment of near-zero emission primary steel.

¹⁵² Identified in Neuhoﬀ, K et al. (2025). *Industrial Decarbonisation in a Fragmented World: An Effective Carbon Price with a 'climate Contribution'*. ¹⁵³ See discussion at the end of Section 1. ¹⁵⁴ Gerardin, M. & Ferriere, S. (2025). *Decarbonising steel and other base metals: let's send the right signals*. ¹⁵⁵ Neuhoﬀ, K. et al. (2025). *Industrial Decarbonisation in a Fragmented World: An Effective Carbon Price with a 'climate Contribution'*. ¹⁵⁶ See for example the comments of Lakshmi Mittal, Executive Chairman of ArcelorMittal, December 2024. ¹⁵⁷ European Commission (2025). *A European Steel and Metals Action Plan*. ¹⁵⁸ Euractive (2025) *Brussels to propose CBAM export support this year as old red lines fall*. ¹⁵⁹ European Commission (2025). *A European Steel and Metals Action Plan*. ¹⁶⁰ Directorate-General for Taxation and Customs Union (n.d.) *CBAM: Public consultation on the extension of CBAM to downstream products*.

Option 2: Clean steel subsidies with a recharge

The subsidy-and-recharge policy avoids all three of the competitiveness risks described above.

- **Export competitiveness:** Any exported steel is exempt from the recharge. This is allowed by WTO rules, because the recharge functions as an excise charge, similar to VAT.¹⁶¹ This means that the recharge has no adverse effect on the competitiveness of steel exporters in foreign markets. With this policy, any near-zero emission primary steel subsidised to achieve cost-parity with BF-BOF production could also be competitive in foreign markets.
- **Resource shuffling:** The recharge applies to all domestically produced and imported steel equally, regardless of the technology used in its production. This removes any opportunity for resource shuffling, so that there is no negative effect on international competitiveness within the domestic steel market.
- **Downstream industries:** The recharge is applied to the steel embedded in any imported products, and the exemption applies to steel embedded in any products that are exported. This avoids any competitiveness risk to downstream industries, whether in the domestic market or in export markets. The administration of this aspect of the subsidy-and-recharge policy is not unduly complex, because it only requires knowledge of the quantity of steel contained in any product. (In contrast, an attempt to apply a CBAM comprehensively to all steel-containing products would require measurement and tracking of the emissions embedded in each steel component of each product, which could be prohibitively difficult.)

A risk of a different kind is that in countries with high renewable energy costs, any subsidy-based policy could preserve a steel industry with relatively high costs instead of letting it be replaced by structurally lower-cost imports from countries with better natural resources. While this is unlikely to affect downstream domestic manufacturers in the short-term, in the long-term it could create competitive pressures. This is discussed further in Section 4.

¹⁶¹ As explained in Neuhoﬀ, K. et al. (2025). ¹⁶² Neuhoﬀ, K et al. (2025). The proposal applies to all energy-intensive industries, and has been developed for the EU. Here we describe it more specifically in its application to steel, and more generally in terms of its potential application by any country.

Option 3: The Clean Industry Contribution proposal developed by Neuhoﬀ et al.

Some of the world's largest steel-producing countries and regions either already have or are developing emissions trading schemes. These include the EU, China, India, Brazil, and South Korea. The political capital and administrative effort invested in creating these policies makes them difficult to abandon even if alternative policy approaches appear preferable. The 'Clean Industry Contribution' offers a way to combine an emissions trading system (ETS) with clean steel subsidies, enabling the deployment of near-zero emission primary steel technologies and managing risks to international competitiveness.¹⁶²

How it works:

- Under the Clean Industry Contribution, a country's ETS continues to provide a carbon price, applied to production of steel and other materials. The continued free allocation of emissions permits to conventional installations would avoid significant international cost differences. This would be conditioned (as is already practice now in the EU ETS) on companies' development and implementation of transition plans towards climate neutral production.
- The Clean Industry Contribution is an additional flat charge levied at an equal rate per tonne on all steel domestically produced or imported. Its rate would match the value of free allowances granted to producers with conventional production processes, and is calculated by multiplying a product-specific emissions intensity benchmark by the carbon price and by the share of free allowances.
- Revenues from the clean industry contribution are then used to fund CCfDs, in which steel producers would be rewarded for emissions saved relative to the benchmark rate of conventional production at the difference between the actual (effective) carbon price and the contracted carbon price. The price for carbon contracts should in principle emerge in competitive tenders and thus reflect the incremental costs of near-zero emission primary steel production. The CCfD policy would provide a credible regulatory framework for investments in and operation of near-zero emission primary steel production.

An important advantage of this approach is that while the carbon pricing framework is preserved, there is no need to wait for free allowances to be gradually phased out (as the EU intends, for example, over an eight-year period), or for global conditions to change, before clean primary steel deployment can begin. CCfDs enable that to happen immediately.

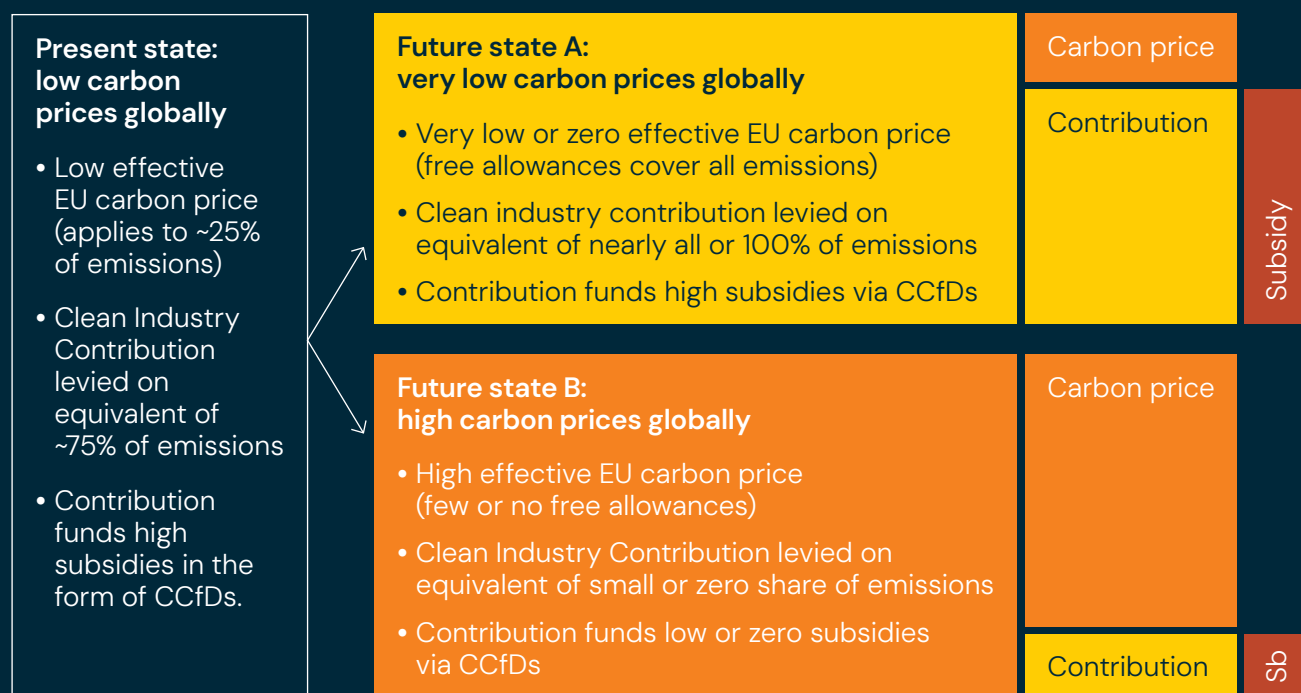
Risks of 'carbon leakage' domestically and internationally could be managed effectively, in much the same way as described above for the subsidy-and-recharge policy. Steel imports would be subject to the same charge as domestic producers, and exported steel would be exempt. This approach therefore adequately addresses carbon leakage and resource shuffling concerns while securing incentives for efficient choice and use of materials, circularity, and revenues to fund carbon contracts for difference and potentially further domestic and international climate action.

Importantly, this approach builds in flexibility over time. The Clean Industry Contribution and the subsidies given via CCfDs would vary automatically in response to policy decisions about the share of free allocations under the ETS. If carbon prices globally become high, policymakers can choose to reduce free allowances so that effective carbon prices rise, and the role of the contribution and subsidies will be minimised. On the other hand, if global carbon prices remain low, policymakers can choose to increase free allowances to limit competitiveness risks, allowing the contribution to rise, and higher subsidies to be paid via the CCfDs. **Figure 12** illustrates the resilience to uncertainty of this approach.



Figure 12:

Flexibility of the Clean Industry Contribution with CCfD policy approach in response to different global market conditions.



Note: Sb, subsidy.

A difference from the subsidy-and-recharge policy is that with the Clean Industry Contribution, policymakers must play an active role in managing competitiveness risks by varying the share of free allowances. A complication arises from the possibility that major trading partners could have different approaches to carbon pricing, while the share of free allowances can only have one value at any moment in time. For as long as some trading partners do not have any carbon pricing, the share of free allowances would need to be maintained at or close to 100%, to avoid any exposure to some unequal competition. In the long term, if the ETS has a cap that falls to a very low level, then there is a risk that eventually scarcity of supply of allowances (even if freely allocated) could result in a high carbon price or penalties, exposing steel producers to competitiveness risks. But this is a feature of the cap's function as a compliance mechanism,

and companies would have ample opportunity to avoid this risk by moving to clean steel production with the support of the CCfDs.

Comparison of the options

A comparison of the three options is presented in **Table 4**. In summary, a carbon price exposes steel producers and downstream industries to competitiveness risks at home and abroad. A CBAM offers only partial protection; substantial risks remain. A subsidy-and-recharge policy avoids creating any competitiveness risk to steel producers or downstream industries. A Clean Industry Contribution with CCfDs can largely avoid competitiveness risks, if managed well. In the near- and medium-term future it is resilient to different global market conditions. In the long-term future, if it is used together with an ETS with a stringent emissions cap, competitiveness risks could increase in a scenario where carbon prices remain low globally.



Table 4:

Risks to international competitiveness created by transition policies.

Risks to international competitiveness

Policy	Steel, domestic market	Steel, foreign markets	Downstream industries
Carbon pricing with CBAM	Medium–high. Resource shuffling: low emission imports undercut domestic production.	High. No export rebate for high emission steel. Clean steel higher cost.	High. Large added costs undermine competitiveness in domestic and foreign markets.
Clean steel subsidy with recharge	None. Recharge applies to all imports.	None. Exports are exempt from recharge. Subsidies make clean steel competitive.	None. Steel in imported products is subject to recharge, steel in exported products is exempt.
Clean Industry Contribution with CCfDs	None, if effectively managed.	None, if effectively managed.	None, if effectively managed.

International influence

A final consideration is the extent to which unilateral policies influence the wider global steel sector transition. Governments may adopt such policies not only with a view to decarbonising their own steel industries, but also with an intention to exert influence internationally, accelerating the global transition to clean steel so as to increase the chances of meeting global goals for avoiding dangerous climate change.

Here we briefly compare the potential international influence of the three policy approaches outlined above for advancing the transition while managing competitiveness risks.



A strong carbon pricing policy in a large and relatively wealthy economy such as the EU may incentivise the use of scrap relative to primary production, and draw in scrap steel from elsewhere.



Option 1: Carbon pricing with a CBAM

A CBAM exerts international influence by regulating market access. If the country or region using a CBAM is a large consumer and importer of steel, such as the EU, steel producers in other countries may be incentivised to reduce their emissions so as to be more competitive when selling to this market. Equally, governments of other steel-producing countries may be incentivised to introduce their own carbon pricing systems in order to retain more tax revenues rather than allow them to be collected by the EU on export.

There are three main limitations affecting the likely international influence of a CBAM:

- **Resource shuffling:**
As indicated above, steel producers in other countries may be able to sell their lowest emission steel to the country with the CBAM, while continuing to sell high emission steel in their domestic market or to other countries. In this case, they may experience no incentive to reduce their emissions.
- **Free allowances:**
Because the CBAM provides incomplete protection against competitiveness

risks, the government implementing it may find itself compelled by political pressures to continue issuing free allowances in its ETS indefinitely. In this case, the effective carbon price remains low, so the CBAM also remains low and creates only a weak incentive for any emissions reduction.

- **A focus on secondary steel:** For the reasons outlined in the first part of this section, carbon pricing when used alone is likely to prompt a shift from BF-BOF to scrap-EAF production, but unlikely to enable the deployment of near-zero emission primary steel production. If this is true for carbon pricing used domestically, it must be even more true in relation to a CBAM's international effect. For example, the top three source regions of steel imported into the EU are Asian countries other than China and Japan (15.3 Mt), European countries other than the EU27 (11.0 Mt), and Russia, other Commonwealth of Independent States, and Ukraine (6.6 Mt). Exports to the EU as a fraction of each of those regions' total steel production are 17%, 24%, and 8% respectively. While steel producers in the EU cannot escape the carbon price,

steel companies in those regions can sell elsewhere. They also face risks if they do move early to adopt high-cost primary clean steel technologies without policy support in their domestic markets.

A further complication arises from the limited availability of scrap steel, compared with potential demand. A strong carbon pricing policy in a large and relatively wealthy economy such as the EU may incentivise the use of scrap relative to primary production, and draw in scrap steel from elsewhere, pushing up the price of scrap or reducing its availability in other countries. This could make the task of steel decarbonisation more difficult for some developing countries.

The use of steel recycling needs to increase globally as part of the steel sector's transition, but a better way to achieve this could be through more widespread use of product design and end-of-life regulations that increase the supply of scrap on the global market. This will tend to reduce its price, making secondary steel more competitive against BF-BOF and more easily adopted as a decarbonisation option.



Steel producers in other countries can sell their lowest emission steel to the country with the CBAM, while selling high emission steel elsewhere.

Option 2: Clean steel subsidies with a recharge

The subsidy-and-recharge policy does not regulate market access and creates no direct economic incentive for any steel producer in other country to reduce their emissions. This is a limitation. Despite this, it could exert influence internationally in a different way.

As outlined near the start of this section, targeted subsidies are the policy most likely to be effective in deploying primary near-zero emission steel technologies. Successful deployment can create the expectations of further such deployment. In transitions generally, the more a new technology is deployed, the more industry perceptions shift from concern about first-mover risk to concern about late-mover risk. Steel companies seeing this policy approach being successfully implemented in another country may lobby for it to be adopted in their own. If adoption of the policy spreads, so could deployment of clean primary steel technologies.

Steel industry stakeholders in Japan suggest that some effects of this kind are already being experienced. According to two steel company representatives interviewed by IGES for this report, the tax credits (operating subsidies) for low emission steel introduced in Japan in early 2024 were significantly influenced by the clean technology subsidies of the US Inflation Reduction Act (2022), as well as by the increasing use of clean steel subsidies in the EU. In addition, Japan's price-difference support scheme for low emission hydrogen production (enacted in October 2024) is said to have been modelled on the contracts for difference in the UK's Hydrogen Production Business Model (announced in 2022).

Option 3: The Clean Industry Contribution with CCfDs

As a hybrid approach, the Clean Industry Contribution shares some of the characteristics of each of the other two approaches. It shares the subsidy-and-recharge policy's potential to enable deployment of near-

zero emission primary steel technologies and create the perception in other countries' steel industries of late-mover risk. It shares the CBAM's potential to exert influence by regulating market access, which could encourage investments in steel recycling instead of new blast furnaces. In this sense, it could be considered to have the best of both worlds.

Importantly, the flexibility of this approach means that it does not share the Option 1 (carbon pricing and CBAM) risk of simply failing as a policy (free allowances being extended indefinitely in response to global market conditions, with neither carbon pricing nor subsidy in place to motivate change), with the potential for negative international effects on industry expectations about the transition. Instead, by enabling decarbonisation without exposure to competitiveness risks, it strengthens a government's position to enter into international negotiations on coordinated carbon pricing or other approaches to advancing the global steel sector transition.



In transitions generally, the more a new technology is deployed, the more industry perceptions shift from concern about first-mover risk to concern about late-mover risk.

The role of bilateral trade partnerships

4

Bilateral trade partnerships offer a significant opportunity to advance the steel sector transition, adding to the momentum generated by countries' unilateral actions.

In this section, we argue that green iron trade could offer a mutually beneficial pathway for exporters with abundant renewable energy and high-quality iron ore, and for importers seeking to decarbonise steelmaking at lower cost and with greater long-term competitiveness. It could enable faster deployment of near-zero

emission steel production, taking advantage of a technology-driven reshaping of global supply chains and industrial competition. Moreover, it could improve the chances that future demand for steel in emerging and developing economies is met by clean, rather than emissions-intensive, production technologies.

Acknowledgements: This section was drafted with significant consultation and input from Hilton Trollip.

Key messages

- New production routes appear likely to reshape global steelmaking. The rise of hydrogen–direct reduced iron (H₂–DRI) promises to break the traditional link between ironmaking and steelmaking, opening up new supply chain configurations.
- Green iron trade could have benefits for both exporter and importer countries. Exporter countries with abundant renewables and high-quality ore can move up the value chain by producing green iron rather than exporting raw ore. The implications for importers are more balanced, but could include the opportunity to reduce near-zero emission primary steel production costs by around 15%, improving long-term competitiveness while easing pressure on electricity grids.
- Bilateral green iron trade agreements could accelerate the global steel transition by supporting deployment of new technologies in the locations where they are most competitive, increasing industry's confidence to invest. Developments of this kind could also improve the chances that future demand for steel from developing and emerging economies is met through clean steel production.
- Agreements that balance risks and opportunities for importers and exporters will be needed. Importers are likely to face political challenges around job relocation, while exporters may need capital, concessional finance, and technical partnerships to get early projects off the ground.
- Policy support will be critical early in the transition, and subsidies are likely to be necessary to cover the cost premium for near-zero emission iron. One possible option for importing countries is to allow a portion of near-zero emission steel supported by subsidies such as carbon contracts for difference (CCfDs) to use imported zero emission iron, while the majority is used to support domestic production. Prices could be minimised through competitive global tenders.



Countries with high renewable energy costs face a choice: retain costly domestic ironmaking with long-term competitiveness risks, or import green iron more cheaply as an input to domestic steelmaking.

The decoupling of iron and steel production

Traditionally, iron and steelmaking have been integrated in production routes such as blast furnace–basic oxygen furnaces (BF–BOFs). In this process, iron must be transferred from the blast furnace to the basic oxygen furnace in liquid form, to avoid heat losses.

The emergence and increasing use of electric arc furnaces (EAFs), combined with a growing rise in DRI processes and hydrogen technologies, has opened new routes of production. EAFs can be charged with cold iron inputs (recycled steel, sponge iron, or hot briquetted iron, HBI). This provides the opportunity to produce iron in a different location from the steelmaking process. The growth of both types of technology, combined with the imperative to decarbonise means that potential new supply chains to feed steelmaking plants are emerging.

In this context, countries with abundant renewable energy resources and high-quality iron ore resources, such as Australia, Brazil, and South Africa, amongst others, have a significant advantage for near-zero emission ironmaking. Cheaper clean energy inputs mean cheaper hydrogen production for H₂–DRI. Rather than exporting iron ore, these countries could process direct reduced iron into HBI which can be transported in the form of dense, stable blocks (called briquettes) to be used in BOF or EAFs for steelmaking around the world.

Prospective green iron exporters eye major opportunities

For countries with abundant renewables and high-quality iron ore, exporting green iron (in the form of HBI) instead of iron ore offers an opportunity to move up the value chain, creating more jobs and increasing export revenues.¹⁶³

The countries with the highest iron ore in reserves (although

the iron quality varies) include Australia (25,000 Mt), Brazil (15,000 Mt), Russia (14,000 Mt) and China (9,000 Mt).¹⁶⁴ Those that exported the most iron ore in 2023 were Australia (899 Mt), Brazil (408 Mt), South Africa (59 Mt), Canada (58 Mt), and India (44 Mt).¹⁶⁵

Over recent years, research has identified that several of these countries are likely to have comparative advantages in producing and exporting green iron produced via H₂–DRI. This is because of their superior solar energy resources, with supplementary onshore wind, combined with their high-quality iron ore. Other factors also play a role, such as low wages and access to other forms of clean power such as hydropower. **Figure 13** shows projections for the levelised cost of green hydrogen-based steel in various countries in 2030, 2040, and 2050.¹⁶⁶



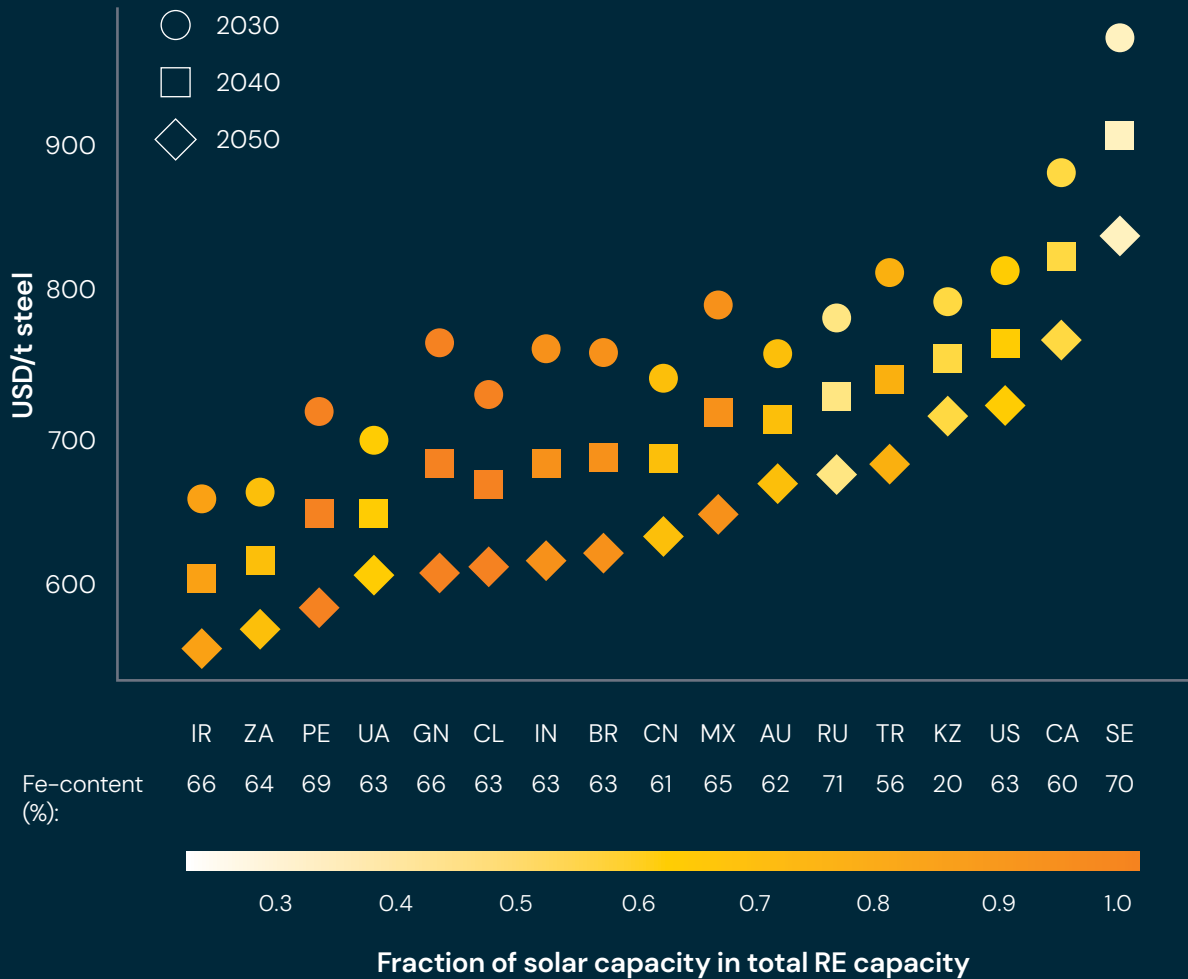
In South Africa, one megatonne of green primary iron production per annum could replace the export value of 7 Mt of coal, amounting to \$300–500 million annually.

