Enabling investment in clean primary steel

The case for subsidy-and-recharge policies

A report of the Breakthrough Agenda Policy Network

Report authors (in alphabetical order):

João Abbud, Luisa Bianchet, Hugo Bolognesi, Thibault Deletombe, Sabarish Elango, Maude Gibbins, Simone Klein, Antonia Kurz, Lin Ziyue, Hemant Mallya, Joe Morrisroe, Prof. Karsten Neuhoff, Stefania Relva, Simon Sharpe, Prof. Wang Pu.

The contents of this report represent the views of its authors, and should not be taken to represent the views of the organisations to which the authors are affiliated, or their funders.

About the Breakthrough Agenda Policy Network

The Breakthrough Agenda Policy Network is a group of institutes in eight countries and regions that conduct joint research and analysis of opportunities for international cooperation to overcome difficult problems in the low carbon transition. In its second year, the Network is focusing on the role of trade in the transition to clean steel, building on analysis on this topic conducted in its first year. S-Curve Economic acts as the secretariat for the network.

Contents

A technical appendix accompanies this report. It is available at:
https://www.scurveeconomics.org/publications/enabling-investment-in-clean-primary-steel/

Executive Summary

Climate goals and competitive advantage

Clean primary steel production is an essential element of the transition to a near-zero emission steel sector, since scrap-based production is only likely to meet around half of global steel demand by 2050.[1] Primary production accounts for 85–90% of current emissions.[2]

While industrial competitiveness in the context of the transition will depend on many factors, for any country it is more likely to be enhanced by early investment in the technologies and supply chains of clean primary steel production than by late investment.

The need for targeted support policies for clean primary steel

> Policy is needed to enable investment in clean primary steel production because of its higher cost compared to conventional steel production – a premium of around 25–50% in the countries covered in this report.

Carbon pricing can be useful for incentivising marginal emissions reductions, influencing investor expectations, and encouraging material efficiency and circularity. But it is unlikely alone to be sufficient to enable investment in clean primary steel production due to the difficulty of setting a high enough carbon price, the uncertainty of carbon prices, and the ability of industry to respond to the policy in other ways that carry lower risks.

Carbon pricing creates competitiveness risks for industry that cannot be fully managed by a carbon border adjustment mechanism (CBAM) of the kind traditionally envisaged and currently implemented by the EU, based on production-specific values. The limitations of the CBAM affect a country's domestic steel producers, steel exporters, and downstream industries.

Targeted subsidies will almost certainly be needed to enable the deployment of clean primary steel production, just as they have been instrumental in the transitions to renewable power and electric vehicles. Long-term subsidy contracts can make clean steel cost-competitive, and reduce the risks of investment to an acceptable level. The process for awarding them can be designed to enable competition between technologies.

Subsidy-and-recharge: a revenue-neutral approach with no competitiveness risks

A clean steel subsidy-and-recharge policy provides subsidies for clean primary steel production, and funds these through a 'recharge' – a levy on all steel domestically produced or imported (that is waived on exports) at a flat rate per tonne of steel. This can be revenue-neutral for the government in each year of implementation.

The subsidy-and-recharge policy can in principle create no competitiveness risks for industry. Domestic steel producers face no additional costs compared to imported steel or any kind. Exporters of steel faces no additional costs, and even clean steel can be exported competitively. The policy can be extended to fully cover downstream industries with less difficulty of administration than a production-specific CBAM since it requires measurement only of the steel content of traded products, and not of the emissions embedded in the steel. In countries with high energy costs, allowing steelmakers the flexibility to use imported green iron can help to ensure long-term competitiveness in the context of the global transition.

---

[1] The Institution of Structural Engineers (2025). The role of scrap in steel decarbonisation. https://www.istructe.org/resources/guidance/the-role-of-scrap-in-steel-decarbonisation/

[2] Morrisroe, J. et al. (2025). Making clean steel competitive in international trade: a positive-sum agenda for policy and diplomacy. S-Curve Economics CIC. https://www.scurveeconomics.org/publications/making-clean-steel-competitive-in-international-trade/

Trivial costs to consumers

The costs of the subsidy-and-recharge policy to consumers would be unnoticeably small. With the policy used to support clean primary steel production equivalent to 10% of a country's total steel production, only small fractions of one percent would be added to the cost of products such as cars, washing machines, or air conditioners. The effect on the costs of buildings, highways, pipelines and railways would be similarly small. Even if the policy is used to decarbonise the entire steel sector and if no technological progress takes place over coming decades (contrary to observed trends), the impact on costs would only rise to a few percent.

A new dynamic: from first-mover risk to late-mover risk

Industry expectations are currently dominated by the perception of first-mover risk in the transition, due to the high cost of clean technologies. Use of the subsidy-and-recharge policy to enable competitive clean primary steel production in one country could shift perceptions towards late-mover risk