¹⁶³ A Bilici, I., Bataille, C., Neuhoﬀ, K., Sartor, O., & Waisman, H. (2024). *Global trade of green iron as a game changer for a near-zero global steel industry? – A scenario-based assessment*. *Energy and Climate Change* 5: 100161. ¹⁶⁴ 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(1): 2578. ¹⁶⁵ World Steel (2025). *World Steel in Figures*. ¹⁶⁶ 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(1): 2578.



Figure 13:

The levelised cost of green hydrogen-based steel in countries in 2030, 2040, and 2050.



Note: RE, renewable energy. IR, Iran. ZA, South Africa. PE, Peru. UA, Ukraine. GN, Guinea. CL, Chile. IN, India. BR, Brazil. CN, China. MX, Mexico. AU, Australia. RU, Russia. TR, Turkey. KZ, Kazakhstan. US, United States. CA, Canada. SE, Sweden. Source: 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(1): 2578. License: CC BY 4.0. Adapted by authors.

The benefits to individual countries of exporting green iron, rather than iron ore, are increasingly well documented. For example:

- **South Africa:** South Africa's steel sector, which accounted for 12.5% of exports and 50,000 jobs in 2019, could be revitalised through green iron production, which could also bolster export and tax revenues and support the transition towards cleaner industry. One megatonne of green primary iron production per annum could replace the export value of 7 Mt of coal, amounting to \$300–500 million annually, mitigating losses from declining fossil fuel trade. Green iron exports would also support local manufacturing of solar photovoltaics (PV) and hydrogen technology by creating greater local demand, enlarging the renewable energy value chain and enhancing national energy security.¹⁶⁷

- **Brazil:** Brazil could boost domestic employment by producing and exporting green iron instead of raw iron ore, given its high renewable energy capacity and some of the world's best iron ore. Estimates suggest producing 15 Mt green iron domestically could create over 53,000 jobs in direct iron production and related industries (solar, wind and electrolyzers). Compared with exporting raw iron ore and green hydrogen, this approach is estimated to result in over \$30bn per year in value added, driven by the additional industrial processes retained within the country.¹⁶⁸

- **Australia:** Australia faces a structural imperative to diversify away from emissions-intensive fossil fuel exports. In 2023, iron ore and metallurgical coal exports were worth \$124 billion and \$62 billion AUD respectively. In this context, green iron presents a compelling alternative, with Australia's green iron export potential lying between

\$96 billion and \$295 AUD billion annually.¹⁶⁹ Investment in clean technology industrial capacity, including hydrogen-based iron production, could support up to 240,000 additional jobs.¹⁷⁰ Australia is well positioned to become a cost-effective exporter of green iron in the Asia-Pacific region, given shorter shipping distances to Japan, South Korea, and China.¹⁷¹

The opportunities for green iron exports extend beyond countries with the largest iron ore reserves. Studies have also explored the opportunities for exporting in other countries. Canada, Chile, the US, Sweden, Mauritania, Mexico, Namibia, and Peru are highlighted as potential beneficiaries despite, in some cases, less solar potential.¹⁷² In Canada, for example, the presence of abundant clean electricity from hydropower in Québec and Ontario makes H₂-DRI an economically attractive decarbonisation route, supported by existing transmission and industrial assets.¹⁷³

South Africa

One megatonne of green primary iron production per annum could replace the export value of 7 Mt of coal, amounting to

\$300–500 million

annually.

Australia

Investment in clean technology industrial capacity, including hydrogen-based iron production, could support up to

240,000

additional jobs.

Brazil

Estimates suggest producing 15 Mt green iron domestically could create over

53,000

jobs in direct iron production and related industries.

¹⁶⁷ Trollip, H., McCall, B., & Bataille, C. (2022). *How green primary iron production in South Africa could help global decarbonization*. *Energy Strategy Reviews* 43: 100943.

¹⁶⁸ Agora Industry (2025). *The role of green iron in accelerating steel transformation*. ¹⁶⁹ Deloitte and WWF–Australia (2025). *Forging Futures: Changing the nature of iron and steel production*. ¹⁷⁰ Australian Government (n.d.). *The Clean Energy Generation*. ¹⁷¹ Deloitte and WWF–Australia (2025). *Forging Futures: Changing the nature of iron and steel production*.

¹⁷² Rocky Mountain Institute (RMI) (2024). *Green iron corridors: building the green iron market to accelerate industrial decarbonization*. ¹⁷³ Algers, J. & Bataille, C. (2025). *Strategic decarbonisation of the Canadian iron and steel industry: a worker-centred path to cut emissions, increase value added and strengthen global supply chains*. IMES/EESS Report series.

Green iron trade also presents opportunities for importer countries

For steel-producing countries with less abundant renewable energy potential, the interests are more finely balanced. There may be a natural desire to retain industrial capacity in all elements of iron and steelmaking, and the jobs associated with them. But there are reasons for the option of importing green iron – instead of raw iron ore – to be considered seriously.

Reducing costs and improving competitiveness: maintaining jobs over the long term

In countries with relatively high renewable energy costs, importing green iron rather than producing it domestically through the H₂-DRI process could bring significant cost reductions of up to 32% for DRI, improving the competitiveness of near-zero emission steel production (see **Figure 14**). Estimates of the reduction in steel production costs that is achievable in this way range from 13 to 15% in Germany (and much of Central and Western Europe), South Korea, and Japan.¹⁷⁴ This stems primarily from the lower cost of renewable energy in green iron exporter countries such as those mentioned above, where hydrogen can be produced more cheaply.

The cost of this approach would be the reduction of ironmaking jobs in importing countries (while they increase in other countries). This would undoubtedly be politically difficult for importers, as jobs

in iron and steel production facilities are often geographically concentrated, and strongly integrated with regional identities and employment patterns formed over decades of industrialisation. However, these shifts in employment are predicted to occur in any case in many developed economies due to labour productivity improvements and increases in the use of less labour-intensive recycled steel, as well as plateauing global demand.¹⁷⁵

This short-term cost must be considered against a longer-term risk. Steelmakers that rely on higher-cost domestic iron production could become increasingly exposed to competitiveness risks as global value chains are reorganised. Steelmaking, rather than ironmaking, involves hundreds of specialised grades requiring customer proximity and deep expertise, and is where most of the value is added and where employment resides. Around 70–95% of jobs in the steel sector are concentrated in manufacturing that is downstream of iron production.¹⁷⁶ The effect of green iron imports could be a net positive for employment if these jobs are preserved, compared with a scenario in which policymakers and companies fail to respond to the industry's transformation. Nonetheless, some importer countries fear that steelmaking processes may follow ironmaking, in any international relocation.

The reconfiguration of trade flows arising from the shift in comparative advantage could be significant. One study finds that in a scenario where countries focus on minimising their steel production costs, up to a fifth of

global crude steel could be produced using traded green iron in its supply chain by 2050. China, India, the EU, Japan, and Korea could be among the largest importers of green iron (see **Figure 15**).¹⁷⁷

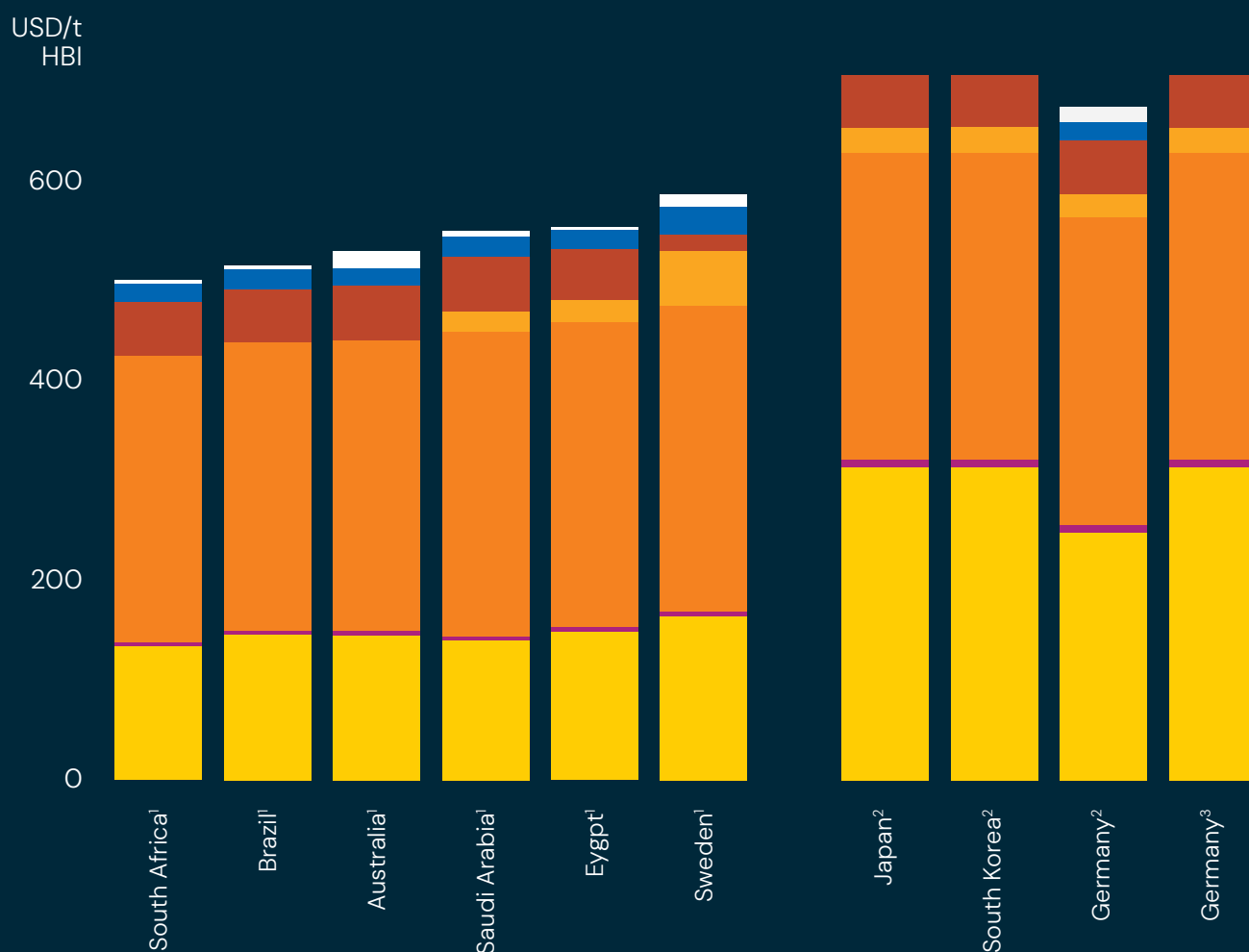
Even if China produces most of its green iron domestically and imports only a small fraction, the huge size of its steel industry (accounting for roughly half of global production) means that it could still be among the largest importers. Some Chinese companies may already be exploring this opportunity. In January 2025, Australian mining firm Fortescue announced it had signed a memorandum of understanding with Baowu Steel to accelerate the development of green iron technology to meet demand in China and globally.¹⁷⁸ In March 2025, HBIS signed a memorandum of understanding with Brazilian mining giant Vale to collaborate on low-carbon steelmaking, including hydrogen metallurgy, carbon capture, and the use of Tecored furnaces, as part of their shared goal of achieving carbon neutrality by 2050.^{179, 180}

Building on this trend of cross-border partnerships, UK-based Liberty Steel also signed a memorandum of understanding with Abu Dhabi's AD Ports Group in 2025 to explore establishing a green iron production facility in the Khalifa Economic Zones (KEZAD), supported by new port infrastructure for exports.¹⁸¹ Likewise, in 2024, Ferrexpo, an iron ore pellet producer headquartered in the UK with operations in Ukraine, reached an agreement with German steelmaker Salzgitter to supply low-carbon iron ore pellets for green steel production in Germany.¹⁸²

¹⁷⁴ Agora Industry (2025). *The role of green iron in accelerating steel transformation*. ¹⁷⁵ Bataille, C. et al. (2025). *Meeting climate targets will lead to major steel production technology shifts and preserve jobs*. Available at SSRN 5278075. ¹⁷⁶ Rocky Mountain Institute (RMI) (2024). *Green iron corridors: Building the green iron market to accelerate industrial decarbonization*. ¹⁷⁷ Bilici, I., Bataille, C., Neuhoﬀ, K., Sartor, O., & Waisman, H. (2024). *Global trade of green iron as a game changer for a near-zero global steel industry: a scenario-based assessment*. ¹⁷⁸ Steel Radar (2025). *Fortescue establishes green iron partnership with China Baowu Steel*. ¹⁷⁹ Reuters (2025, March 20). *China's HBIS collaborates with Vale to advance steel decarbonisation*. ¹⁸⁰ Mining Technology (2025, March 21). *HBIS Group partners with Vale to advance steel decarbonisation*. ¹⁸¹ Liberty Steel and AD Ports Group (2023, December 11). *LIBERTY Steel signs MoU with AD Ports Group to explore plans to host a green iron production facility in KEZAD*. GFG Alliance. ¹⁸² Ferrexpo and Salzgitter (2024, May 24). *Ferrexpo and Salzgitter to further green steel co-operation via supply of high-quality DR pellets under SALCOS programme*. Salzgitter AG.



Figure 14:
Cost of HBI production in 2040 by country
(medium cost, derisked scenario).



Agora Industry (2025)

1 Solar PV/onshore wind-driven hydrogen production

2 Grid-based electricity procurement

3 Hydrogen imports via pipeline from European and neighbouring countries



Source: Agora Industry (2025). The role of green iron in accelerating steel transformation.
Licence: CC BY-NC-SA 4.0. Adapted by authors.



Figure 15:

Green iron trade balance in major countries and regions in two future scenarios.



Notes: In the Max Trade scenario, countries prioritise minimising the costs of steel production and take advantage of opportunities to reduce costs by importing green iron as soon as possible. In the Intermediate Trade scenario, the EU, Japan and South Korea pursue the same strategy as in Max Trade, but China, India, the USA, and other countries focus on expanding their domestic capacity for green iron production for reasons of self-sufficiency and strategic independence. Source: Bilici, I. et al (2024). *Global trade of green iron as a game changer for a near-zero global steel industry: a scenario-based assessment*. License: CC BY 4.0. Adapted by authors.

Energy security and supply chain resilience

Importing green iron could also have benefits for energy security and supply chain resilience. The extent of green iron production required to fully replace existing conventional iron production in some regions could be difficult, given the huge scale of new clean electricity generation capacity that would be needed. For example, the REPowerEU Strategy of 2022 set out the aim of producing 10 million tonnes of hydrogen and importing 10 million tonnes by 2030. The need to import hydrogen suggests that officials already recognise domestic production will be insufficient.¹⁸³ The EU estimates that 500 TWh of renewable electricity is needed to meet the domestic 10 million tonnes production target.¹⁸⁴ In 2023, 45% of the EU's electricity was made up of renewables, generating 1,200 TWh.¹⁸⁵ This suggests that an additional 40% renewable energy capacity would be needed, showing the scale of the challenge. A report by the European Court of Auditors assessed that this target is unrealistic and suggested that a 'reality check' and strategic choices on the way ahead are needed.¹⁸⁶

Importing green iron could reduce electricity requirements for steelmaking by up to 60%, reducing pressure on electricity grids and freeing up renewable power for other uses.¹⁸⁷ Restructuring half of primary steelmaking across ten priority importers (as identified

by RMI) to use green iron could avoid the need for around 20–50 GW of additional renewable power capacity.¹⁸⁸ This could be valuable in countries where the expansion of electricity grids is constrained by land availability or other factors.

Green iron trade can also support the diversification of clean steel input sources, improving resilience to global supply shocks. While governments have faced pressure around the risks of losing their primary steelmaking capacity in entirety, a combination of some primary production from imported iron ore, scrap recycling, and imported green iron would diversify inputs into the steelmaking process.

Strategic choices must be faced by countries with high renewable energy costs. Yet between the alternative strategies of seeking to preserve all ironmaking jobs, and allowing them to be entirely replaced by imports, a middle way is possible. At this early stage of the transition, countries can choose to support some domestic near-zero emission ironmaking, while also enabling the import of lower-cost green iron to contribute to overall competitiveness and supply chain resilience.

A shared opportunity to accelerate the global transition

While all countries are likely to prioritise their national political and economic interests in their steel transition strategies, the

effect on the global transition is also worth considering.

There are several ways in which bilateral green iron partnerships could help to accelerate the global transition to clean steel. Perhaps most importantly, focusing effort on regions with the best natural resources and potential for the lowest-cost production could increase industry confidence in the competitiveness of the product, helping to secure decisions to invest in the first wave of near-zero emission plants. In addition, joint investment by green iron importers and exporters in hydrogen-based production could help to overcome key technological barriers to near-zero emission steel more quickly. It could also accelerate the rise of new business models and challenger firms capable of disrupting incumbent steel producers, creating fresh competitive dynamics in the global market. Added to the effect of countries' unilateral policies, as described in Section 3, this could contribute to reorienting competition in the sector away from conventional high emission production and towards clean steel technologies.

A second important consideration is that green iron partnerships could improve the chances that future demand for steel from developing and emerging economies is met through clean steel production. Future global demand growth will be driven by countries with low in-use steel stocks and greater need for steel to meet

¹⁸³ European Commission (n.d.) *Hydrogen: topic*. ¹⁸⁴ Directorate-General for Energy (2023, July 20). *Renewable hydrogen production: new rules formally adopted*. ¹⁸⁵ Eurostat (2024, June 27). *Renewables take the lead in power generation in 2023*. ¹⁸⁶ Eurostat (2024, June 27). *Renewables take the lead in power generation in 2023*. ¹⁸⁷ Bilici, I., Bataille, C., Neuhoﬀ, K., Sartor, O., & Waisman, H. (2024). *Global trade of green iron as a game changer for a near-zero global steel industry: a scenario-based assessment*. ¹⁸⁸ Rocky Mountain Institute (RMI) (2024). *Green iron corridors: building the green iron market to accelerate industrial decarbonization*.

the basic needs of the populations in their economies. To the extent that these countries are unwilling to rely solely on imports, they will be faced with a choice of whether to build new production capacity using the cheapest available technologies (e.g. BF-BOFs) or to invest in near-zero emission steel technologies. Green iron agreements and potential export markets can help to shift investment decisions in favour of clean technologies, avoiding the lock-in of high emission capacity.

Strategic partnerships will need to address practical and political challenges, to get new projects started

Although there are many upsides to exporting green iron for countries that have this opportunity, the main challenge faced is that demand for green iron, a premium product, does not yet exist. Without capital investment to set up new facilities, and subsidies or demand measures to pay the additional operating costs, these investments remain unattractive to investors in the short term, and new business models may take longer to emerge. In emerging and developing economies, additional challenges are also present. These include higher costs of finance, less established industrial ecosystems and perhaps less access to relevant intellectual property and technological know-how, and lower fiscal headroom to mobilise the finance.

For these reasons, collaboration with buyers is important to get early green iron facilities off the ground. Strategic partnerships that provide demand for near-zero emission steel (in the form of demand and/or subsidies from importer countries), concessional finance, and potentially technical assistance may be necessary.

Countries involved in green iron agreements will need to agree on a number of issues and principles. This includes not only agreeing on the volume of green iron desired and the price, but also agreeing on arrangements such as how to share the costs of any subsidies and issues of ownership. Collaborating countries may also need to agree on shared definitions of green iron, addressing questions such as whether the emissions of electricity production should be considered within scope, and if so, how they should be calculated.

The challenge of closing the cost gap

A central question will be how to share the costs of a new project. In a country with high energy costs, importing green iron could reduce the cost gap between BF-BOF and H₂-DRI-EAF steel production by nearly 50%, compared with integrated domestic iron and steel production.¹⁸⁹ But it is not expected to eliminate the cost gap. Consequently, subsidies are likely to be needed for this approach to be viable, perhaps in the form of 10- to 15-year contracts for difference. These may need to be integrated within long-term offtake agreements to make the risks acceptable to investors.

This is likely to involve political risks for governments of both countries. For importers, subsidising green iron production in other countries may be politically unpopular if it is associated with local job losses, even if this increases the chances of retaining steelmaking jobs over the longer term. For exporters, subsidies could be criticised for supporting steel production elsewhere, instead of developing or growing that capacity domestically.

Other policies could contribute to closing the cost gap and creating demand, but none of these are likely to be effective on their own:

- **Carbon pricing:** A high carbon price in the importer country could make near-zero emission steel produced with imported green iron competitive. However, this would require carbon prices to be significantly higher than they are at present in the EU, for example. A carbon price of \$220/tCO₂ is likely to be needed to eliminate the cost gap between BF-BOF and H₂-DRI in countries such as Germany, Japan, and South Korea. With imports, this could be as low as \$120/tCO₂. Some analysts estimate that level of carbon price could be reached in the early 2030s in the EU, but this is far from certain. In addition, investors would need to have confidence in carbon prices remaining high enough for the lifetime of the plant, and in the CBAM being effective. The competitiveness concerns raised in Section 3 could be a key challenge to carbon prices reaching these levels in the near term under current international conditions.

¹⁸⁹ Agora Industry (2025). Presentation to the Breakthrough Agenda Policy Network.

- **Public procurement mandates:** Demand signals in the form of public procurement mandates for near-zero emission steel could support efforts to scale green iron. However, these signals are unlikely to be sufficiently concentrated to prove the business case for investment in new facilities. These would also need to allow near-zero emission steel produced with imported green iron, rather than having local content requirements.
- **Financial and technical assistance:** It is likely that developing countries may need financial and technical assistance to develop new green iron production capacity. Concessional lending could help to reduce the costs of capital for a new plant, but would not close the gap in operating costs.

In summary, while different policies could contribute to reducing the cost premium of imported green iron, some form of long-term subsidy from either the producer or importer is likely to be needed, to enable the first green iron offtake agreements.

Allowing imported iron use in projects supported by CCfDs

A practical design for a subsidy to close the cost gap, as proposed by Hilton Trollip for this report, could be for the government in a high-energy-cost country to award CCfDs to steel producers to produce clean primary steel using verified near-zero emission inputs that can be sourced locally or internationally. The CCfD contracts would be long-term and allocated based on a competitive auction process. Steelmakers with EAF plants (or consortia of such companies) that win these contracts could then issue global tenders for HBI supply through green iron offtake agreements.

This approach could be phased in as global supply develops. A market-based mechanism for price discovery would improve competition, and maximise the cost savings to the taxpayers in importer countries compared with CCfDs that only support domestic production. At the same time, it would support the creation of green iron industries in developing countries that lack the fiscal capacity to subsidise H₂-DRI development themselves.

An important aspect of this approach is that governments could moderate the amount of

green iron that can be imported for near-zero emission steel production. By balancing the percentage allowed to be imported versus domestically produced, governments could choose the extent to which they support domestic iron producers versus foreign exporters through CCfDs. This would mitigate the risk that governments lock in less competitive H₂-DRI-EAF production in their own countries, leading to competitiveness challenges in the longer term.

Giving direction to financial and technical assistance efforts

Financial and technical assistance could form a part of bilateral green iron agreements, alongside the contractual arrangements of the costs and amount to offtake. Several examples of strong relationships between donor countries and developing countries already exist, which could provide a starting point for these arrangements. One green iron bilateral trade partnership already exists between Germany and Namibia (see case study). Existing partnerships between the UK and Brazil and other countries could in future be oriented towards matching supply and demand for green iron.



A government in a high-energy-cost country could support clean primary steel production using verified near-zero emission inputs that can be sourced locally or internationally.

Case study: Germany–Namibia Green Iron Partnership

The Namibia–Germany Green Hydrogen and ‘PtX Partnership’, established in 2022 through a Joint Communiqué of Intent, is an example of a bilateral green iron partnership. Anchored in Germany’s Federal Ministry for Economy and Energy (BMWE) and supported by the German development agency GIZ and by Namibia’s Green Hydrogen Council, it combines technical assistance, policy support, capacity-building, and finance. The partnership is part of Germany’s National Hydrogen Strategy, which aims to secure climate-neutral inputs for sectors such as steelmaking.^{190, 191, 192, 193}

Its central project is the Hylron–Oshivela facility, which

became operational in early 2025 and is Africa’s first industrial-scale green hydrogen-DRI facility. The pilot phase, which received €13.7 million from Germany’s BMWK, produces 15,000 tonnes of green sponge iron annually using a 12 MW electrolyser powered by a 20 MW solar PV system.^{194, 195} The EU and the Netherlands are providing an additional €12.0 million to support the second phase, which aims to expand to 200,000 tonnes per year by 2026 and ultimately reach 1 million tonnes per year by 2030, making Namibia an exporter of green iron.¹⁹⁶ A German steelmaker, Benteler, has already signed an offtake agreement.

This partnership is aligned with Namibia’s national strategy for green economic transformation

and its Green Hydrogen and Derivatives Strategy and the Green Industrialisation Blueprint, which aim to position Namibia as a global hub for green hydrogen and its value-added derivatives, including green ammonia and green iron.^{197, 198, 199} However, the extent to which the project is supported locally, and how far its benefits will be shared amongst the local population, are currently unclear.

For Germany, the partnership offers a potential supply of low-carbon industrial feedstocks. Germany’s 2023 Hydrogen Import Strategy prioritises bilateral supply agreements with countries like Namibia, recognising their renewable energy resources, geopolitical standing, and investment conditions.²⁰⁰



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per year by 2026
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¹⁹⁰ BMWK (Federal Ministry for Economic Affairs and Climate Action) (2024). *Pioneering collaboration on hydrogen and PtX: Germany and Namibia intensify cooperation on green hydrogen*. ¹⁹¹ Climate and Energy Partnerships (2023). *German–Namibian Hydrogen and PtX cooperation*. ¹⁹² GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) (2025). *German–Namibian green hydrogen and PtX cooperation*. ¹⁹³ BMBF (Federal Ministry of Education and Research) (2021). *Germany and Namibia launch partnership for green hydrogen*. ¹⁹⁴ Green H₂ Namibia Report (2024). *Green Hydrogen Production in Namibia: technical feasibility & value-chain analysis*. ¹⁹⁵ BMWK (Federal Ministry for Economic Affairs and Climate Action) (2024). *Pioneering collaboration on hydrogen and PtX: Germany and Namibia intensify cooperation on green hydrogen*. ¹⁹⁶ European Commission (2025). *Global Gateway: Namibia becomes a pioneer in Africa’s green transition*. ¹⁹⁷ Government of the Republic of Namibia (2024). *A blueprint for Namibia’s green industrialisation*. ¹⁹⁸ Dechema (2023). *Green H₂ Namibia – Feasibility study for Green Hydrogen in Namibia*. ¹⁹⁹ GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) (2024). *Namibia and Germany further expand cooperation on green hydrogen*. ²⁰⁰ BMWK (Federal Ministry for Economic Affairs and Climate Action) (2024). *Pioneering collaboration on hydrogen and PtX: Germany and Namibia intensify cooperation on green hydrogen*.



The Namibia–Germany
Green Hydrogen and
'PtX Partnership',
established in 2022,
is a first example
of a bilateral
green iron partnership.

The need for alignment on standards for green iron

If governments from two or more countries are using policy to support an international green iron offtake agreement, it is likely that they will need to agree on a shared definition of 'green iron'. If carbon pricing is part of the policy mix, they will also need to agree how any emissions from the iron production process will be counted.

There is currently no universally accepted definition of low emissions or near-zero emissions steel, although there is increasing alignment around the 'sliding scale' standard (see Section 5). Proposed definitions and standards vary in scope, stringency, and other details.²⁰¹ There is to our knowledge no clarity on the definition of low or near-zero emissions iron.²⁰²

The opportunity for an economic 'win-win' in an international green iron offtake agreement arises from the lower cost of renewable-powered electrolytic hydrogen production in one of the countries, enabling lower-cost iron production using H₂-DRI. Governments would therefore need to decide on what form of power supply is low-carbon enough for the end product to be considered 'green iron' and worthy of policy support.

Stringent requirements in the EU

The EU has legislated to enact stringent requirements that hydrogen and other

non-biological fuels must meet to be considered 'renewable' and eligible for policy support.²⁰³ These apply to fuels consumed in the EU, whether produced domestically or imported. The main requirements, in simplified form,²⁰⁴ are:

- If the fuel is produced using electricity then the electricity used must be renewable.²⁰⁵
- The renewable electricity generation capacity used to produce the fuel should be new, installed no more than three years before the fuel production comes into operation, without subsidy. This is known as the *additionality rule*. An exception to this requirement is made for electricity grids where renewables account for over 90% of generation, or where the emission intensity of electricity is below 18gCO₂eq/MJ.
- The production of hydrogen should take place at times and in places where renewable electricity is available ('temporal and geographic correlation').
- The use of the fuel should reduce greenhouse gas emissions by at least 70%.

The purpose of these requirements is to avoid the use of electrolytic hydrogen leading to *increased* emissions, either directly, or indirectly from its effect on the power system. The direct risk exists because producing hydrogen using fossil-based electricity can cause substantially higher emissions than producing hydrogen from natural gas using conventional processes

(often referred to as 'grey' hydrogen). The indirect risk is that the production of electrolytic hydrogen could increase overall demand for power, and new fossil-based power generation capacity could be installed or existing capacity operated more intensively to meet the additional demand, leading emissions to increase.

The EU regulation incorporates a transitional phase, with fuel plants that come into operation before the beginning of 2028 benefiting from an exemption from the additionality rule until the beginning of 2038.

Strict 100% renewable energy criteria could hold back investment in H₂-DRI production

Overly stringent standards for hydrogen production could be counterproductive in the steel transition, despite the considerations mentioned above.

Decarbonisation requires two types of action: reducing emissions today, and building the systems that deliver near-zero emissions eventually. Efficiency improvements and lower emission technologies can cut emissions in the short term, but only the deployment of near-zero emission technologies will deliver the end-goal of a net-zero economy.²⁰⁶ In the early stages of a transition, these actions differ: the rollout of solar PV in the twentieth century barely reduced emissions, but it enabled the rapid transition to clean power systems that is now taking place.

²⁰¹ European Commission (2025). *Defining low-carbon emissions steel: a comparative analysis of international initiatives and standards*. ²⁰² IEA and UN Climate Change High Level Champions (2025). *The Breakthrough Agenda Report 2025* (forthcoming). ²⁰³ European Commission (n.d.). *Renewable hydrogen: topic*. ²⁰⁴ The full details can be read in the two legislative documents: *Delegated Regulation (EU) 2023/1184 on a methodology for renewable fuels of non-biological origin* and *Delegated Regulation (EU) 2023/1185 a minimum threshold for GHG emissions savings of recycled carbon fuels*. ²⁰⁵ To be considered fully renewable, the electricity can be either generated by the fuel producer using renewables in their own facilities, bought from a renewable generator using a direct connection, or bought through renewable power purchase agreements from a supplier connected to the grid. ²⁰⁶ Lilliestam, J., Patt, A., & Bersalli, G. (2022). On the quality of emission reductions: observed effects of carbon pricing on investments, innovation, and operational shifts. A response to van den Bergh and Savin (2021). *Environmental and Resource Economics* 83(3):733–758.

Where transitions span sectors, the sequencing of action matters. Electric vehicles are a case in point: EVs have been shown to reduce emissions directly in almost all world regions.²⁰⁷ But even in the few countries that are the exceptions, if governments only deployed EVs once their electricity grids were emissions-free, this would slow the development of demand, supply chains, and infrastructure, and undermine the transition in the road transport sector. Developing EV and clean power systems together creates the conditions for a rapid and better managed transition.²⁰⁸

Hydrogen production presents a greater tension between near-term emissions reductions and long-term systems change, since hydrogen pathways are less efficient than direct electrification. But focusing too narrowly on point-in-time emissions risks delaying investment and stalling the development of technology and supply chains. The IEA cautions that overly strict criteria could slow technology and infrastructure scale-up and undermine system co-evolution with renewables, and notes that the risk of any increase in power sector emissions will decrease as the power sector decarbonises.²⁰⁹

In the steel transition, these risks could be particularly significant. If qualifying for policy support is made too difficult for hydrogen-based production, investment in this necessary technology will be

held back, with gas-DRI likely to be favoured instead in jurisdictions where policies impose pressure to reduce emissions. As we noted in Section 1, barely any near-zero emission primary steel production is yet operating globally, and over 100 Mtpa of such capacity is estimated to be needed by 2030 for a transition consistent with net zero emissions by 2050.²¹⁰ At this early stage in the transition, the urgent priority is to deploy the new technology and begin the processes of learning by doing, developing supply chains, and building investor confidence. Holding back the start of these processes to avoid point-in-time increases in emissions in the power sector – a sector that is far further ahead in the transition, with clean technologies outcompeting fossil fuels on cost and accounting for over 90% of capacity additions globally²¹¹ – risks putting the steel transition even further off-track. Meanwhile, the planned construction of over 60 Mtpa capacity of new blast furnaces risks locking more investment into high-emitting assets with long lifetimes.²¹²

Strict additionality criteria could affect the prospects of green iron trade, with impacts varying across countries

The practical effect of requiring fully renewable power to be used in H₂-DRI iron production could be to force the over-building of solar and wind generation and the local deployment either of energy storage at the sites of generators supplying power via

direct connection or on-grid power purchase agreement (to ensure a reliable supply of fully clean power to the electrolyser), or of hydrogen storage at the iron production facility (to ensure a continuous supply of hydrogen to the DRI plant). This could add significantly to costs, compared with the iron producer instead taking power from the grid at whatever carbon intensity the grid provides.

In the long term, large increases in electricity generating capacity will be needed in any country using hydrogen-based iron production at scale, and this must take place together with the completion of the transition to clean power. In the near term, any additional costs could risk holding back the first wave of investment in H₂-DRI plants. The practical implications vary significantly between countries.

Brazil has an exceptionally clean electricity grid, benefiting from large-scale hydropower as well as abundant high-quality solar and wind resources. In years of normal rainfall, its grid-based power is clean enough to be exempt from the EU's additionality rule. In 2023, for example, 96% of power generation in the national grid was from renewable sources²¹³ and the grid's average emissions intensity was 13 gCO₂/MJ.²¹⁴

²⁰⁷ Knobloch, F., et al. (2020). Net emission reductions from electric cars and heat pumps in 59 world regions over time. *Nature Sustainability* 3(6): 437–447. ²⁰⁸ IEA (2024). *Towards common criteria for sustainable fuels*. ²⁰⁹ IEA (2024). *Towards common criteria for sustainable fuels*. ²¹⁰ IEA (2024). *The Breakthrough Agenda Report 2024*. ²¹¹ IRENA (2025). *Renewable Capacity Statistics 2025*. Renewables accounted for 92.5% of global power capacity additions in 2024. Solar power alone accounted for over three-quarters of renewable additions. ²¹² OECD (2025). *OECD Steel Outlook 2025*. OECD Publishing, Paris. ²¹³ Empresa de Pesquisa Energética (EPE) (2024). *Caderno de Consolidação de Resultados*. ²¹⁴ Ministério da Ciência, Tecnologia e Inovações (MCTI) (2024). *Fatores de emissão MDL/SIN*.

But analysis by the E+ Energy Transition Institute has found that in years of hydrological stress, such as 2013, 2014, and 2021, and in the recovery periods after these years, the power system's increased reliance on fossil fuel generation meant that it failed to meet the threshold (see **Figure 16**).²¹⁵ As the frequency of extreme drought is increasing, grid carbon intensity increasingly fluctuates. This creates significant uncertainty for any prospective investors in green iron plants around whether they will be exempt from the additionality rule. If the additionality rule is taken to apply, then with prime renewable generation sites already taken by developers in earlier years, new generation capacity (along with storage capacity) must be added in less favourable sites, raising costs unnecessarily and deterring investment.²¹⁶ The additionality rule will also make overall project costs more vulnerable to high interest rates.

South Africa's situation is markedly different. Renewables accounted for only 14% of electricity generation in the year from July 2024 to June 2025, with nuclear providing a further 4%.²¹⁷ Over 80% was from coal. Renewable power is growing slowly, with one of the most significant barriers being the availability of grid capacity for new renewable projects. The problem, related to the powerful position of coal interests in the political economy, is particularly acute in provinces where wind and solar resources are more abundant. In this context, the delays and risks involved in sourcing the necessary renewable power from the national grid could be prohibitive for a green iron project, whatever level of carbon intensity is required. Building renewables and local storage dedicated to supplying a single industrial plant has been shown to be capable of delivering cost-competitive H₂-DRI,²¹⁹ and is a much more plausible solution.

In India, solar power is low-cost and reliable on a daily basis, and most industrial electricity is already consumed via power purchase agreements, meaning that the requirement of additionality is not in itself difficult to fulfil. However, while a hybrid solar and wind supply could be used to provide approximately 80% of a plant's power at relatively low cost with the remainder being supplied by the grid, the costs would rise steeply to meet a 100% clean power requirement, because expensive battery or hydrogen storage would be required (see **Figure 17**). The difficulty would be reduced if the iron plant could sell surplus power from its own renewable generation to the grid in the daytime, and buy power from the grid at night (through a mechanism referred to as 'banking' in Indian regulations), achieving a net consumption of zero grid power on average, but this could be disallowed by a strict interpretation of 'temporal correlation' rules requiring hydrogen to be produced at times when renewable power is available.²²⁰



In Brazil, the additionality rule could raise costs unnecessarily and deter investment.

²¹⁵ Passos, E., Leite, C., & Santos, R. (2024). Implications of the national grid on the emission factor of low-carbon hydrogen produced in Brazil. *Implicações do SIN no fator de emissão do hidrogênio de baixo carbono produzido no Brasil*. ²¹⁶ Passos, E. & Guedes, P. (2024). *Additionality for hydrogen in the Brazilian context*. ²¹⁷ LowCarbonPower (n.d.). *Electricity in South Africa in 2024/2025*. ²¹⁸ Molepo, P. M., Aboale, K., & Mathaba, T. N. D. (2025). Analysis of Barriers to South Africa's Energy Transition: Perspectives from industry experts. *Energy for Sustainable Development* 88: 101777. <https://doi.org/https://doi.org/10.1016/j.esd.2025.101777>. ²¹⁹ Trollip, H., McCall, B., & Bataille, C. (2022). How green primary iron production in South Africa could help global decarbonization. *Climate Policy* 22(2): 236–247. <https://doi.org/10.1080/14693062.2021.2024123>. See also: Agora Industry, Agora Energiewende, and Instituto E+ Transição Energética (2024). *12 insights on hydrogen – Brazil Edition*. ²²⁰ The EU regulation requires temporal correlation on a monthly basis initially, and temporal correlation on an hourly basis for 1 January 2030. The rules apply irrespective of when a plant is built, meaning that a green iron production plant built before 2030 would be subject to the stricter hourly-based version of the rule for most of its operating lifetime. This could disincentivise investment in the near term.



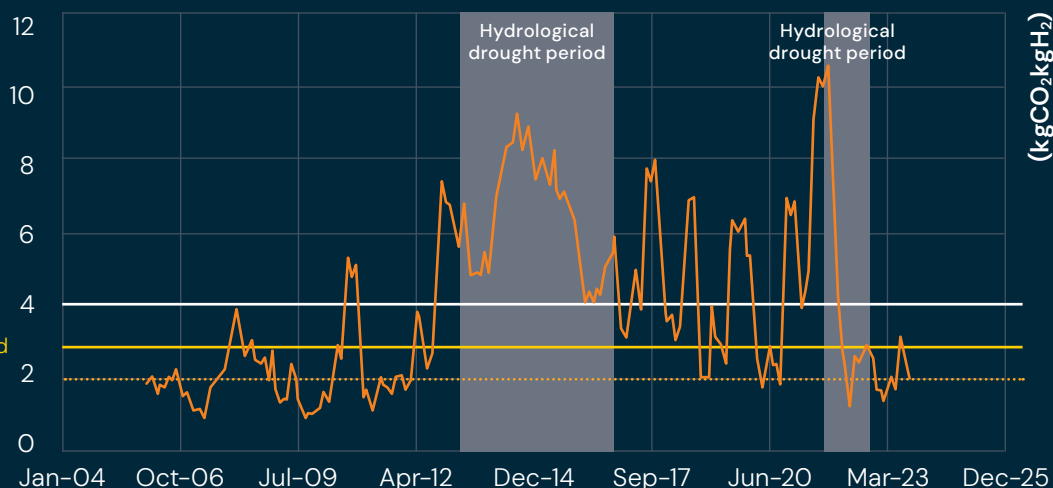
Figure 16:

Emissions factor of hydrogen produced from electricity from Brazil's national grid.

Emissions factor of hydrogen produced from electricity from the Brazilian National Interconnected System (SIN)

Bill proposal Federal Senate and Chamber of Deputies

European Union standard
Favorable Hydrology

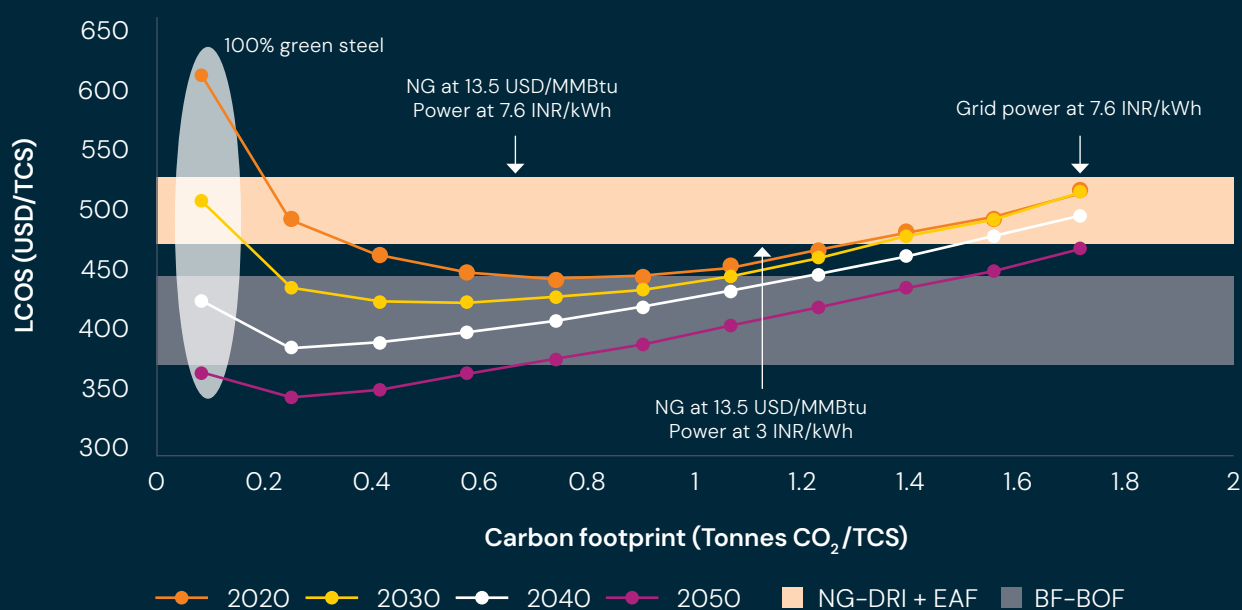


Source: E+ Energy Transition Institute, based on data from the Brazilian MCTI (Ministry of Science, Technology and Innovation).



Figure 17:

Transition pathways for blending green and grey hydrogen in steelmaking in Bellary, Karnataka.



Notes: NG, natural gas; LCOS, levelized cost of steel. Source: Yadav, D., Guhan, A., & Biswas, T. (2021). Greening Steel: Moving to Clean Steelmaking Using Hydrogen and Renewable Energy. New Delhi: Council on Energy, Environment and Water. Licence: CC BY-NC 4.0. Adapted by authors.



Conclusion

Bilateral trade in green iron could become a major feature of the global steel industry as it makes the transition to clean technologies. Countries with cheap renewable energy and high-quality iron ore have strong interests in accessing the new industrial growth and export opportunities that this presents. For steelmaking countries with high energy costs, importing green iron can enable near-zero emission steelmaking at lower cost, enhancing competitiveness over the long term.

Well-designed strategic partnerships between importer and exporter countries – combining offtake agreements, subsidies, concessional finance, and aligned standards – could ensure commercial viability and speed up deployment, realising the benefits for both countries. The challenge lies in overcoming political and financial barriers, particularly around job relocation, capital costs, and subsidy sharing. If these challenges are overcome, these partnerships could have an important positive effect on the pace of the global transition.



Well-designed strategic partnerships between importer and exporter countries – combining offtake agreements, subsidies, concessional finance, and aligned standards – could ensure commercial viability and speed up deployment, realising the benefits for both countries.

The role of plurilateral cooperation on trade

5

Unilateral and bilateral measures can start the transition to near-zero emission primary steelmaking, but they may not be enough to put the global steel sector on track for a transition aligned with the Paris Agreement goals. In this section, we examine whether plurilateral cooperation could influence trade in a way that accelerates the steel transition.

We argue that while international coordination on common policies that put pressure on the highest-emitting technologies is attractive in theory, uneven effects across countries make plurilateral agreements of this kind particularly difficult in practice. Instead, we suggest that at this stage of the transition, governments should focus diplomatic efforts on creating new markets for near-zero emission steel. This could include agreeing a tariff exemption for near-zero emission steel, principles for subsidies for clean steel projects, and relevant clean steel standards. These policies carry fewer immediate competitiveness risks and could directly support investment and the emergence of international trade in near-zero emission steel.

Key messages

- Plurilateral cooperation on trade could accelerate the steel transition, but approaches to this vary in their effectiveness, feasibility, and political acceptability.
- Policies that incur immediate and uneven costs for countries' existing steel industries are likely to be particularly difficult to agree. These include coordinated carbon pricing and common emissions intensity regulations for steel production.
- A plurilateral tariff exemption for near-zero emission steel, which is not currently produced at a significant level by any country, would have no immediate impact on steel production costs or trade. Together with national policies that closed the cost gap between clean and conventional steel, it could give clean steel an advantage in international trade, creating a powerful incentive for investment.
- An agreement on principles for clean steel subsidies could help to level the playing field between countries, and could increase industry confidence to invest in new clean steel facilities by partially reducing the risks of future trade disputes.

Comparing options to create trade conditions that enable investment in near-zero emission steel

To address the question of how governments could cooperate on trade to advance the steel transition, we compare the current context, feasibility, and effectiveness of the following options:

- Coordinated carbon pricing
- Harmonised emissions intensity regulations
- A plurilateral clean steel tariff exemption
- Agreed principles for clean steel subsidies
- Coordinated clean steel production mandates

In this section, we do not focus in detail on harmonisation of standards or coordinated action on public procurement as areas for plurilateral action, not because they are unimportant, but because substantial international cooperation is already under way in these areas and they are well covered in other reports. On standards and definitions, initiatives such as the IEA Working Party on Industrial Decarbonisation, the Climate Club, the OECD, and the Steel Standards Principles group, alongside others, are advancing

harmonisation and interoperability. Similarly, on demand creation, governments and industry have stepped up through efforts such as the IDDI Green Public Procurement Pledge, the Sustainable Steel Buyers Platform, and the Near-Zero Steel 2030 Challenge. These forms of cooperation are essential and should be further bolstered. However, they are not directly concerned with the question of how to ensure the emergence of competitive near-zero emission steel in trade, which is the central focus of this report.

Option 1:

International coordination on carbon pricing

Carbon pricing instruments continue to spread globally

Carbon pricing instruments continue to spread as a policy tool used in many countries, and they now cover around a quarter of global emissions. Initially implemented largely by high-income countries, they are increasingly gaining traction in emerging and developing countries. Indonesia has launched an emissions trading system (ETS) for its power sector. China is expanding its ETS from the power sector to also cover steel, cement, and aluminium.²²¹ Türkiye, India, Brazil, and several other Asian and African countries have schemes under consideration, although the extent to which these schemes cover steel varies.²²²

Existing carbon prices vary widely between countries, ranging from under \$1/tCO₂ to over \$100/tCO₂ at some points in time in the EU.²²³ The global average is currently \$3/tCO₂²²⁴ – a level unlikely to make a difference in any sector. Even in the EU, where the nominal carbon price is currently around \$70–80/tCO₂, free allowances mean that the effective carbon price paid by steel producers is around a quarter of that level – far lower than needed to close the cost gap between BF-BOF (blast furnace–basic oxygen furnace) and near-zero emission primary steel.²²⁵ As noted in Section 2, there is uncertainty around the size of the cost gap. One study estimates the carbon price needed to close the cost gap between BF-BOF and H₂-DRI-EAF (hydrogen–direct reduced iron–electric arc furnace process) in Europe at around \$90/tCO₂.²²⁶ Another study estimates a required carbon price of \$165/tCO₂,²²⁷ and higher estimates can exceed \$200/tCO₂.²²⁸

Carbon pricing is likely to be most effective at encouraging scrap recycling and intermediate–emissions technologies

Carbon pricing has long been advocated in academic and policy circles as an ‘efficient’ means of reducing emissions in the industry sector.²²⁹ By raising the cost of emissions-intensive production, carbon pricing can



create an incentive for producers to switch to lower emission technologies. For reasons discussed in Section 3, we argue that carbon pricing is likely to incentivise the deployment of scrap-EAF and intermediate technologies, but unlikely to support the deployment of near-zero emission primary steel technologies when used alone, although it could contribute to achieving this when used in combination with other policies.

²²¹ International Carbon Action Partnership (2025). *China National ETS*.

²²² World Bank (2025). *State and Trends of Carbon Pricing 2025*.²²³ Trading Economics (2025). *EU Carbon permits*.²²⁴ Parry, I., Black, S., Roaf, J. (2021) *Proposal for an international carbon price floor among large emitters*. International Monetary Fund.²²⁵ Eurofer (2025). *EU ETS revision: benchmarks and CBAM free allocation phase out*.²²⁶ Richstein, J.C. & Neuhoﬀ, K. (2022). Carbon contracts-for-difference: How to de-risk innovative investments for a low-carbon industry? *IScience*, 25(8).²²⁷ Agora Industry, Wuppertal Institute and Lund University (2024). *Low-carbon technologies for the global steel transformation. A guide to the most effective ways to cut emissions in steelmaking*.²²⁸ Agora Industry (2025). *The role of green iron trade in accelerating competitive steel transformation*.²²⁹ Bashmakov, I. A. (2022). *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Chapter 11*.

The impacts of a common carbon price would be unequal

Plurilateral coordination on carbon pricing could, in theory, create a level playing field between countries. It could reduce the risk of carbon leakage – where firms relocate to jurisdictions with weaker climate policies – and remove the need for unilateral carbon border adjustments. To achieve this, a harmonised carbon price would be needed to create consistent incentives across countries and prevent competitive distortions in global steel trade. This approach would not have to be universally adopted, but could be adopted by a group of countries, together with carbon border adjustment mechanisms (CBAMs) applied to steel imports from outside the group.

In practice, harmonised carbon pricing is more complex than that. A common carbon price may not in fact create a level playing field. Proponents increasingly recognise that different carbon prices are likely to be necessary in different countries to achieve an equivalent effect, given variations in the cost of emissions reduction, the interactions of carbon prices with other policies, and differing cross-sector implications. The challenge is further complicated by distributional impacts, and social and political acceptability, which also vary across countries.²³⁰

Proposals such as the IMF's differentiated carbon price floor – tailored to countries' income levels – are intended to address equity concerns while encouraging wider participation in carbon pricing. The IMF has proposed that countries align on a carbon price floor based on different country development status (e.g. of \$25, \$50, and \$75 per tCO₂).²³¹ This proposal is based on a principle of equity and assumptions about the costs of economy-wide emissions reductions needed to bring emissions in line with global warming below 2°C, rather than consideration of the effectiveness of carbon prices at these levels specifically in the steel sector. It appears likely from analysis such as the modelling presented in Section 3 that at best, carbon pricing at these levels could

encourage increased steel recycling or other incremental emissions reduction measures.

Common carbon pricing is likely to be particularly difficult to agree between major steel-producing countries, given its immediate uneven effects on countries' existing industries

There are likely to be significant challenges with a common carbon price being adopted by a group of countries including the major steel producers. The differing carbon intensities of countries' existing steel fleets mean that a common carbon price would have uneven effects on their costs of steel production. National average emission intensities of BF-BOF steelmaking vary between 2 tCO₂e/t-steel in Canada and nearly 3 tCO₂e/t-steel in India.²³² Based on this data, **Figure 18** shows that a common carbon price of \$200/tCO₂ would have significantly uneven effects on some of the world's largest steel producers, raising the cost of BF-BOF steel production by around 100% in Canada, 110% in the EU, 125% in Brazil, 140% in China, and 150% in India. Another comparative study estimated a wider range of carbon intensities between integrated steelmaking in different countries, with South Africa having an even higher carbon intensity than India.²³³ This comparison excluded the gas-DRI-EAF route, whose emissions intensity is significantly lower than that of BF-BOF, in the range of 1.1–1.6 tCO₂/t-steel.

The emissions intensity of EAF-based steelmaking varies similarly widely across countries, from below 0.5 tCO₂e/t-steel in the EU, Brazil and Canada to around 1.2 tCO₂e/t-steel in China, and over 2 tCO₂e/t-steel in India.²³⁴

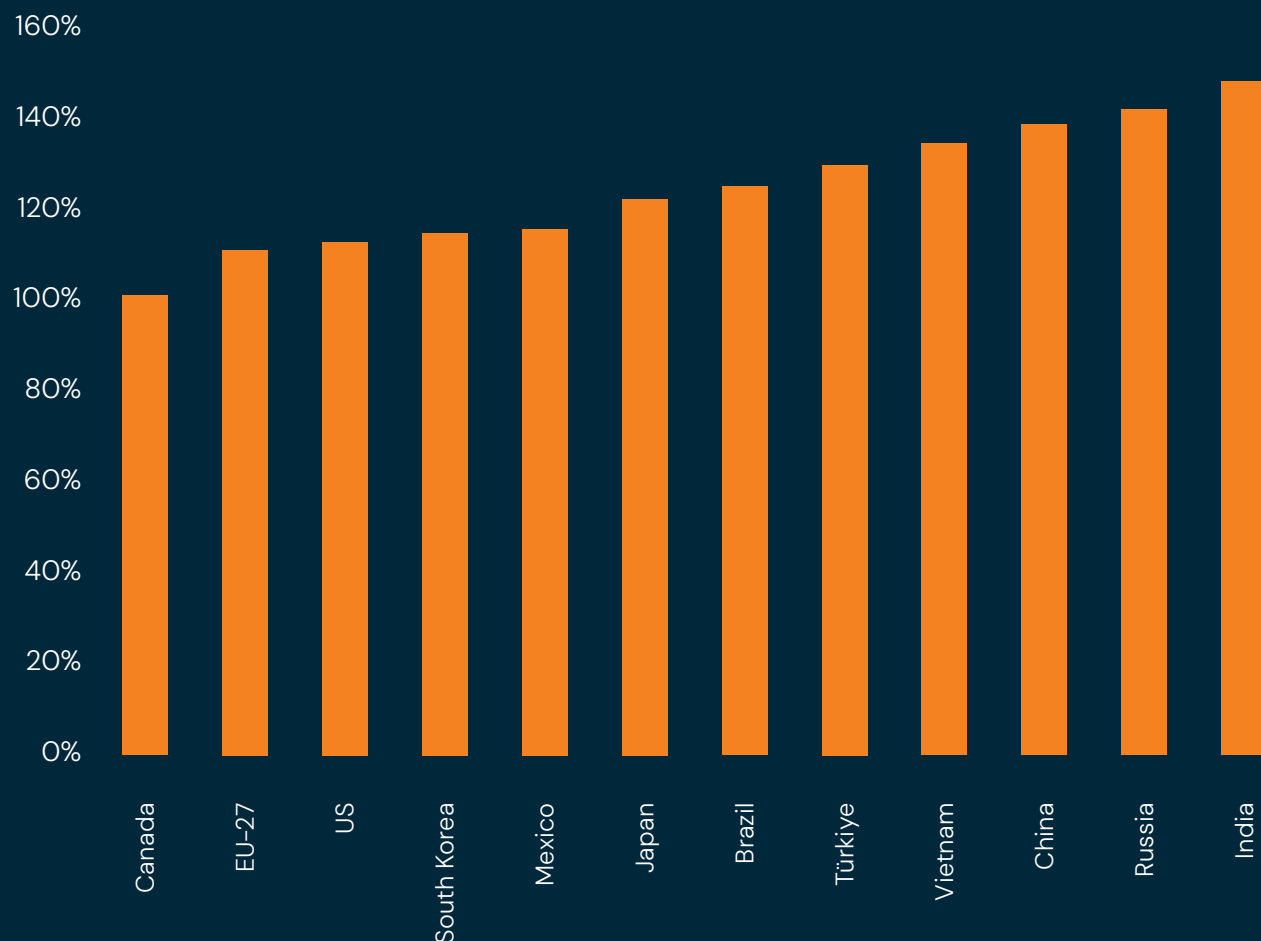
The uneven effects of a common carbon price on the cost of steel production would immediately affect countries' competitiveness in international trade. The factors affecting the carbon intensity of production, which include the fuel mix (coal or gas, in the BF-BOF route), the electricity generation technology mix, the feedstock (scrap, DRI, and pig iron),

²³⁰ Stiglitz, J. E. et al. (2017). *Report of the high-level commission on carbon prices*. ²³¹ Parry, I., Black, S. & Roaf, J. (2021) *Proposal for an international carbon price floor among large emitters*. International Monetary Fund. ²³² Hasanbeigi, A. (2025). *Steel Climate Impact 2025: An International Benchmarking of Energy and CO₂ Intensities*. Global Efficiency Intelligence. ²³³ Koolen, D. and Vidocic, D. (2022). *Greenhouse gas intensities of the EU steel industry and its trading partners*. European Commission Joint Research Centre. ²³⁴ Hasanbeigi, A. (2025). *Steel Climate Impact 2025: An International Benchmarking of Energy and CO₂ Intensities*. Global Efficiency Intelligence.



Figure 18:

Effect of a common global carbon price of \$200/tCO₂ on the cost of BF-BOF steel production in different countries/regions.



Increase in countries/regions' cost of BF-BOF steel production resulting from the application of a common \$200/tCO₂ carbon price, assuming a baseline cost of \$400/t crude steel, based on national average carbon intensities of BF-BOF production estimated by Hasanbeigi, A. (2025). *Steel Climate Impact 2025: An International Benchmarking of Energy and CO₂ Intensities*. Global Efficiency Intelligence.

and the age and efficiency of plants,²³⁵ are not all easy to change quickly, meaning that uneven effects could be long-lasting.

A further uncertainty arises from countries' varying levels of reliance on primary and secondary steel production. In the first half of 2024, recycling of scrap steel accounted for just under a quarter of crude steel production in China and India, and around two-thirds of production in the EU and USA.²³⁶ In a fully competitive market, the price of scrap steel should rise to offset the effect of a carbon price, equalising the cost of primary and secondary production, but the effect may not be fully offset if there are differences in carbon pricing across jurisdictions.²³⁷

While the effect of a common carbon price on trade is difficult to predict quantitatively, its impact on countries' relative costs of production can be known with a reasonable degree of confidence. No country is likely to agree to an arrangement that puts its steel producers at an immediate and substantial disadvantage compared with international competitors. This could be a critical obstacle, since a common carbon price would need to be agreed by a large enough group of major steel-producing countries to avoid substantial competitiveness risks arising from the limitations of CBAMs as discussed in Section 3.

Option 2:

International coordination on emissions intensity regulations

As an alternative to carbon pricing, an international approach could focus on coordinated emissions intensity regulations. Emissions intensity regulations could be applied either to steel production or to steel use in downstream sectors such as vehicles or buildings.²³⁸

Steel production emissions intensity regulations are most likely to drive a shift towards recycling or intermediate-emissions technologies

Steel production emissions intensity regulations would set a limit on the maximum allowable emissions per tonne of steel. This threshold could either be static or be tightened over time to progressively phase out the most carbon-intensive production methods. It could apply only to new investments, or also to existing plants.

Modelling suggests that the main effect of static emissions intensity regulations on new investment in steel production (which can also function as blast furnace capacity caps) is likely to be to drive the uptake of scrap-EAF production or other intermediate emissions technologies.²³⁹ When used on their own, they are unlikely to drive the deployment of near-zero emissions technologies. When the regulations prohibit further investment in high emission technologies, such as BF-BOFs, switching to the next lowest-cost option is likely to be the most profitable path for industry.

The effect of a steel production emissions intensity regulation that increased in stringency over time would depend on its design. If a policy were set at a stringency and timeframe that could only be met by deploying near-zero emission steel technologies in future, this could influence firm and investor behaviour if there was sufficient confidence the policy would remain in place. However, the practical

²³⁵ Hasanbeigi, A. (2025). *Steel Climate Impact 2025: An International Benchmarking of Energy and CO₂ Intensities*. Global Efficiency Intelligence. ²³⁶ BIR (2024). *World steel recycling in figures: January–June 2024 update*. ²³⁷ Gerardin, M. and Ferriere, S. (2025). *Decarbonising steel and other base metals: let's send the right signals*. France Stratégie. ²³⁸ IEA (2025). *Demand and supply measures for the steel and cement transition*. ²³⁹ Dayal, S. et al. (2025). *Towards near-zero emission steel: modelling-based policy insights for major producers*. EEIST.



barriers to using such a policy early in the transition are extremely high. If implemented without further any other policy support, stringent emissions intensity regulations could increase the cost of steel production and make some plants instantly unprofitable.

A more technical challenge is that emissions intensity regulations would require high-quality data with clear measurement and reporting of emissions across the supply chain.²⁴⁰ This could be difficult, given that existing approaches to emissions reporting often rely on default values, and producing comparable product-level data presents several challenges.²⁴¹

Steel production emissions intensity regulations are unlikely to be possible to agree among major steel producers, given the difference in impact on countries' existing industries

International coordination on steel production emissions intensity regulations could be considered as a way to lower the difficulty of the transition, by lessening the risks that any

country would face if pursuing this approach alone. But coordination of this kind across a group of countries as diverse as the largest steel-producing countries is likely to be politically difficult to the point of impossibility, due to its uneven effect on countries' existing industries.

Analysis of the emissions intensity of countries' steel industries by technology and the percentage of production that would be affected by emissions intensity regulations at different stringencies illustrates the challenge (**Figure 19**). It shows that the effect of a common carbon intensity regulation that progressively tightened over time would be highly uneven across countries. In China, over 80% of the existing steel production would be affected by a regulation when the allowable emissions intensity fell to 1.7 tCO₂/t-steel, compared with 60% in the EU and 40% in the United States.

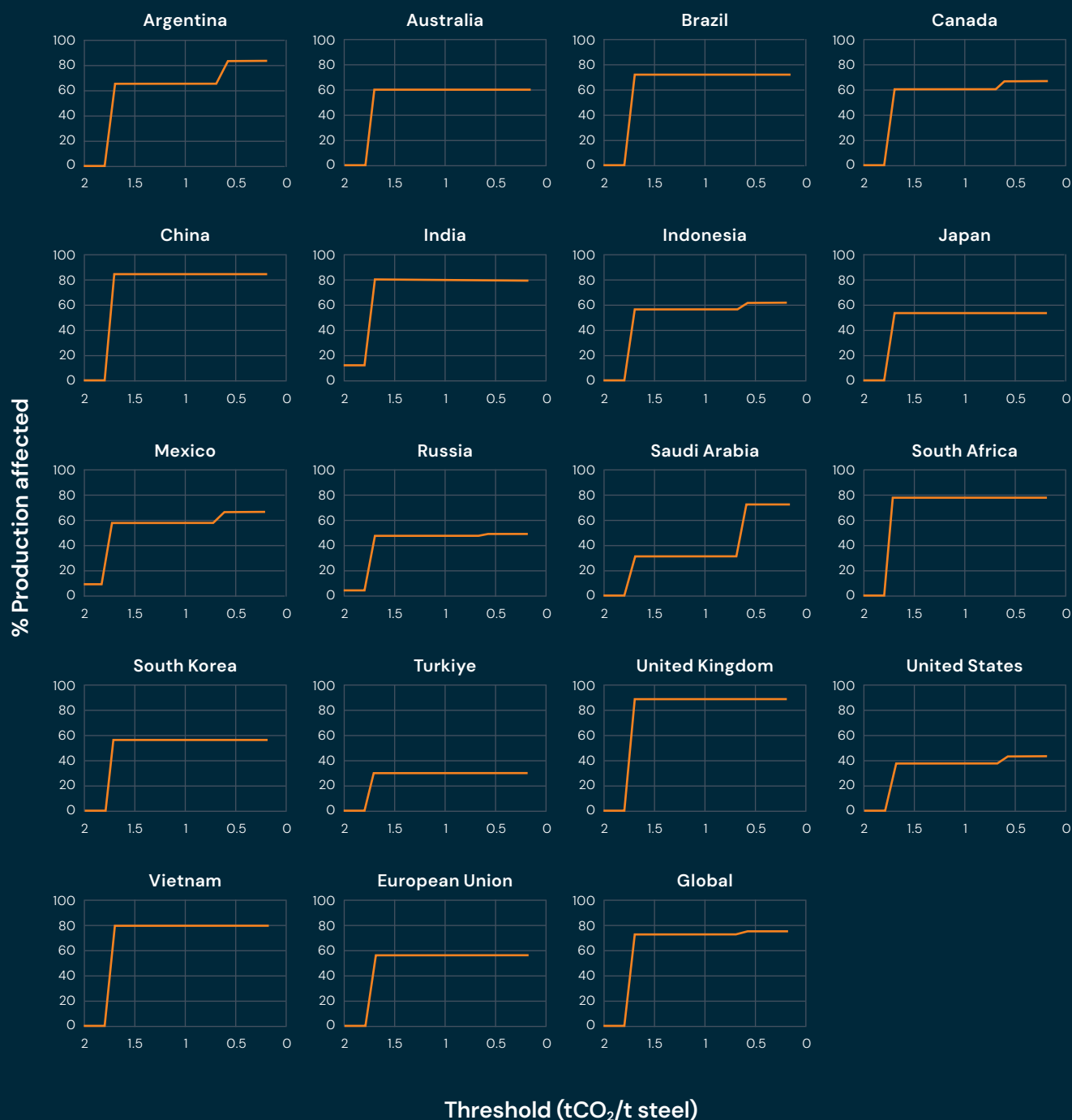
²⁴⁰ IEA (2025). *Demand and supply measures for the steel and cement transition*.
²⁴¹ OECD (2025) *Carbon intensity metrics in the steel and cement sectors of Climate Club members*.



Figure 19:

Percentage of countries' existing steel production affected by emissions intensity regulations at different stringencies.

Baseline year 2025 threshold sensitivity analysis (% production)



Source: Francis Li and Chris Bataille, analysis for the Breakthrough Agenda Policy Network using the SteelPath model.²⁴²

²⁴² SteelPath is a steel sector model with explicit representation of over 1,000 real-world steel production facilities (blast furnaces, electric arc furnaces, direct reduction plants, etc.), covering upwards of 97% of global crude steel output. See: Bataille, C., Stiebert S., & Li, F. (2024). *Facility level global net-zero pathways under varying trade and geopolitical scenarios: Final Technical & Policy Report for the Net-zero Steel Project, Part II*.

This analysis presents a simplified picture: it uses average values for the emissions intensity of all plants with a given technology, and so does not account for differences in carbon intensity across countries' BF-BOF plants. If actual values were used for each plant, an even greater unevenness of impact across countries would be visible. Nor does it show any of the changes that could take place in countries' steel fleets over the course of time. However, it illustrates two points. First, a steel production emissions intensity regulation is a crude and binary tool: it has no direct effect until the threshold falls to the level of BF-BOF plants, at which point it makes some or all conventional BF-BOF plants unviable without substantial retrofitting. This makes it less useful than carbon intensity regulations in road transport, which have been used to drive continuous improvement in vehicle efficiency over a large range of possible values. Second, it shows that a common emissions intensity regulation would force difficult decisions on the deployment of new clean steel technologies to be taken earlier in some countries than in others: those with a large BF-BOF share of production in their steel fleets would be forced to make difficult and costly changes on a larger scale, at an earlier date, than those with smaller BF-BOF shares. Similarly, countries with newer, more efficient BF-BOFs would be penalised later than those with older, less efficient BF-BOFs.

Steel production emissions intensity regulations are therefore unlikely to be a productive starting point for plurilateral discussions on the steel transition. A common policy would see large differences in effect at the domestic level and in international trade, given the heterogeneity of countries' steel industries, as well as immediate and potentially challenging cost increases for steel producers. While they may prove effective within national or regional jurisdictions, especially if combined with subsidies, procurement, or other complementary measures, they are unlikely to serve as the foundation for international cooperation at this stage.

Emissions intensity regulations in end-use sectors are untested but in development, and could play a helpful role

In downstream sectors where steel is used, emissions intensity regulations can set a maximum allowable threshold either for the total emissions embedded in a specific product such as a car or a building, or for the emissions embedded in a specific material that is used in that product. To date, no country has applied an emissions intensity regulation to specific materials in end-use sectors. However, emissions intensity regulations for total lifecycle emissions of products in end-use sectors are gaining in prominence in Europe. Notably, they are being applied in the construction sector to limit the lifecycle emissions of new buildings (such as in Denmark's National Strategy for Sustainable Construction, Finland's Building Act, France's RE2020 regulations, and the EU's Ecodesign for Sustainable Products Regulation).²⁴³

Emissions intensity regulations applied to end-use sectors do not create competitiveness risks for steel producers, because they create demand for clean steel that could be met by producers anywhere. They do not force a change in the domestic industry. Their effect on competitiveness of downstream manufacturers is likely to be small, since decarbonising steel makes little difference to the cost of a product such as a car, as discussed in Section 3. Consequently, it is plausible that countries could coordinate the implementation of end-use emissions intensity regulations to rapidly grow global demand for clean steel. It would be difficult for these regulations to be implemented with enough stringency to require the use of near-zero emission steel until at least some supply of such steel was available on global markets. Other measures may be needed first – particularly subsidies, to de-risk investment in near-zero emission steel plants – before end-use regulations can have their greatest accelerative effect on the steel transition.

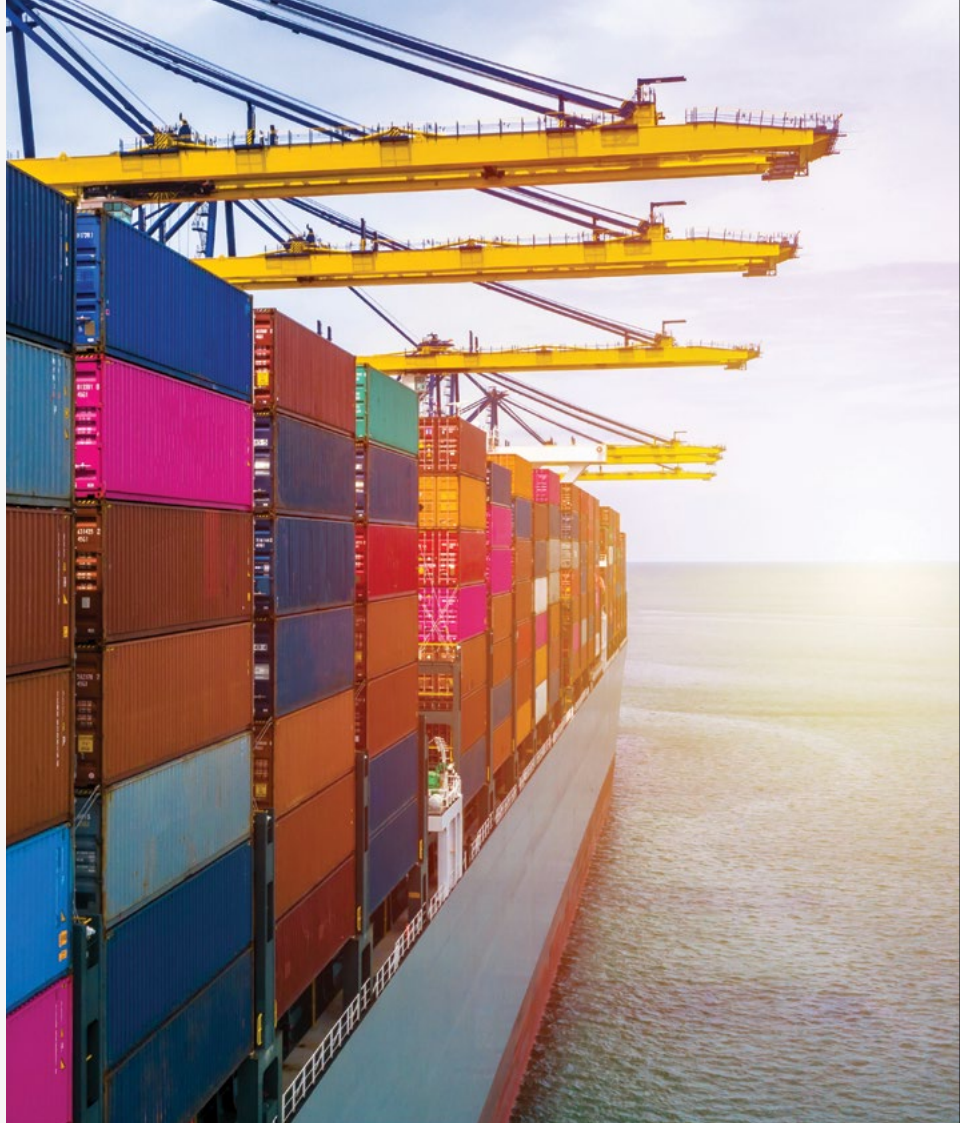
²⁴³ International Energy Agency. (2025). *Demand and supply measures for the steel and cement transition*.

Option 3:

A clean steel tariff exemption

Instead of focusing on restricting or disincentivising the use of the old, high emission technologies, international cooperation could focus on supporting the growth in use of new, near-zero emission steel technologies. This would be consistent with the ‘first build, then break’ pattern that is visible in technology transitions of the past, and in examples of success in the low carbon transition at present.²⁴⁴

An option aligned with this approach would be for countries to agree tariff reductions or exemptions for near-zero emission steel. Tariffs alter the price of steel imports relative to domestic production and are generally used to protect domestic producers from cheaper imported steel because of excess capacity in the global market, or to address perceived unequal conditions for producers in different countries. Tariffs are not currently used as a policy tool to influence steel decarbonisation, and steel products are not currently differentiated by their emissions. However, countries could use tariffs to influence the relative cost of low and high emission imports, leading to trade conditions more conducive to investment in clean steel.



Countries could use tariffs to influence the relative cost of low and high emission imports, leading to trade conditions more conducive to investment in clean steel.

²⁴⁴ Murphy, A., Sharpe, S., Geels, F.W., Lilliestam, J., and Patt, A. (2025). *First build, then break: a policy framework for accelerating zero-carbon transitions*. S-Curve Economics.

The use of differentiated tariffs for high and low emission steel has been discussed before, but not implemented

To date, no country has applied differentiated trade tariffs on the basis of the emissions embedded in steel.²⁴⁵

The most ambitious attempt to create a tariff-based mechanism was the US–EU effort in 2021 to negotiate a Global Arrangement on Sustainable Steel and Aluminium (GASSA). These negotiations sought to address multiple challenges simultaneously: to resolve the dispute over US tariffs and EU countermeasures from 2018; to protect European and US producers against global steel overcapacity; to accelerate decarbonisation of the steel and aluminium sectors; and to find a path forward for US and EU cooperation on the EU’s emerging CBAM, with the possibility of expanding cooperation to other partners.²⁴⁶

Differences in positions emerged on several issues. The US proposal favoured applying common external tariffs based on the average emissions intensity of steel production across countries participating in the agreement. The EU proposal argued for replacing tariffs with national policies and border adjustments, similar to its own CBAM. Disagreements also included whether these arrangements could replace or exist alongside the EU CBAM, and what criteria should be used to determine which other countries could

join in the arrangement (their industrial emissions only, or also their ‘non-market’ excess capacity).²⁴⁷ Many areas of disagreement contributed to the failure of the negotiations, including differences over adherence to international trade rules, and the US wanting an arrangement that would give greater advantage to recycled steel, which its industry already produces competitively in high volumes.²⁴⁸

The experience of the GASSA negotiations highlights the difficulty of reaching agreement on the use of tariffs as a tool for steel decarbonisation when done in a way that would have an immediate unequal effect on existing industry, as well as potentially not being WTO-compliant. At the same time, the fact that policymakers seriously considered linking tariff policy to emissions demonstrates a willingness to think about trade measures in new ways.

A tariff exemption for near-zero emission steel would have no immediate impact on the costs or competitiveness of countries’ steel industries

A tariff exemption or reduction for near-zero emission steel could be less difficult to agree than any of the other options for plurilateral cooperation discussed above. Since no near-zero emission steel is yet produced at commercial scale by any of the major steel-producing countries, a tariff reduction or exemption for such steel would have no

immediate impact on the cost or international competitiveness of steel production in any country. Countries with better clean energy resources or those that are ahead in developing clean primary steel technologies would have more to gain from such an arrangement, but that is unavoidable in any scenario in which decarbonisation of the global steel sector takes place. The measure would immediately change incentives for investment, but would not have any immediate effect on trade.

To have effect, a clean steel tariff exemption or reduction would need to be agreed and implemented at the same time by a group of countries so that each country would have the potential for its own clean steel exports to benefit from the measure. It would not be in a country’s direct economic interests to make the exemption unilaterally. (The case could be made for this policy to encourage wider climate action, but it would be likely to meet stiff resistance from industry.) To be consistent with WTO trade rules, the tariff exemption or reduction would need to be made available to all countries, and not only those that had agreed to jointly implement it. We discuss the legal considerations further below. **Table 5** summarises the factors that could make a clean steel tariff exemption more feasible to agree than a common carbon price.

²⁴⁵ The EU’s Carbon Border Adjustment Mechanism (CBAM) is not a tariff; it is the extension of a domestic carbon pricing policy to apply to imports. A tariff does not have to be linked to any particular domestic policy. Tariffs could be differentiated by product category or emissions threshold, and do not have to function as carbon prices. ²⁴⁶ Rimini, M. et al., (2023). *The EU–US global arrangement on sustainable aluminium*. E3G. ²⁴⁷ Rimini, M. et al., (2023). *The EU–US global arrangement on sustainable aluminium*. E3G. ²⁴⁸ Mana, I., & Kopans-Johnson, H. (2023). *In green steel discussions, the United States is playing dirty*. Council on Foreign Relations.



Table 5:

Comparison of the difficulty of a common carbon price and a clean steel tariff exemption.

	Coordinated carbon pricing	Clean steel tariff exemption
Steel plants affected	All existing plants have costs increased to some extent	No existing plants (if a near-zero emission standard is used)
Effect on competitiveness	Immediate (changes in cost affect trade flows)	Only in future (fires the starting gun for the transition)
Countries needed to agree	Large majority of the global market, to avoid competitiveness risks not fully managed by CBAMs	Just enough major steel markets to make it worthwhile for the participants

A tariff exemption could give clean steel the advantage in international trade, providing a powerful incentive for investment

A tariff exemption applied to near-zero emission primary steel could reduce the cost gap between this steel and high emission BF-BOF steel, from the perspective of an importer country, by a significant amount (see **Table 6**). The amount varies

widely between countries since it depends on the level of each country's current tariffs or steel safeguards, and ranges from 0 to 36% for H₂-DRI steel, and 0 to 59% for steel produced with natural gas-DRI with carbon capture and storage (CCS).

These estimates are conservative, as they are based on most-favoured nation (MFN) average ad valorem duties for iron and

steel products (product code HS72 under the WTO's statistics). In practice, iron products have very low tariffs relative to steel. In some steel product segments, tariffs are much higher than these averages. In the case of the US, EU and UK, where MFN tariffs are low, estimates are based on the current level of steel safeguards at 25%. This analysis was carried out prior to these safeguard levels being raised in the US, and prior to



Table 6:

Fraction of the cost gap between near-zero emission primary steel and BF-BOF steel that would be closed by applying a tariff exemption to near-zero emission steel, from the perspective of the importing country.

Notes: Costs are based on median cost of imported steel by technology type in each country, estimated using the SteelPath model.²⁵⁰ Tariffs are based on average iron and steel tariffs or (*) steel safeguards.

Source: Francis Li and Chris Bataille / S-Curve Economics CIC.

Importing country	Gas-DRI-CCS-EAF	H ₂ -DRI-EAF
Argentina	22%	13%
Australia	9%	6%
Brazil	22%	13%
Canada	0%	0%
China	14%	8%
EU*	58%	35%
India	36%	22%
Indonesia	19%	12%
Japan	1%	0%
Mexico	30%	18%
Russia	11%	7%
Saudi Arabia	30%	18%
South Africa	13%	8%
South Korea	1%	0%
Türkiye	23%	14%
UK*	59%	36%
United States	56%	35%

EU proposals to raise them to 50%. Furthermore, this analysis is based on production cost data and estimates in which the median cost gap between DRI-H₂-EAF production and BF-BOF in 2025 is around \$290–350 per tonne of crude steel for G20 countries, compared to a typical cost of BF-BOF steel production in the range of \$410–470 per tonne.²⁴⁹ This is at the high end of the range of estimates of the cost difference between the two technology routes.

Tariff exemptions alone would not be expected to result in the deployment of near-zero emission primary steel, since they appear unlikely to fully close the cost gap to conventional steel. A tariff exemption or reduction would be a complement to domestic deployment policy. If countries used targeted subsidies to level the cost of near-zero emission primary steel production and BF-BOF production, then a steel tariff exemption or tariff reduction

agreed among countries would create a positive advantage for clean steel in international trade. This could create a powerful incentive for investment in near-zero emission steel plants.

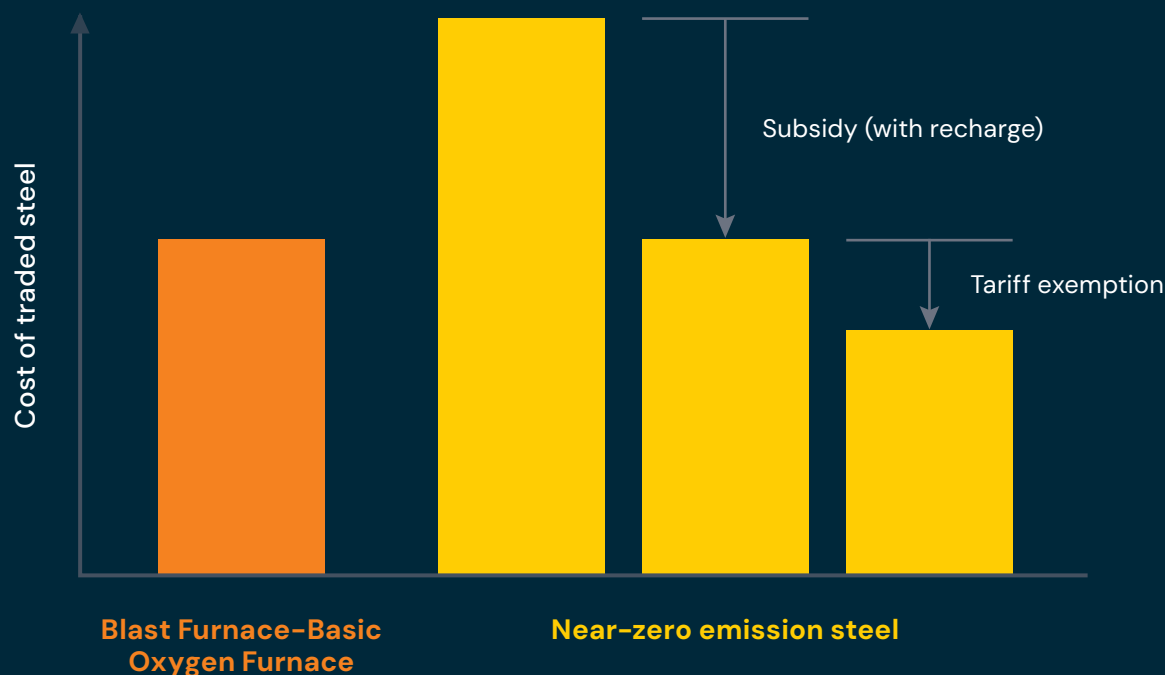
²⁴⁹ Francis Li and Chris Bataille for the Breakthrough Agenda Policy Network.

²⁵⁰ SteelPath is a steel sector model with explicit representation of over 1,000 real-world steel production facilities (blast furnaces, electric arc furnaces, direct reduction plants, etc.), covering upwards of 97% of global crude steel output. See: Bataille, C., Stiebert S., and Li, F. (2024). *Facility level global net-zero pathways under varying trade and geopolitical scenarios: Final Technical & Policy Report for the Net-zero Steel Project, Part II*.



Figure 20:

A plurilateral clean steel tariff exemption could give near-zero emission steel the advantage in international trade (illustrative).



Countries that could exert a significant positive influence on the global steel transition by adopting this approach are those that have relatively high steel imports, and existing tariffs or safeguards at significant levels. Countries that might see this approach as aligned with their interests are those that have strong potential to be competitive in clean steel (based on

renewable energy or iron ore resources, or technological capability and leadership in demonstration projects), and/or strong political commitments to advancing decarbonisation or reducing fossil fuel import dependence. The EU, China, Brazil, and Mexico each meet the criteria for influence, and have relatively strong alignment of interests with the transition.

These countries together accounted for around 26% of global steel imports in 2024.²⁵¹ India has strong influence but less clearly aligned interests. South Africa and the UK have strongly aligned interests, but less influence. An overview of the influence and interests of selected G20 countries is presented in **Table 7**.

²⁵¹ World Steel (2024). *World Steel in Figures*.



Table 7:

Influence and interests of selected G20 countries in relation to clean steel tariff exemptions.

How much would tariffs influence the transition?				Interests
G20 countries	Gross imports of steel in 2024 (1)	Average MFN tariff on iron and steel (HS72) (2)	Level of steel safeguard	Considered
With tariffs/safeguards on iron and steel greater than 5%	(Mt)		(only applied to some countries) (see section 1)	Renewable energy resources (3), iron ore resources, clean steel technological capability based on planned iron and steel projects using low or near-zero emission steel (H ₂ -DRI, NG to H ₂ -DRI, biomass, MOE, CCS) (4), energy security, decarbonization ambitions (latest NDC).
Argentina	–	8.5%		Potentially good renewable resources. No planned projects.
Brazil	5.9*	9.4%	25%	Abundant renewable energy and iron ore resources. One planned project.
China	8.7	4.5%		Good renewable resources. Four planned projects. Fossil fuel importer.
EU	42.8	0.3%	25%	Deep near-term decarbonisation targets. 25 planned projects. Fossil fuel importer.
India	11.5	15.2%	12%	Good renewable resources. Fossil fuel importer. Low quality iron ore. No planned projects.
Indonesia	12.8	8.2%	0–20%	Fossil fuel exporter. Constraints on renewables. No planned projects.
Mexico	17.6	12.7%		Good renewable resources. Near-term emissions reduction target. One planned project.
South Africa	0.13*	5.6%	9%	Very good renewable and iron ore resources. No planned projects.
Türkiye	19.7	9.3%		Fossil fuel importer. Moderate renewable resources. No planned projects.
UK	6.6 *	0%	25%	Deep decarbonisation targets. Fossil fuel importer.
United States	27.3	0.3%	50%	Fossil fuel exporter. Withdrawing from the Paris agreement. Two planned projects.

Notes: (1) <https://worldsteel.org/data/world-steel-in-figures/world-steel-in-figures-2025/>; *alternative source used; (2) WTO (2025). *WTO Stats Portal*. <https://stats.wto.org/>. NG, natural gas; NDC, Nationally Determined Contribution. (3) Miyake, S. et al. (2024). *Solar and wind energy potential under land-resource constrained conditions in the Group of Twenty (G20)*. *Renewable and Sustainable Energy Reviews* 202: 114622. (4) LeadIT (2024). *Green Steel Tracker*. Leadership Group for Industry Transition. <https://www.industrytransition.org/green-steel-tracker/>

Although most steel trade is intra-regional, the value of flows between five of the largest iron and steel-producing countries with interests relatively aligned with the transition is substantial, despite their being on different continents (see **Figure 21**). Trade between these five countries/regions accounts for 14–39% of each country/region's iron and steel exports, and has a total value of approximately \$27bn.

This picture understates the opportunity for countries such as South Africa and Brazil, which currently have lower exports than others in the group, but whose exports of green iron could increase significantly along with market demand for near-zero emission steel.

A consideration is that the risks of a tariff exemption versus the perceived export opportunities would differ by company. Those firms that primarily serve a domestic market may resist tariff exemptions, while others with a more international outlook might welcome the

competition and new export opportunities. Governments would need to take a view of the national interests, as in all trade diplomacy.

If countries considering participating in a plurilateral clean steel tariff exemption have concerns about how their industries' competitiveness will change as the transition progresses and new steelmaking technologies gain a larger share of the market, there are several ways that such concerns could be managed.

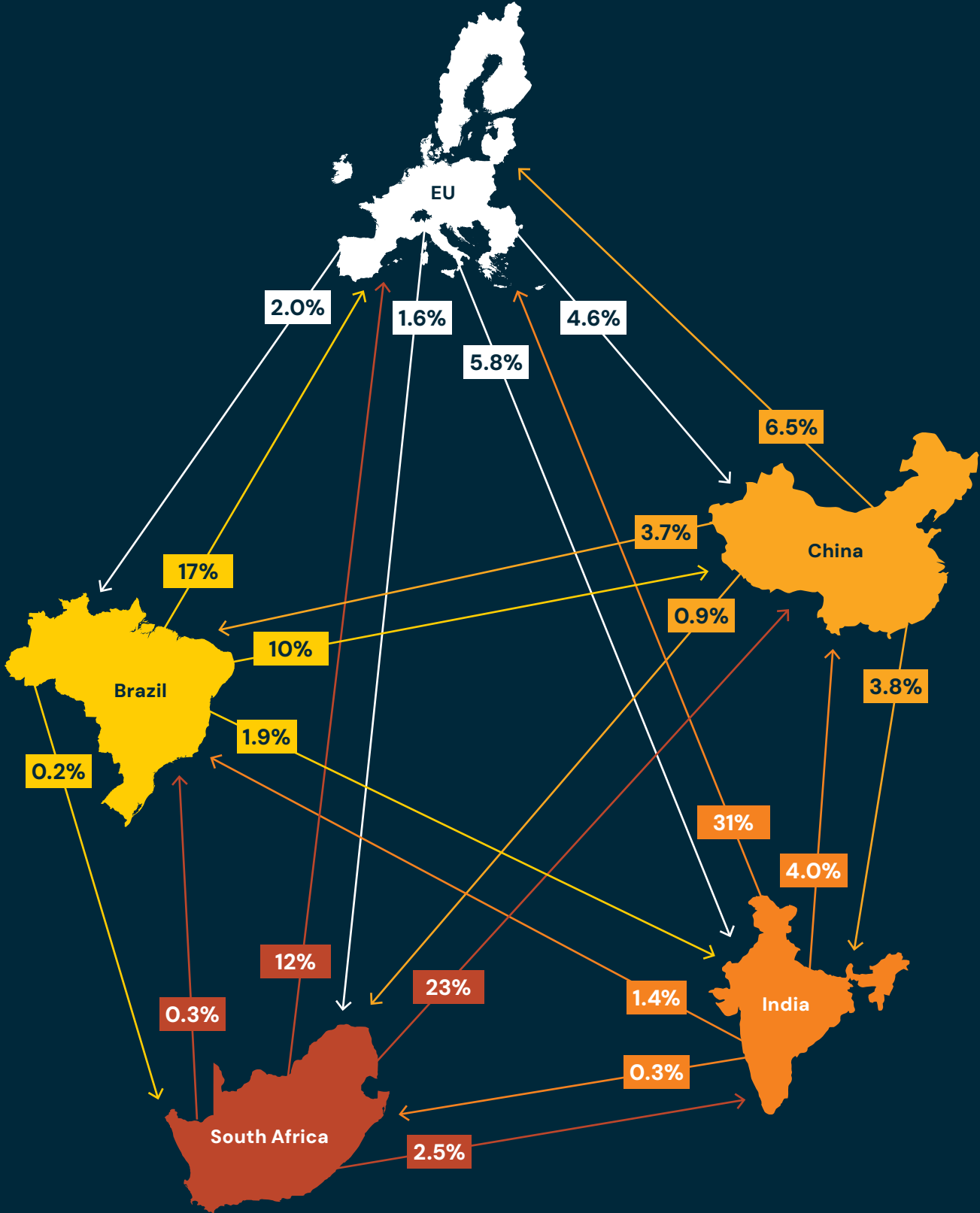
One option would be to design the plurilateral tariff exemption as a time-limited arrangement, with a sunset clause based on an end-date or a quantity of near-zero emission steel production capacity having entered the global market. This would recognise that the most important role of the tariff exemption would be to encourage investment in the first wave of near-zero emission plants. An alternative would be to progressively tighten the standard used as the basis for steel to qualify for the exemption, so that the measure

continues to encourage technological progress while only directly affecting a small proportion of existing plants. A further option would be to combine the tariff agreement with quotas, so that the exemption would only apply to a certain amount of near-zero emission steel imported from any individual country.

As a further protection against competitiveness risks, the tariff exemption could be made contingent on countries respecting agreed principles in their domestic steel transition policies. These could include principles for fair implementation of clean steel subsidies – discussed below, potentially accompanied by commitments to transparency.

Steel-producing countries with relatively high clean energy costs could strengthen their competitiveness in this context by keeping open the option to import green iron, including for use within plants supported by clean steel subsidies, as discussed in Section 3.

Figure 21:
 Iron and steel trade between selected countries/regions:
 share of exports from each to the others.



	EU	South Africa	India	Brazil	China
Value of steel exports	\$39bn	\$7.5bn	\$13bn	\$11bn	\$66bn
Total export share to the four countries	\$5.5bn/14%	\$2.9bn/39%	\$4.9bn/37%	\$4.0bn/30%	\$9.9bn/15%

Source: OEC. (2025). Exporters of Iron and Steel in 2023. *Product code HS72 (Iron and Steel)*.
 Note EU figures are for extra-regional exports.

The role of definitions and standards in a clean steel tariff exemption

Countries engaging in this approach would need to agree on the standards and/or definitions that would determine which steel qualified for the tariff exemption or reduction. They would also need to agree the means of tracking steel products from origin to import destination, the means of verifying their production method and of measuring their emissions, and the extent of the tariff reductions. These choices would strongly influence the policy's effectiveness in addressing the difficult and high-priority challenge of enabling investment in clean primary steelmaking.

The current state of international alignment on standards

There are no universally agreed standards for low or near-zero emission steel. Standards that have been proposed by governments, industry associations, and international organisations vary widely in their emissions boundaries, stringency, approaches to technology, and other characteristics.²⁵²

The approach that has gained the most support internationally is that of the 'sliding scale' standards developed by the IEA and

ResponsibleSteel. These set several different thresholds for low emission and near-zero emission steel based on carbon intensity of production. The ResponsibleSteel standard has four levels (1–4) with 'near zero emissions' (level 4) having a maximum allowable emissions threshold of 0.4 tCO₂e per tonne of crude steel if 0% scrap is used, and 0.05 tCO₂e emissions per tonne of crude steel if 100% scrap is used.²⁵³ The IEA uses the same thresholds, but with 'near-zero emission' being its own level, and low emission thresholds ranging from bands A to E.²⁵⁴ The German Steel Association has published its own sliding scale standard in consultation with the German government, using the same principles but expanding the boundaries beyond crude steel production to differentiate between 'quality steel' and 'structural and reinforcing steel'. The China Iron and Steel Association has developed the Chinese Method C2F Steel standard through a collaborative process with industry. This also aligns with the sliding-scale approach proposed by the IEA and supported by ResponsibleSteel and the Low Emission Steel Standard (LESS).²⁵⁵

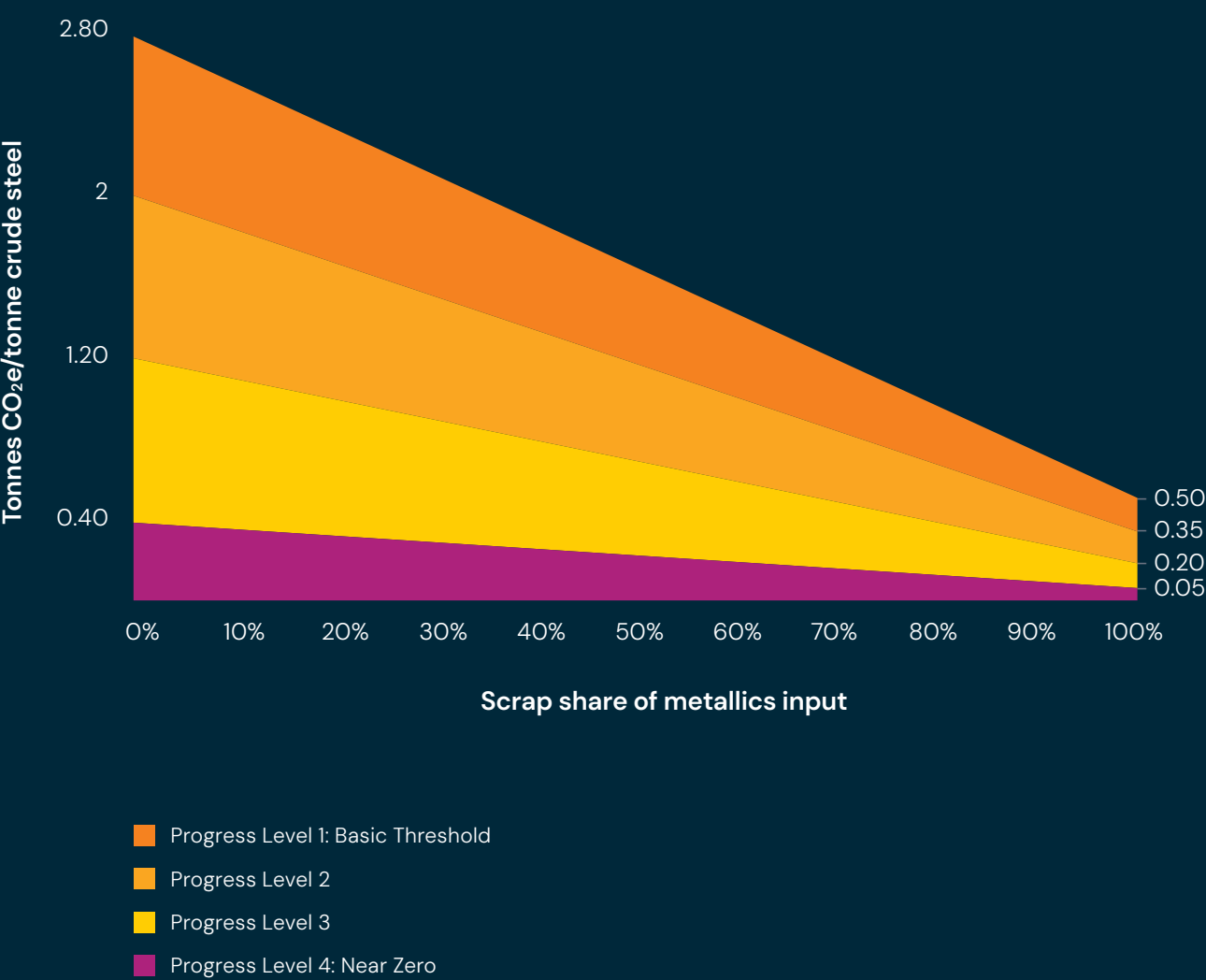
The logic behind the sliding scale approach is that given the limited global supply of

scrap steel, policies that simply shift flows of scrap around the world (increasing its use in one place, and decreasing its availability in another) do little to advance the steel transition. While there is scope to increase recycling rates in some regions, the challenge of deploying clean primary steel is far greater (as we discussed in Section 2). Requiring deeper emissions reductions to meet a given standard when more scrap is used as an input is intended to ensure that policies using these standards incentivise the decarbonisation of both scrap-based and primary steel production.²⁵⁶

Alternative standards developed by industry association groups such as the Global Steel Climate Council differ from the sliding scale by not differentiating between primary and secondary production.²⁵⁷ This approach gives a large advantage to secondary steelmaking over primary steelmaking, as the majority of emissions in steelmaking come from the ironmaking step. Given the arguments made in the previous section for the necessary prioritisation of accelerating primary near-zero emission production, we do not discuss this approach further here.

²⁵² Blanco Perez, S. et al. (2025). *Defining low carbon emissions steel: a comparative analysis of international initiatives and standards*. European Commission Joint Research Centre. ²⁵³ ResponsibleSteel and Low Emission Steel Standard (2025). *The steel decarbonisation scale: a briefing for policymakers inside the EU designing a label for low-emission steel*. ²⁵⁴ International Energy Agency. (2024). *Definitions for near-zero and low-emissions steel and cement, and underlying emissions measurement methodologies*. IEA, Paris. ²⁵⁵ Blanco Perez, S. et al. (2025). *Defining low carbon emissions steel: a comparative analysis of international initiatives and standards*. European Commission Joint Research Centre. ²⁵⁶ ResponsibleSteel and Low Emission Steel Standard (2025). *The steel decarbonisation scale: a briefing for policymakers inside the EU, designing a label for low-emission steel*. ²⁵⁷ Global Steel Climate Council. (2024). *The steel climate standard: framework for steel product certification and corporate science-based emissions targets*.

Figure 22:
ResponsibleSteel International
Production Standard.



Source: ResponsibleSteel (2025). *International Production Standard. Version 2.1.1.*

The choice of standard to use with a clean steel tariff exemption

The sliding scale could be a good starting point for international negotiations on a clean steel tariff exemption, given the support it has already attracted. Governments considering this alongside any alternative options would need to carefully consider three aspects: the stringency of emissions thresholds; the system boundary for measuring emissions; and the degree of differentiation between primary and secondary steel.

²⁵⁸ ResponsibleSteel and Low Emission Steel Standard (2025). *The steel decarbonisation scale: a briefing for policymakers inside the EU designing a label for low-emission steel*.

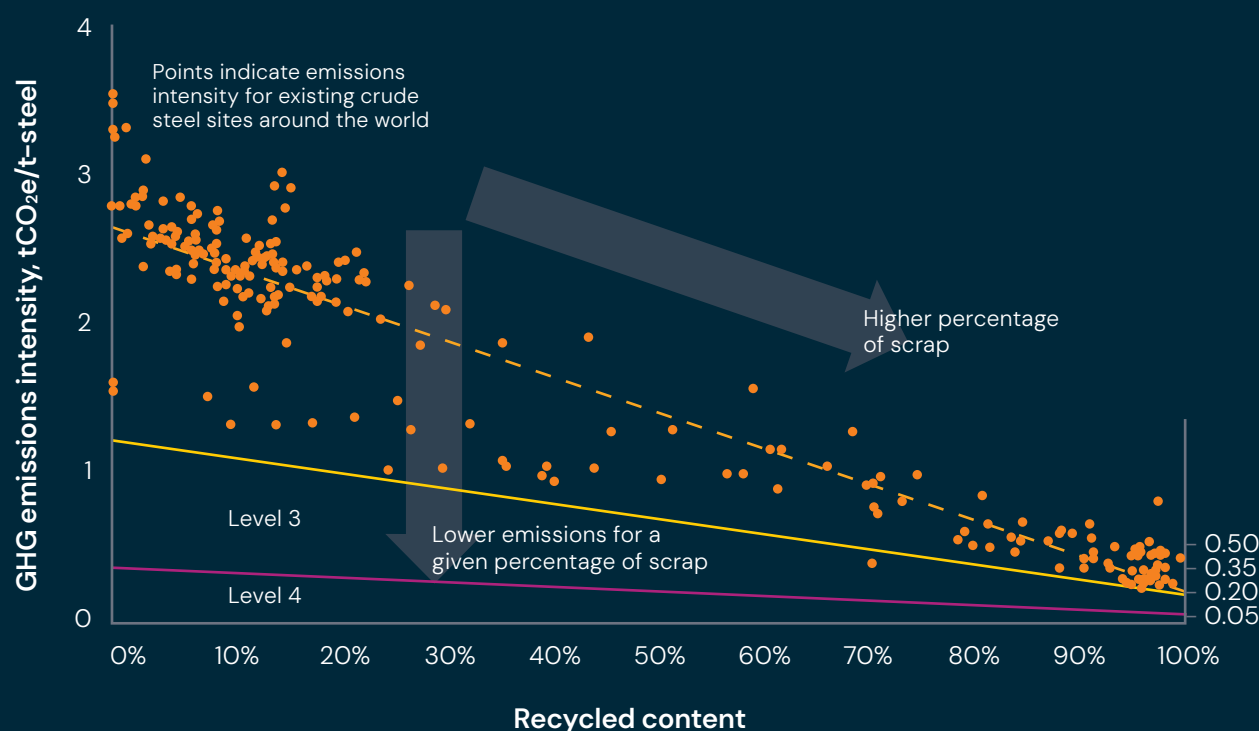
1. Stringency of emissions thresholds

The first consideration is stringency. If the emissions threshold chosen is too high (easier to meet), it could be met by existing or intermediate-emissions technologies. This would fail to incentivise investment in near-zero emission technologies. It could also be too difficult to agree, because it would create immediate advantages for one country over another. If the threshold is set too low, it could be too difficult to meet in the short term using available technologies, creating uncertainty around feasibility and failing to incentivise investment.

An assessment of 300 steelmaking sites carried out by ResponsibleSteel in 2022 and represented by the Institution of Structural Engineers showed the current emissions intensity of plants and their use of recycled steel. This graph suggests that no plant in the world at that time made near-zero emission steel (Level 4), but that some might meet Level 3 of ResponsibleSteel's Decarbonisation Progress Levels (see **Figure 23**).²⁵⁸ A low but technologically feasible threshold that can only be met by very low or near-zero emission technologies could meet the criteria of being possible to agree internationally, and capable of incentivising investment in new clean steel plants.

Figure 23:

GHG emissions compared with scrap levels for 300 production sites.



Source: Adapted from Institution of Structural Engineers (2025). *The role of scrap in steel decarbonisation*.

Note: All numbers have been added by the authors of this report. The first (dashed) line is based on the Level 1 threshold from previous ResponsibleSteel standards (V2.0). Levels 3 and 4 have been added by the authors and are approximations.

2. The system boundary for measuring emissions

A second consideration for policymakers selecting a standard for the tariff differentiation policy would be the system boundary relating to emissions used (or scope). Most (perhaps all) standards that have been proposed include electricity emissions within scope, as well as other upstream emissions such as those from mining and agglomeration, when calculating the emissions associated with steel production. The logic for this is that all emissions relevant to steel production should be accounted for. However, the combination of a broad system boundary with a stringent emissions threshold could make the qualifying criteria for the tariff exemption too difficult to achieve in the near term.

Including power sector emissions within scope would help to avoid the tariff exemption causing increases in short-term emissions from grid-powered electrolysis of hydrogen. Excluding power sector emissions would recognise that the levers for power sector decarbonisation exist outside the steel sector, and could more strongly incentivise investment in new steelmaking technologies. (This trade-off is discussed in Section 4, in relation to the additionality rule.) However, it would be likely to strongly advantage secondary

steelmaking unless combined with some discrimination between primary and secondary production.

3. Degree of differentiation between primary and secondary steel

A third consideration is the degree of differentiation between primary and secondary steel. Without any differentiation, the tariff exemption would be more easily accessible to secondary steel, given its technological maturity and cost advantages compared with clean primary steel. This would intensify global competition for scrap steel without helping to address the difficult challenge of deploying primary near-zero emission production technologies.

One option would be to use the sliding scale as the basis for differentiation. As outlined above, the gradient in the sliding scale is designed to reflect the additional difficulty, and the necessity, of deploying near-zero emission primary steel technologies. It has the advantages of already having significant support from industry, and of being seen to be 'fair' in its treatment of different technologies. However, the relative difficulty of achieving the near-zero emission standard at either end of the scale is not known with confidence. Governments using the sliding scale for the tariff differentiation policy could accept the risk that it

might incentivise more near-zero emission secondary than primary production, and consider future refinements to reverse this if necessary.

An alternative approach would be to apply the tariff exemption only to primary steel, defined either as being purely ore-based, or as having a scrap share of metallic inputs below a certain threshold. This would increase confidence in the policy's ability to incentivise investment in clean primary steel production. A non-zero threshold for scrap content would recognise that most planned H₂-DRI-EAF production anticipates using a significant amount of scrap, as well as DRI, and tough limits on scrap use could raise the cost of projects. The IEA has proposed 30% scrap use as the threshold below which primary near-zero emission production could be explicitly recognised.²⁵⁹ While this would create stronger incentives for investment in near-zero emission primary steel, it would prevent near-zero emission production above a certain scrap threshold from claiming a tariff exemption; sections of industry would be likely to oppose this, potentially adding to the political challenges of agreement.

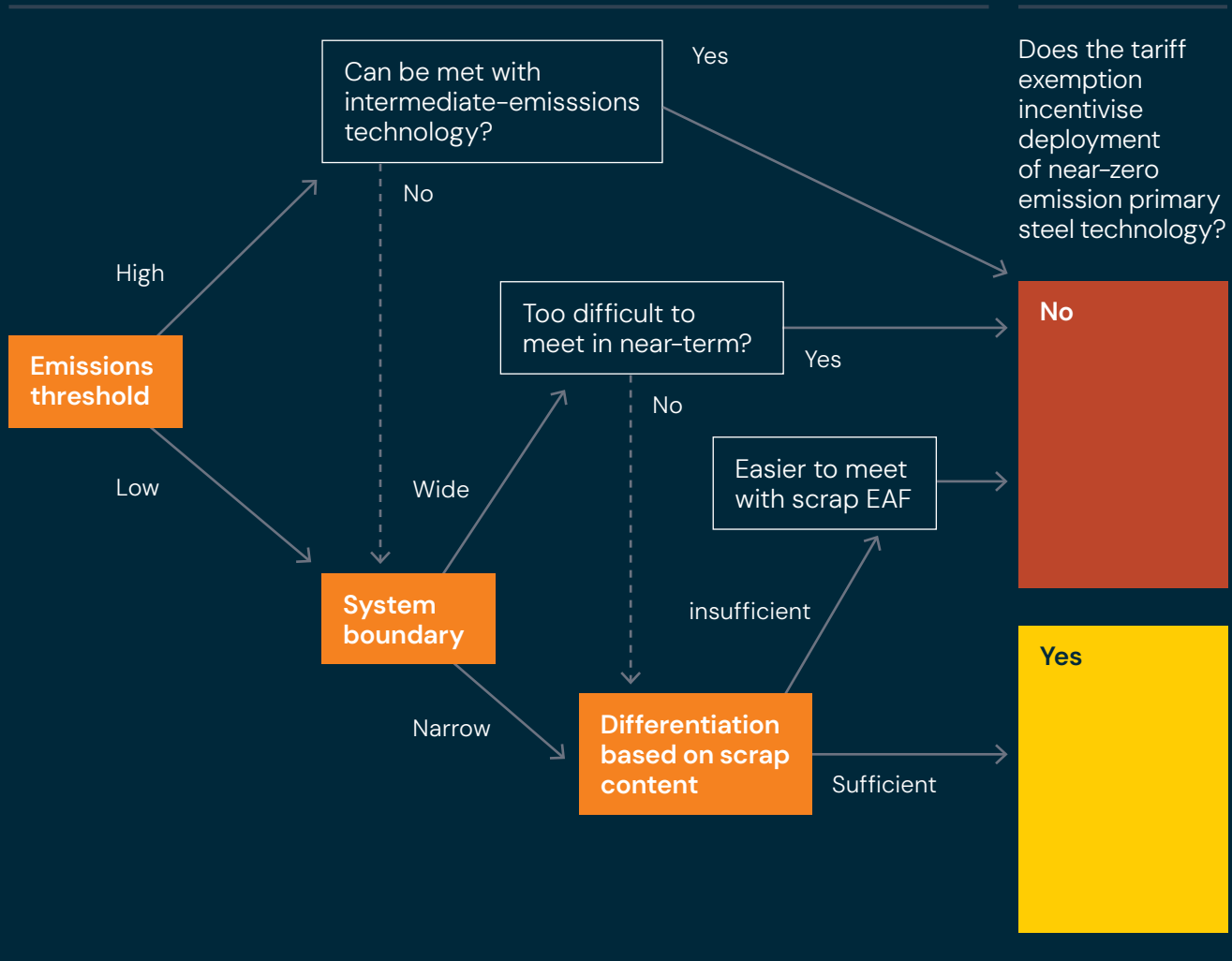
Figure 24 illustrates how the three choices described above are interdependent and together affect the ability of the plurilateral tariff exemption to achieve its objective.

²⁵⁹ IEA (2022). *Achieving net zero heavy industry sectors in G7 members*.



Figure 24:

How choices of standards affect the likelihood of the tariff exemption policy meeting its objective.



Summary

The choice of standards will determine whether the plurilateral tariffs exemption can meet its intended objective of incentivising investment in the first wave of near-zero emission primary steel plants. Agreement on definitions, thresholds, and system boundaries will shape which technologies benefit from the measure. A sliding-scale approach, such as that advanced by the IEA (through its proposed thresholds) and ResponsibleSteel (through its

Decarbonisation Progress Levels and International Production Standard) offers the advantage of broad international support and an integrated approach to primary and secondary production. However, further analysis, or experience, is needed to understand whether the sliding scale would tilt incentives more toward primary or secondary steel. Tighter emissions thresholds, narrower system boundaries, and limits on scrap input could sharpen incentives for investment in near-zero emission primary steel

technologies, but may have trade-offs in relation to feasibility, cost, and near-term emissions. The central task for governments considering a clean steel tariff exemption agreement would be to strike a balance: setting standards that are credible and stringent enough to drive the deployment of near-zero emission primary steel technologies, while being flexible enough to build consensus across diverse steel industries and national circumstances.

The legal basis for a clean steel tariff exemption

Acknowledgements: This subsection summarises the findings of a detailed assessment carried out pro-bono by Alexander Ehrle and Frederik Doerr, facilitated by the Net Zero Lawyers Alliance.

An important consideration in relation to a tariff exemption policy would be the extent of its basis in international law. Here, we consider the potential compatibility of a clean steel tariff exemption with WTO rules. We find that the policy could be justified in its discrimination between high and low emission steel using arguments that have previously been accepted by the WTO. The policy's additional discrimination between primary and secondary steel could be challenged, but the need for such discrimination is already recognised by prominent international organisations and industry associations, and a strong case could be made for its necessity. Several aspects of the policy's design would be important to minimising

the risk of successful legal challenge.

Context: a weighing of interests and risks

The objective of sustainable development is recognised in the first paragraph of the Marrakech Agreement of 1994 that established the World Trade Organization (WTO).²⁶⁰ Despite this, sustainability has arguably not been a central consideration in the writing or interpretation of international trade law over the past few decades, and there now exist substantial tensions between trade law as it stands, and governments' climate change policy objectives.²⁶¹ The legality of policy measures critical for the low carbon transition, including clean technology subsidies and targeted

public procurement, is unclear. Measures that directly affect trade may face a high risk of legal challenge. As one example, while there are good arguments in favour of the compatibility of the EU's CBAM with international trade law and despite EU officials having spent years attempting to calibrate the measure to be compatible with WTO rules, Russia initiated a WTO dispute against the CBAM in May 2025.

In this context, the options available to governments are to attempt compliance with WTO rules as closely as possible, to reform the rules through negotiation with other partners, or to ignore the rules. Their choice is likely to be guided by a weighing of interests – in upholding a

²⁶⁰ World Trade Organisation (n.d.). *Marrakesh Agreement establishing the World Trade Organisation*.

²⁶¹ Trachtman, J. P. et al. (2024). *Villars framework for a sustainable global trade system. V2.0*.

rules-based system of international trade, in avoiding successful legal challenges and the imposition of reciprocal measures, and in meeting policy objectives such as avoiding dangerous climate change or increasing industrial competitiveness.

Freedom to reduce tariffs

Countries or jurisdictions that are members of the WTO agree to maximum tariff levels known as ‘bound rates’ for specific product categories.²⁶² They cannot legally exceed these levels, but can impose additional anti-dumping or anti-subsidy duties, or safeguard measures (often in the form of additional tariffs) to protect domestic industries against sudden import surges, if investigations show that these are justified.

WTO members are free to apply tariffs at any level below their bound rates.²⁶³ The act of reducing or exempting tariffs is not in itself restricted by WTO law. However, countries must comply with certain core principles when doing so. The most important of these are concerned with the fair treatment of all WTO members.

The Most-Favoured-Nation principle

The Most-Favoured-Nation principle, as set out in Article I:1 of the General Agreement on Tariffs and Trade (GATT), requires that countries give equally advantageous

treatment to like products from all WTO members. Its purpose is to ensure equal trading terms among all 166 WTO members.

A clean steel tariff exemption is likely to be considered to be in violation of this principle (and so in need of an exception, as discussed below), because it would treat high and low emission steel differently, and this could have unequal consequences across countries.

High and low (and near-zero) emission steel are likely to be considered ‘like products’ because they are the same in their physical properties, end uses, and tariff classifications. Attempts to argue that products are different based on how they have been produced, and how this relates to consumer preferences, have so far been unsuccessful.²⁶⁴

The tariff exemption could be seen as affecting countries unequally, even if it was granted to all countries and even if it was applied with a near-zero emission standard that no country’s steel industry yet met, because of countries’ differing capacities to adapt their industries to the production of near-zero emission steel.²⁶⁵

The basis for differentiating between high and low emission steel

An important set of exceptions exists (in Art. XX of the GATT) that allows WTO members

to justify measures that would otherwise violate core trade rules, such as the Most-Favoured-Nation principle, if those measures are taken to protect important public interests such as health or the environment, and are applied fairly and in good faith.

The clean steel tariff exemption could fall within the scope of one of these exceptions: Art. XX (b), which justifies measures ‘necessary to protect human, animal or plant life or health’. In recent years, WTO judicial decisions have consistently confirmed that measures aiming to address climate change by reducing greenhouse gas emissions contribute to the protection of human, animal, and plant life or health within the meaning of this article of law.²⁶⁶

It would be straightforward to show that the clean steel tariff exemption has the objective of reducing emissions. To qualify for this exception, the policy would also have to be shown to be necessary to achieve that objective. This could be justified with reference to the critical role that trade plays in the steel transition, as described in Section 1 of this report. The WTO itself has acknowledged that ‘trade policy must be a part of the policy toolbox to achieve shared climate goals at the depth and speed required by the climate emergency’.²⁶⁷

²⁶² Van den Bossche, P. & Zdouc, W. (2021). *The Law and Policy of the World Trade Organization, 5th edn.*, p. 477ff. ²⁶³ Appellate Body Report, *Argentina—Textiles and Apparel* (1998), para. 46. ²⁶⁴ The WTO Panel report in *EU—Palm Oil*, issued in January 2025, is the most current and directly relevant ruling on whether the environmental impact associated with production methods can affect product likeness. ²⁶⁵ Note: The ‘climate club’ approach, in which participating countries grant advantages such as tariff reductions or exemptions exclusively to each other and not to outsiders, would violate the Most-Favoured-Nation principle more directly, involving *de jure* discrimination in contrast to the *de facto* discrimination of the tariff exemption. ²⁶⁶ The Panel in *Brazil—Taxation* specified that “the reduction of CO2 emissions is one of the policies covered by subparagraph (b) of Article XX, given that it can fall within the range of policies that protect human life or health”. Panel Report, *Brazil—Taxation*, 2017, para. 7.880. The Panel in *EU—Palm Oil* held that the objective of limiting greenhouse gas emission “*prima facie* relates to the protection of human, animal or plant life or health” since “global warming and climate change pose one of the greatest threats to life and health on the planet”. Panel Report, *EU—Palm Oil* (2025), para. 7.1093. ²⁶⁷ WTO (n.d.) *Trade and Climate Change*.

In addition, Art. XX (g) GATT, which justifies measures ‘relating to the conservation of exhaustible natural resources’, could also provide the basis for an exception. Despite a lack of WTO jurisprudence to date affirming that measures to combat climate change concern and relate to the conservation of exhaustible natural resources, there are convincing arguments that such measures should in principle be amenable to justification under that provision.²⁶⁸ The availability of the exception would, however, require an essentially equal treatment of domestic producers.²⁶⁹

Treating countries fairly: the relevance of standards

For the clean steel tariff exemption to be justified as a measure necessary for the protection of life or health, it must be applied in a way that satisfies two further requirements. (These are set out in the introductory clause of Art. XX, known as the chapeau.)²⁷⁰ The purpose of the chapeau is to balance the right of a country to invoke one of the exceptions against the general rights of other WTO members as provided for in the GATT.²⁷¹

One requirement is that the application of the measure must not constitute a ‘disguised restriction on international trade’, or in other words, a form of hidden protectionism.²⁷² Since the tariff exemption would make imports of near-zero emission

steel less costly to consumers, while tariffs on high emission steel would remain within countries’ bound rates, it is unlikely that the measure could be construed as protectionist or restrictive.

The other requirement is that the application of the measure should not result in ‘arbitrary or unjustifiable discrimination between countries where the same conditions prevail’. This means that any discrimination – any departure from the principle of giving equal advantage to like products from all WTO members – must be rationally related to the policy objective that is the basis of the exception (in this case, protecting life and health from the dangers of climate change).²⁷³ There should be no loopholes that allow equivalent products – those that contribute equally to the pursued objective – to be treated differently, or inequivalent products to be treated the same.²⁷⁴

The tariff exemption’s discrimination between steel products on the basis of their emissions would be clearly related to the climate change policy objective and difficult to characterise as arbitrary or unjustifiable.

The tariff exemption would also involve some degree of discrimination between primary and secondary steel, as outlined in the previous section. If preferential tariffs were applied only to near-zero emission primary steel and not to near-zero emission

secondary steel, or if the emissions thresholds required to qualify for the exemption varied in relation to scrap content, then it would be important to demonstrate that the industrial transformation to near-zero steel production technologies is ultimately required in order to significantly reduce carbon emissions in the steel sector and achieve the stated climate change policy objective, in order to increase the likelihood that the measures will be considered WTO-compatible. This could be demonstrated firstly with reference to climate science, which shows that the risks of climate change will only decrease when net global anthropogenic emissions fall to zero (with this being recognised in the ultimate objective of the UN Framework Convention on Climate Change (1992) being to achieve ‘stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system’²⁷⁵) and secondly with reference to data on the limited availability of scrap steel. The IEA projects that the supply of scrap steel will only be enough for recycling to meet 46% of global demand for new steel in 2050, even in a scenario where demand is limited by improvements in material efficiency.²⁷⁶ This makes the deployment of near-zero emission primary steel (which, unlike secondary steel, is not yet present in the global market or commercially viable) essential to meet the policy objective.

²⁶⁸ Hillman, J. A. (2013) *Changing Climate for Carbon Taxes: Who's Afraid of the WTO?* p. 10. ²⁶⁹ Appellate Body Report, *US—Shrimp* (1998), para. 126–145. ²⁷⁰ Appellate Body Report, *US—Gasoline* (1996), p. 22. ²⁷¹ Appellate Body Report, *US—Shrimp* (1998), para. 156. ²⁷² Lo, C. F. (2013) *The Proper Interpretation of ‘Disguised Restriction on International Trade’ under the WTO: The Need to Look at the Protective Effect*, *Journal of International Dispute Settlement* 4, 111 (130f.). ²⁷³ Appellate Body Report, *EC—Seal Products* (2014), para. 5.306. ²⁷⁴ Leonelli, G. C. (2023). Anti-deforestation npr-PPMs and Carbon Border Measures: Thinking About the Chapeau of Article XX GATT in Times of Climate Crisis. *Journal of International Economic Law* 26, 416 (423f.). ²⁷⁵ UNFCCC (n.d.) *Convention documents*. Note: Stabilization of greenhouse gas concentrations in the atmosphere can only be achieved when net anthropogenic emissions fall to zero. ²⁷⁶ IEA (2021). *Net zero by 2050: a roadmap for the global energy sector*.

The need to discriminate between primary and secondary steel in policies for steel decarbonisation is recognised in the 'sliding scale' standards that have been developed by the IEA, ResponsibleSteel, the German Steel Association, and the China Iron and Steel Association.²⁷⁷ The WTO recognises that 'One key consideration... is how to account for different levels of scrap use in steelmaking', in its information brief on decarbonisation standards in the iron and steel sector.²⁷⁸ The likelihood of a legal challenge on this issue may depend in part on the severity of the discrimination, being more likely if the tariff exemption is applied only to primary steel, and less likely if it is applied to a sliding scale threshold.

Discriminatory trade measures are more likely to be considered compliant with Art. XX if they give flexibility to other countries in pursuing shared policy objectives, with any advantages in market access being conditional on other countries having regulatory programmes *comparable in effectiveness* to that of the importing country,

rather than precisely the same.^{279, 280} The clean steel tariff exemption could provide this flexibility by discriminating only on the basis of two factors: emissions, and the share of scrap steel (as in the sliding scale standards mentioned above). With the right design (such as a near-zero emissions threshold, and sufficient discrimination between primary and secondary steel), the tariff exemption could serve as a driver of the technological transformation of the steel industry. But the measure itself would make no specifications about the technologies to be used in steel production (allowing for the choice between H₂-DRI-EAF, BF-BOF-CCS, biomass-CCS, molten oxide electrolysis, or other possibilities), nor about the policies to be used to deploy those technologies (which may be subsidy-based, tax-based, or regulatory). In this regard, the tariff exemption may have an advantage over a CBAM, which can be seen as compelling other countries to adopt carbon pricing as a policy instrument.²⁸¹

Ensuring that steel producers' compliance with the tariff exemption's qualifying criteria is verified in a transparent, reliable, and non-discriminatory manner would also be important to avoid accusations of arbitrary or unjustifiable discrimination.

A duty to negotiate

A final principle relevant to compliance with Art. XX is that a country should engage in bilateral or multilateral negotiations, making 'serious, good faith efforts' to reach an international agreement on shared goals, before resorting to unilateral, trade-restrictive measures.²⁸² Although the tariff exemption is not restrictive, it is discriminatory, and so this principle could still apply. Countries could initiate such discussions in the WTO or in smaller groups of steel-producing countries. The difficulty of agreeing a coordinated clean steel tariff exemption among a group of countries is likely to increase with the number of countries involved. On the other hand, involving more of the countries with strong interests in the sector could reduce the risks of legal challenge.

²⁷⁷ ResponsibleSteel and Low Emission Steel Standard (2025). *The steel decarbonisation scale: a briefing for policymakers inside the EU designing a label for low-emission steel*.²⁷⁸ WTO (2022). *Decarbonization standards and the iron and steel sector: how can the WTO support greater coherence*. Information brief no. 7.²⁷⁹ Art. 21.5 DSU Appellate Body Report, *US—Shrimp* (2001) para. 144.²⁸⁰ Van den Bossche, P. & Zdouc, W. (2021). *The Law and Policy of the World Trade Organization*, 5th edn., p. 477ff.²⁸¹ This argument can be made because a CBAM does not (easily) take into account other countries' non-price regulatory instruments that may be comparable in environmental effectiveness to carbon pricing and that may also decrease the carbon leakage effect. See, e.g., Durán G. M. (2023) Securing Compatibility of Carbon Border Adjustments with the Multilateral Climate and Trade Regimes, *International and Comparative Law Quarterly* 72 (2023), 73 (96f.); Leonelli G. C. (2023) Anti-deforestation npr-PPMs and Carbon Border Measures: Thinking About the Chapeau of Article XX GATT in Times of Climate Crisis, *Journal of International Economic Law* 26 (2023), 416 (432).²⁸² Art. 21.5 DSU Appellate Body Report, *US—Shrimp* (2001), para. 134.

Conclusion

The justification in trade law of the clean steel tariff exemption could rely on arguments that have previously been accepted by the WTO for discriminating between high and low emission products. The policy's additional discrimination between primary and secondary steel could be

challenged, but the need for such discrimination is already recognised by prominent international organisations and industry associations, and a strong case could be made for its necessity. Designing the policy so as to give countries flexibility in how their industries can qualify for the exemption,

ensuring a fair and transparent verification process, and engaging in good faith to seek agreement with countries before implementation, would all be important to minimise the risks of the policy being held to discriminate between countries unjustifiably.

Option 4:

Agreement on principles for clean steel subsidies

Acknowledgements:

Within this section, the subsections 'The legal grey area' and 'More radical options' summarise the findings of a detailed assessment carried out pro-bono by Alexander Ehrle and Frederik Doerr facilitated by the Net Zero Lawyers Alliance.

Unlike carbon prices or regulations, clean steel subsidies could enable the deployment of near-zero emission steel technologies without disadvantaging domestic industry in international markets, as we described in Section 3. This means that they could prove to be governments' most important policy lever for the transition.

Although subsidies have been prevalent in the steel sector for decades, their use to support the deployment of clean steel technologies is relatively recent. The status of these clean steel subsidies in international trade law is not entirely clear.

An agreement among major steel producers on the principles for clean steel subsidies could potentially reduce the risks of legal challenge, increase governments' confidence in the use of this policy, and, by extension, increase the industry's confidence in taking advantage of policy support to deploy near-zero emission steel technologies.



Unlike carbon prices or regulations, clean steel subsidies could enable the deployment of near-zero emission steel technologies without disadvantaging domestic industry in international markets.



The legal grey area

The WTO Agreement on Subsidies and Countervailing Measures (SCM Agreement) is the main source of international trade law regarding subsidies. A clean steel subsidy does not qualify as a prohibited subsidy in accordance with Art. 3 of the SCM Agreement, provided that it is not conditional on the steel being exported or on the substitution of imports with domestically produced steel. However, it may be considered 'actionable', meaning that it could be challenged by other WTO members. A challenge could take the form of a country either conducting an investigation and imposing countervailing duties on subsidised imports that are found to cause injury to its domestic industry, or initiating a formal dispute within the WTO against the countries granting the subsidy with the aim of requiring the withdrawal of the subsidy, the removal of its adverse effects, or the payment of compensation.

A clean steel subsidy would be considered actionable if it were found to have adverse effects on the interests of other WTO members. A subsidy is considered to have adverse effects if it results in an injury to the domestic industry of another WTO member, nullifies or impairs benefits accruing directly or indirectly to other WTO members under the GATT, or causes serious prejudice to the interests of other WTO members. Adverse effects could in particular include subsidised imports undercutting domestic production, significantly depressing prices, or impeding

the export of other steel to a third country market, leading to loss of sales or market share. The threat of such consequences also counts as an adverse effect. Designing the subsidy so that it only offset the additional costs of near-zero emission production could potentially avoid the subsidised clean steel undercutting another country's domestic production or exports, and could potentially exclude its qualification as having adverse effects. Whether the subsidy resulted in significant price suppression might depend on the extent to which it led to additional production capacity in the country where it was implemented, rather than simply displacing existing conventional capacity. Ultimately, the determination of whether a subsidy caused adverse effects would be based on a detailed assessment of its economic impact. Whether or not clean steel subsidies would ultimately be considered to qualify as actionable subsidies will depend on the concrete details of the subsidies granted and cannot be entirely clarified upfront.

There is ongoing legal debate over whether the exceptions under GATT Article XX (such as that relating to the protection of life and health, as discussed above), can be used to justify subsidies.²⁸³ This question is at present unresolved. The US government has argued for the applicability of Art. XX exceptions (as well as other exceptions relating to national security) in the ongoing WTO dispute over the tax credits granted under the US Inflation

Reduction Act, but no decision has yet been reached.^{284, 285} Even if the WTO Panel in this case were to find that Art. XX could be applied, there would still be uncertainty over exactly how it should be applied – for example, how the necessity of a subsidy for the protection of life or health might be evaluated.

The case for agreeing principles

Given the uncertainty in the legal position, it seems likely that governments implementing clean steel subsidies are designing them carefully, judging the legal risks to be acceptable, and perhaps expecting growing international concern over climate change to increasingly influence how WTO rules are interpreted and applied. As we noted in Section 3, these governments include Germany, Japan, the USA (former administration), the EU, and the UK, and their approaches to supporting the deployment of clean steel or its component technologies include carbon contracts for difference (CCfDs), tax credits, capital grants, and operating subsidies.

Without any form of international agreement, there are some risks inherent in this approach. A government could spend time, money, and political effort supporting its steel industry to embark on the transition to near-zero emission technologies, only to find that its trading partners consider its approach to be unfair and impose countervailing duties or other trade restrictions. China's experience with electric vehicles is a case in point: its

²⁸³ See, e.g., Rubini, L. (2012). Ain't Wastin' Time No More: Subsidies for Renewable Energy, the SCM Agreement, Policy Space, and Law Reform, *Journal of International Economic Law* 15, 525 (559ff.). ²⁸⁴ Lester, S. (2025). *The U.S. Argument that GATT Article XX Applies to Non-GATT Goods Agreements* (Including the SCM Agreement), International Economic Law and Policy Blog. ²⁸⁵ *First Written Submission by the United States of America, US—IRA Tax Credits* (2025, 21 March).

policies for the transition have been spectacularly successful, and its EVs now face tariffs of up to 45% in the EU,²⁸⁶ and 100% in the USA even under the Biden administration.²⁸⁷ If steel companies anticipate such outcomes in future, those whose business depends heavily on exports may be less willing to undertake government-supported investments in clean steel technology deployment now.

Looked at from the opposite perspective, if there is no consensus internationally on the extent to which clean steel subsidies are acceptable, a risk to any steel-producing country is that its competitors may embrace subsidies too enthusiastically, achieving dominance in the new technology as a result. Policymakers in the EU and US may take this view of what has happened in the automotive sector.

These risks cannot be eliminated, but they could be mitigated. A political agreement on principles for clean steel subsidies could establish some mutual understanding of what may be considered acceptable among trading partners. There would be advantages in discussing this sooner, before subsidy policies are widely designed and implemented, rather than later. This could allow governments and industry to invest in clean steel production with more confidence, and could go some way to establishing a level playing field.

An agreement on principles for clean steel subsidies could also be important to enable joint

action on a clean steel tariff exemption. Countries implementing the tariff exemption would naturally have a strong interest in the fairness of each other's deployment policies, particularly subsidies.

Political difficulty, and a practical starting point

An agreement on *principles* for clean steel subsidies could be difficult to reach in the current context, depending on the level of detail attempted, but would not be as difficult as agreeing substantive policies such as carbon prices or tariff reductions.

Countries currently subsidise their steel industries at very different levels. Compiling accurate data on subsidies is difficult because of the wide variety of subsidy mechanisms – ranging from tax relief to low-cost financing. While acknowledging these constraints, the OECD estimates that subsidies in the form of cash grants, cash awards, and cost refunds were ten times higher in OECD partner countries (such as China, India, and Brazil) than in OECD member countries, in the period from 2008 to 2020. In the same period, OECD data for 19 of the largest steel-producing countries suggests that subsidies for capacity extension, new investment, and capital equipment were significant in all but one year. There were contrasting directions of change within this period: cash grants and cost refunds fell by 80% between 2011 and 2017 in OECD countries, and increased by 219% in non-OECD countries between 2008 and 2014.²⁸⁸

The extent of subsidies has caused widespread consternation amongst OECD countries, expressed through fora such as the Global Forum on Steel Excess Capacity. In a Ministerial Statement OECD countries argued that excess steelmaking capacity is being fuelled by non-market policies and practices in some countries, and reaffirmed the principles of the founding members of the forum in 2017, calling for a level playing field in the steel industry, refraining from market-distorting subsidies, and increasing transparency. They also encouraged steel-producing and steel-consuming countries with similar concerns to cooperate with the forum to jointly develop effective responses.²⁸⁹

In this context, governments may be reluctant to disclose full details of subsidy levels or methodologies, making it difficult, if an agreement is reached, to assess whether a country is acting in accordance with the principles or not. Differences in industrial and economic structures – such as the extent of state or private ownership – further increase the difficulty of comparing subsidies or other forms of policy support between countries.

While deep subsidy transparency may be politically unachievable in the short term, developing voluntary principles or non-binding guidelines could provide a constructive starting point for future cooperation or for managing future disputes.

²⁸⁶ De Prez, M. (2025). *Threat of tariffs raises questions over Chinese electric vehicle takeover*. FleetNews. ²⁸⁷ Sherman, N. (2024). *Biden hits Chinese electric cars and solar cells with higher tariffs*. BBC News. ²⁸⁸ OECD. (2023). *Subsidies to the steel industry*. Note: Cash grants, awards and cost refunds make up three-quarters of subsidies, followed by tax benefits (11%) and subsidised lending, equity infusions and debt-to-equity swaps (4%) ²⁸⁹ Global Forum on Steel Excess Capacity (2024, 8 October). *Ministerial statement*.

Countries are already committed to common rules on subsidies generally through the WTO Agreement on Subsidies and Countervailing Measures. A starting point could be to agree how the spirit of these rules should be reflected in practice, in policies to advance the transition to near-zero emission steel. The European Commission has committed to provide guidance to EU governments on how clean steel subsidies can best be structured in line with EU State Aid rules.²⁹⁰ Instead of developing such guidance unilaterally, the EU and other countries could develop it jointly.

More radical options

A more radical approach would be to try to change the rules of international trade, either temporarily or permanently. Ngozi Okonjo-Iweala, Director-General of the WTO, recently wrote, 'WTO members should use the present crisis [of confidence in the international trading system brought about by the US's unilateral actions] to tackle the problems they feel bedevil the system. This would mean modernising the rule book, which mostly dates back to the early 1990s.'²⁹¹ Improving alignment with sustainability objectives is one of the most obvious ways in which trade rules could and should be modernised, and extensive consultations on this issue have taken place in recent years, most notably through the Remaking Trade for a Sustainable Future project.²⁹²

The strongest approach to changing the rules would be to modify the existing WTO agreements, but this would also be the most difficult. It would require not only consensus among WTO members, but also formal ratification through domestic legislative or constitutional processes. One level down in strength and difficulty would be an 'authoritative interpretation' of the WTO agreements, by WTO members. This could, for example, decide that products otherwise identical should not be considered 'like products' if they differ in the emissions caused in their production. The European Parliament passed a resolution in 1998 urging the European Commission to advocate such a rule change, but a formal proposal was never submitted.²⁹³ An authoritative interpretation does not require ratification but, despite this, is still likely to be prohibitively difficult. Formally, it requires the support of three-quarters of the WTO membership, but in practice all decisions within the WTO are made by consensus, meaning no member formally objects.²⁹⁴ No authoritative interpretation has yet been adopted, throughout the WTO's history.

An alternative approach could be to agree a temporary waiver, allowing deviation from specific rules for specific reasons. In contrast to the rarely used option of amending WTO law, waivers are a familiar

instrument to WTO members and have been used repeatedly in the past. Historically, waivers have been granted on the basis of unanimous decisions among the WTO members and primarily to provide preferential treatment to developing countries or to address urgent economic or humanitarian needs. Examples include the Kimberley waiver, which permits trade-restrictive measures concerning conflict diamonds; the Lomé and Cotonou waivers, which allowed the European Communities to grant preferential treatment to certain African, Caribbean, and Pacific nations; and a waiver under the TRIPS Agreement aimed at making COVID-19 vaccines more accessible to developing countries.

The idea of a 'climate waiver' has been put forward by trade law experts including former WTO Appellate Body member James Bacchus. It has been suggested that this could cover 'all trade-restrictive climate response measures that are based on the amount of carbon used or emitted in making a product, and that are taken in furtherance of and in compliance with the Paris Agreement and the UNFCCC.'²⁹⁵ This could enable discrimination based on the emissions involved in processes and production, removing uncertainty around the applicability of Article XX exceptions. A climate waiver would be 'considerably more extensive than any previous collective waiver', but this

²⁹⁰ European Commission (2025). *A European steel and metals action plan*, p16. ²⁹¹ Okonjo-Iweala, N. (2025). *A stress test for global trade*, *Financial Times*. She also wrote that 'The treasured consensus decision-making system must not become a recipe for paralysis. One way to do this would be to make plurilateral agreements easier.' ²⁹² Trachtman, J. P. et al. (2024). *Villars framework for a sustainable global trade system. V2.0*. ²⁹³ European Parliament (1998, 18 May). *Resolution on environmental, health and consumer protection aspects of world trade*. ²⁹⁴ Would also apply to authoritative interpretations according to Ehlermann C. D. & Ehling, L. (2005) The Authoritative Interpretation under Article IX:2 of the Agreement Establishing the World Trade Organization: Current Law, Practice and Possible Improvements, *Journal of International Economic Law* 8: 803 (805f.). ²⁹⁵ Bacchus, J. (2017). *The Case for a WTO Climate Waiver*, CIGI Report, p. 20; see also Crowe, P. (2021). *Carbon Tariffs and Conflict Diamonds – A WTO Climate Waiver and the UK's Role in the International Legal Order*, Cambridge International Law Journal Blog.

could arguably be justified by the urgency and scale of the climate change problem.²⁹⁶ It would undoubtedly be difficult to agree, as it would require consensus among all WTO members. The political conditions for it to become possible have been described in the following terms: 'WTO Members must, first of all, be persuaded that a multilateral effort to frame a WTO climate waiver is far better for the multilateral trading system than waiting for the approaching legal collision between trade and climate change that will add to all that is already threatening the survival and continued success of the system.'²⁹⁷

A final option is the adoption of a peace clause, where WTO members agree to a time-limited and conditional moratorium on the use of dispute settlement procedures on a particular issue.²⁹⁸ There are precedents for this: for example, in 2013 all WTO

members agreed on an interim peace clause concerning public stockholding programmes for food security in developing countries.²⁹⁹ Under this agreement, subsidies provided through such programmes would not be subject to legal challenge under the WTO dispute settlement system. It was agreed that the peace clause would remain in place 'until a permanent solution is found'. The difficulty, as with the other approaches to changing or suspending WTO rules, is that the adoption of a peace clause would require the consensus of all WTO members.³⁰⁰

Conclusion

The path of least resistance is for governments to muddle through, accepting the legal uncertainty, designing subsidy policies carefully, and tolerating the risks. But this could reduce confidence in clean steel investment in the near term, and store up problems for the transition in the medium term.

A political agreement between major steel-producing countries on principles for clean steel subsidies could make it easier for governments to invest in clean steel production with confidence in the near term, and at least partly reduce the risk of subsidy races followed by retaliatory protectionist measures which then hold back the transition in future. This would be difficult to agree, but much less so than the more radical options of reforming or suspending WTO rules or processes.



A political agreement between major steel-producing countries on principles for clean steel subsidies could make it easier for governments to invest in clean steel production.

²⁹⁶ Bacchus, J., *Reimagining Trade Rules to Address Climate Change in a Post-Pandemic World*, Presentation at Chatham House (2020, 5 May). ²⁹⁷ Bacchus, J., *Reimagining Trade Rules to Address Climate Change in a Post-Pandemic World*, Presentation at Chatham House (2020, 5 May). ²⁹⁸ Trade Justice Education Fund (2022). *The Case for and Design of a Climate Peace Clause*, Paper; Das, K. et al. (2018). *Making the International Trade System Work for Climate Change: Assessing the Options*, Climate Strategies Paper, p. 21f.; Porges, A. & Brewer, T. L. (2013). *Climate Change and a Renewable Energy Scale-up: Responding to Challenges Posed to the WTO*, The E15 Initiative Think Piece, p. 7. ²⁹⁹ WTO Ministerial Decision of 7 December 2013, *Public Stockholding for Food Security Purposes*. ³⁰⁰ Trade Justice Education Fund (2022). *The Case for and Design of a Climate Peace Clause*, Paper; Das, K. et al. (2018). *Making the International Trade System Work for Climate Change: Assessing the Options*, Climate Strategies Paper, p. 21f.; Porges, A. & Brewer, T. L. (2013). *Climate Change and a Renewable Energy Scale-up: Responding to Challenges Posed to the WTO*, The E15 Initiative Think Piece, p. 7.



Option 5:

Clean steel mandates

A clean steel mandate would require companies to produce a certain proportion of their steel output using near-zero emission forms of production, with the required proportion increasing over time. This policy has not yet been used by any country in the steel sector, but it has precedent in other sectors. Most notably, zero emission vehicle mandates used in the road transport sector have proven to be powerful tools to reallocate industry investment towards the new technologies.

In the steel sector, a mandate imposed without any other

form of policy support would create immediate competitiveness risks due to the higher cost of clean technologies. There are two ways this could be overcome. One option is for the mandate to be imposed as a complement to clean steel subsidies (which may be funded by a recharge, as described in Section 3). Alternatively, the mandate could include a compliance credit system, where companies that produced more near-zero emission steel than required could sell credits, and those that did not meet the obligation would be

required to buy credits, or else face fines.³⁰¹

The economics of the credit system would be similar to those of the subsidy-and-recharge policy, with the steel industry effectively paying for its own subsidies.

There could be several benefits to international coordination on clean steel mandates. If used in parallel by major steel-producing countries, mandates would rapidly expand the market for clean steel, spurring the development of supply chains, incentivising innovation, and

³⁰¹ Bataille, C. et al. (2024). *Triggering Investment in First-of-a-kind and early near-zero emission industrial facilities*.



In the steel sector, a mandate imposed without any other form of policy support would create immediate competitiveness risks due to the higher cost of clean technologies.

accelerating cost reduction through economies of scale. By forcing the pace of the transition in major producers, this approach could increase the chances of a global steel transition in line with internationally agreed climate change goals. Early in the transition, if a credit trading system was operated internationally, the finance needed to support the first wave of near-zero emission primary steel plants would be drawn from a large pool, incurring only very small costs for the industry as a whole.

The main difficulties facing international coordination on a clean steel mandate arise from its being a policy that prescribes a rate of change over the course of time, rather than simply changing the conditions in the present. Governments tend to have low confidence in the rate of change that will be possible, early in a transition. (Government targets set in 2006 for solar PV deployment in 2020 were collectively more than ten times lower than the actual global deployment achieved in 2020.)³⁰²

In addition, the fact that differences in existing technologies and resources are likely to make the transition to clean steel production methods more difficult in some countries than in others is likely to increase the perceived risks of committing to a certain trajectory. It may be possible to overcome these differences if at first the mandates are set to cover a very short period of time, and to only require a small share of clean steel in production.

An international credit trading system is an option, not a prerequisite, for international coordination on clean steel mandates. (National credit trading systems, or no credit trading, are alternative options.) A difficulty specific to this option is that it would involve steel companies in some countries cross-subsidising early-mover steel companies in other countries. This could be a barrier to agreement, even though the credit-trading would take place within a market-based system.

Coordinated clean steel mandates are worth considering as an option for plurilateral cooperation on the steel transition, but uncertainties related to the pace of the transition could be a significant barrier to agreement. A short-term, low-level mandate could contribute to enabling investment in the first wave of near-zero emission primary steel plants. The feasibility of coordination around more powerful, long-term mandates may increase when more progress in the transition has been made and there is greater confidence in the new technologies.

³⁰² Beinhöcker, E. et al. (2018). *The Tipping Point: How the G20 can lead the transition to a prosperous clean energy economy.*



Conclusion

Plurilateral cooperation offers a potentially important way to support the global transition to near-zero emission steel as a complement to effective national policies and bilateral cooperation. It is likely to be more viable if it avoids measures that front-load costs on existing steel producers in uneven ways. The most widely discussed approach of coordination on carbon pricing is likely to be particularly difficult to agree among major steel producers due to its highly uneven effect across countries. International coordination on emissions intensity regulations would face similar difficulties, making this approach similarly unlikely to be viable at this early stage of the transition.



Plurilateral cooperation is likely to be more viable if it avoids measures that front-load costs on existing steel producers in uneven ways. A more promising near-term pathway involves positive-sum collaboration to create and grow new markets for clean steel.

A more promising near-term pathway involves positive-sum collaboration to create and grow new markets for clean steel. An agreement on a tariff exemption for near-zero emission steel could be viable, since this would have no immediate impact on countries' costs of steel production or balances of steel trade. Together with national policies that closed the cost gap between conventional steel and near-zero emissions steel, this could give clean steel an advantage in international trade. An agreement on principles for clean steel subsidies could increase industry confidence to invest in new production facilities.

Although these approaches would still face significant political challenges, they present fewer immediate competitiveness concerns than those that impose costs or restrictions on existing industries, and may be more aligned with the interests of countries that are investing early in clean steel technologies.

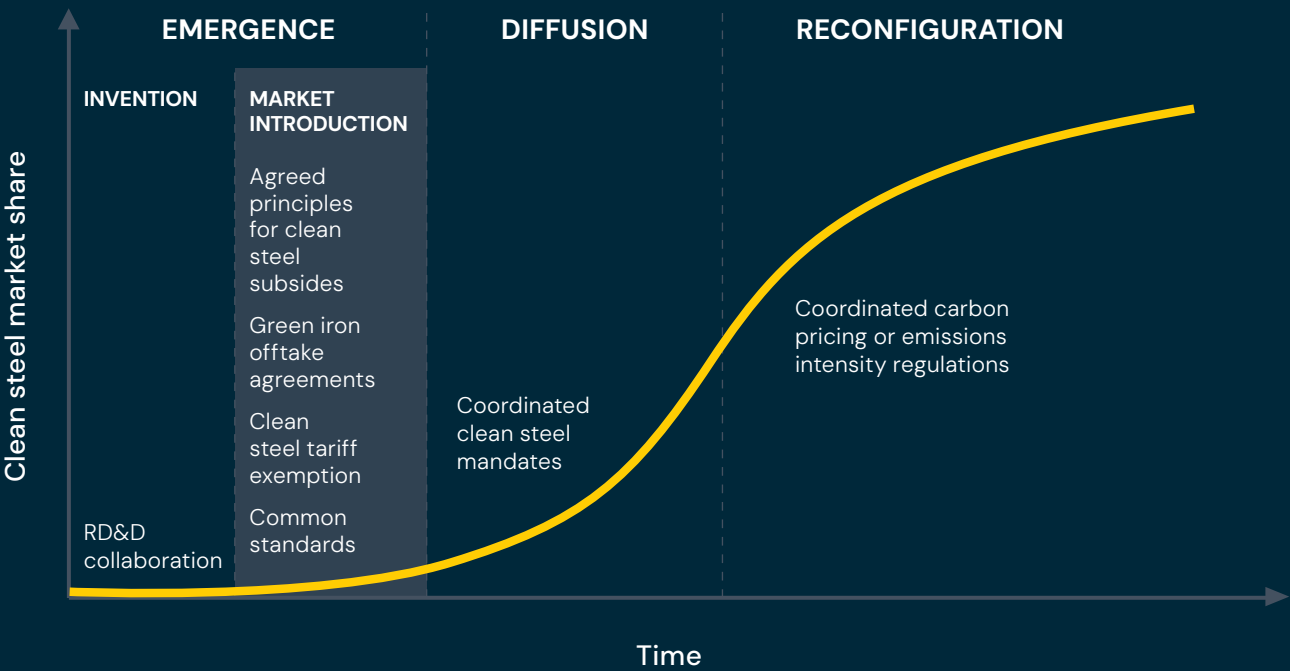
This assessment is specific to the current stage of the steel transition: the 'market introduction' stage, where the most pressing challenge is to achieve the first deployment of near-zero emission primary steel production technologies. As the transition progresses, the relative feasibility and

importance of different forms of international cooperation will change.³⁰³ Clean steel mandates could be used to greater effect in the diffusion stage, when the new technologies are well established and the challenge is to spread them through markets more rapidly. Coordination on carbon pricing or emissions intensity regulations may become more feasible in the late stages of the transition, when the high emission technologies represent a small share of the market and have decreasing economic importance. **Figure 25** gives a rough illustration of this sequence.

³⁰³ IEA and UN Climate Change High-Level Champions (2022). The Breakthrough Agenda Report 2022.



Figure 25: Relative importance of different forms of plurilateral cooperation at each stage of the global transition to clean steel.





Next steps for international diplomacy

6

The transformation of the global steel sector is a defining test of the international community's ability to deliver deep decarbonisation in a sector characterised by acute exposure to international trade.

This report has examined the multiple levers available to policymakers – unilateral, bilateral, and plurilateral – and evaluated their potential to accelerate the deployment of near-zero emission primary steel production. In this section, we review current international

diplomatic efforts to address steel decarbonisation and the issue of trade. We argue for greater focus by governments on creating trade conditions that support the deployment of near-zero emission steel, and suggest how this could be achieved.

Key messages

- The steel sector is a defining test of whether the international trading system can enable deep decarbonisation in a trade-exposed, emissions-intensive industry.
- International cooperation is taking place on various aspects of the steel transition, but trade diplomacy on the transition is relatively underdeveloped.
- Multilateral discussions on climate change and trade are beginning to take place through the WTO, but are limited by the trade-off between breadth of participation and depth of potential cooperation.
- Plurilateral cooperation among a small group of major iron- and steel-producing countries could be instrumental in accelerating the transition to clean steel. None of the existing plurilateral fora have the necessary focus and participation. A new strategic dialogue is needed, focused on creating the trade conditions to enable rapid deployment of near-zero emission steel.

International cooperation on the steel transition is progressing in several areas

International cooperation on steel decarbonisation between policymakers, industry, and civil society is advancing across a number of policy areas.³⁰⁴ The breadth of collaborative activity is demonstrated by the actions agreed by governments as part of the Breakthrough Agenda (a process in which countries work to strengthen international collaboration on the transition in major-emitting sectors),³⁰⁵ and is documented in the independent assessments of progress made annually by the IEA and UN Climate Change High-Level Champions.³⁰⁶ It includes:

- **Research and innovation:** Countries including China, Germany, Canada, and South Korea, as well as the European Commission, are working to align research, development and demonstration efforts and share learning to accelerate clean technology innovation in steel and other industries, as part of Mission Innovation's Net-Zero Industries Mission.
- **Definitions and standards:** Governments and a broad range of stakeholders are working towards the interoperability of emissions measurement methodologies, facilitated by international organisations. Dialogues are taking place through initiatives such as the IEA Working Party on Industrial Decarbonisation and the Climate Club, as well as the Steel Standards Principles group and the Industrial Deep Decarbonisation Initiative (IDDI). However, political decisions on the adoption and implementation of definitions and standards have not yet been made.³⁰⁷

³⁰⁴ IEA and UN Climate Change High-Level Champions (2024). *The Breakthrough Agenda Report 2024*. ³⁰⁵ The Breakthrough Agenda (2025). *Steel breakthrough: priority international actions for 2025 (n.d.)*. ³⁰⁶ IEA and UN Climate Change High-Level Champions (2024). *The Breakthrough Agenda Report 2024*. ³⁰⁷ IEA and UN Climate Change High-Level Champions (2024). *The Breakthrough Agenda Report 2024*.



- **Demand creation:** Public procurement commitments for low emission or near-zero emission steel have been made at varying levels by some countries through the IDDI Green Public Procurement Pledge. However, these are at different stages of implementation in national policy.
- **Finance and investment:** Governments have increased international funding to support industry decarbonisation in developing countries, including a \$1.3 billion pledge at COP29 through the Climate Investment Fund and funding from the UK, Germany, and Canada.³⁰⁸ The Climate Club Work Programme 2025–26 has established a Global Matchmaking Platform to enhance industrial decarbonisation, with members tasked to ‘systematically map and report industry decarbonisation assistance’ and share best practices, including on accounting and standards.³⁰⁹



The tensions that already exist between countries on the issue of overcapacity, and the risk of future disputes over clean steel subsidies, are a reason for diplomacy, not an argument against it.

³⁰⁸ *COP29 Global Pledge: scaling international assistance for industry decarbonisation* (2024, November 18). ³⁰⁹ Climate Club (2025). *Climate Club work programme 2025–26*.

No existing forum has the focus and participation necessary for strategic trade diplomacy on the steel transition

In the area of trade, diplomacy on the steel transition is relatively underdeveloped.

Multilateral discussions on the interface between climate, trade and environmental issues, including in the steel sector, are beginning to take place through the World Trade Organization. The Committee on Trade and Environment was established in 1995 as a forum for dialogue but not decision-making, and includes all WTO members.³¹⁰ However, this forum has not focused on issues relating to the steel transition in any depth. The Trade and Environmental Sustainability Structured Discussions (TESSD) were launched in 2020 to advance discussions broadly on trade and environmental sustainability, with a membership covering 80% of global trade. Although not steel-specific, this forum can discuss steel-related trade policy issues, such as steel standards principles, which were discussed in 2024.³¹¹

Multilateral discussions benefit from a high degree of legitimacy, and are useful for establishing shared goals and norms. But they are limited by the trade-off between breadth and depth: the more countries participate, the more difficult it is to agree on substantive actions.³¹² At this early stage of the steel transition, while there are significant uncertainties around technological feasibility

and the economic implications of the transition, it appears highly unlikely that there could be any multilateral agreement of a substantive nature.

Plurilateral diplomacy could be valuable as a complement to national policy and bilateral cooperation, because aligned action by a few major steel-producing countries could strongly influence conditions in the global market. Plurilateral diplomacy would be most likely to be effective if it included a small number of countries that are influential in the sector and whose economic interests are aligned with the transition. China, India, and the EU are important as the three largest steel producers, and their various interests in energy security, technology leadership, and near-term decarbonisation are more aligned than opposed to the transition. Australia, Brazil, and South Africa have strong economic interests aligned with the transition due to their extensive renewable energy and iron ore resources, and could be increasingly influential within the sector for the same reason. There is potential for positive-sum cooperation between these countries to advance the transition, at the same time as they compete for market share. The tensions that already exist between some of these countries on the issue of overcapacity, and the risk of future disputes over clean steel subsidies as discussed in

Section 4, are a reason for diplomacy, not an argument against it.

Governments participating in the Breakthrough Agenda process have responded to the IEA and UN Climate Change High-Level Champions' recommendation for a strategic dialogue on trade and the steel transition by agreeing to work through the WTO, the OECD Steel Committee, and the Climate Club to continue dialogue on policies relating to the trade of near-zero emission steel.³¹³ But the WTO faces the limitations of multilateralism described above, and none of the existing plurilateral fora have both a clear focus on the problem of trade in the steel transition and the necessary participation of relevant countries.

The OECD Steel Committee was established in 1978 and has a broader mandate to discuss multilateral problems in the global steel industry and policy solutions to them. Its objectives are to foster closer cooperation, to ensure markets for steel remain as open and free of distortion as possible, and to ensure that the steel industry contributes to global efforts to address climate change.³¹⁴ Its most recent chair's statement highlighted a focus on growing excess capacity, 'non-market' policies and practices, and headwinds to decarbonisation efforts.

³¹⁰ WTO (n.d.). *Committee on Trade and Environment*. ³¹¹ WTO (n.d.). *Trade and environmental sustainability*. ³¹² Victor, D. G., Geels, F. W., & Sharpe, S. (2019). *Accelerating the low carbon transition: the case for stronger, more targeted and coordinated international action*. Energy Transitions Commission. ³¹³ The Breakthrough Agenda (2025). *Steel breakthrough: priority international actions for 2025* (n.d.). ³¹⁴ OECD (n.d.). *Steel Committee*.

This forum has potential to advance dialogue on the role of trade in the steel transition, but an important limitation is that neither China nor India, the world's two largest steel-producing countries, is a participant.³¹⁵ The OECD's Global Forum on Steel Excess Capacity has the same limitation of membership,

and is focused on the problem of overcapacity rather than the problem of how to achieve the transition.³¹⁶

The Climate Club, initiated by Germany in 2022, is focused on industrial decarbonisation and includes trade and finance, competitiveness, and carbon leakage among its priority

topics for dialogue.³¹⁷ It has a broad membership of developed countries and smaller emerging economies, but lacks the participation of major emerging economies important to the steel transition, such as China, India, Brazil, and South Africa.

³¹⁵ India declined an invitation to become an Associate in 2006 but is invited as a 'participant'. China is on the 'invitee list', meaning it may be invited to individual meetings or items.

³¹⁶ Global Forum on Steel Excess Capacity (2024, October 8), [Ministerial Statement](#). ³¹⁷ Climate Club (n.d.), [An inclusive high-level forum for industry decarbonisation](#).

A new dialogue on trade and the steel transition

A new strategic dialogue is needed for effective plurilateral diplomacy on the steel transition, given the lack of an existing one with the appropriate focus and participation. This could begin with an informal dialogue convened by any of the countries that have a strong interest in the transition and influence in the sector.

Governments should not be deterred by the idea that there are 'too many initiatives' for advancing global decarbonisation. Initiatives are not synonymous with serious diplomacy. The importance of trade in relation to decarbonisation of energy-intensive industries has been obvious for decades, and serious diplomacy on this issue involving the most influential countries in these sectors is long overdue.

Plurilateral diplomacy among a group of the largest producers of iron and steel could start from the recognition that although conflict and tension on trade in conventional steel is unlikely to be resolved in the foreseeable future and will require its own diplomatic channel, due to the structural challenges of overcapacity and differences in subsidies, these disagreements do not have to prevent action to advance the transition to clean steel. International cooperation should aim to align the forces of competitive international trade with the near-term deployment of near-zero emission steel production technologies. Discussions could usefully focus on exploring the opportunities for agreement on:

1. A set of principles for subsidising near-zero emission steel.
2. A tariff exemption for primary near-zero emission steel, so that trade in global markets further incentivises its deployment.
3. International green iron offtake arrangements (which may be best negotiated bilaterally, but could also be plurilateral).
4. Shared definitions and standards for near-zero emissions iron and steel, to be used as the basis for any of the above measures (while more general discussions of definitions and standards continue in other fora).

Although reaching agreement on these issues will certainly not be easy – substantive diplomacy never is – cooperation of this kind could have the best chance of giving the steel transition the near-term acceleration that it needs to meet the Paris Agreement goals, turning trade from a barrier to a driver of progress. It could also establish a foundation for more comprehensive trade arrangements in the future, which may become possible when the transition is further advanced.



Conclusion

7

The transformation of the global steel sector depends on reconciling the policy objectives of industrial competitiveness and decarbonisation.

Today, these objectives are in opposition. Trade acts primarily as a barrier to the sector's transition: high trade exposure means that steel producers cannot absorb the higher cost of clean steel production, and persistent overcapacity further reduces their willingness to risk investment in new technologies. Existing trade policies are primarily concerned with

protecting domestic industry against global overcapacity or 'carbon leakage', rather than establishing conditions conducive to the transition in global markets.

With the right conditions in place, trade could shift from blocking progress in the transition to driving it forward – by creating demand signals across borders, enabling

production where resources are most favourable, reorienting competition towards near-zero emission steel technologies, and supporting pathways for industrialisation in developing countries.

There are opportunities to achieve this through unilateral policies, bilateral agreements, and plurilateral diplomacy.

Recommendations

We recommend that governments should focus on the following priorities:

1.

Implement national deployment policies to close the cost gap for near-zero emission primary steel.

Targeted subsidies are likely to be needed for this purpose, and, if funded by a recharge, can be revenue-neutral for government while avoiding competitiveness risks to industry. Public procurement and mandates can also be used to create demand for clean steel. Carbon pricing can be used in parallel, to incentivise a shift from high emission primary production to increased steel recycling.

2.

Develop green iron trade partnerships where these could be beneficial for long-term industrial competitiveness. In countries with high renewable energy costs, policies can blend support for domestic near-zero emission steel production with the option to import green iron from countries with resource advantages. Countries rich in iron ore and renewable energy can pursue this as an opportunity to move up the value chain. These partnerships can build on existing arrangements for cooperation on industrial decarbonisation.

3.

Initiate plurilateral diplomacy focused on creating trade conditions that enable deployment of near-zero emission primary steel production capacity. This should involve the most influential countries in the sector whose interests are not opposed to the transition. Talks could usefully focus on seeking to agree principles for clean steel subsidies, a tariff exemption for clean steel, and the standards and definitions to be used as the basis for these or any other coordinated measures. This approach avoids the immediate, uneven effects on countries' steel production costs and trade that would be inherent in any form of coordinated carbon pricing.



Taken together, these steps could move trade diplomacy in the steel sector out of its defensive position by creating global market conditions where investment, innovation, and competition accelerate the deployment of clean steel technologies.



About us

S-Curve Economics CIC is a non-profit research organisation focused on advancing the understanding of the economics and diplomacy of the energy transition. Our analysis focuses on the power, road transport, and steel sectors, and cross-cutting issues of economics, policy appraisal, and diplomacy.

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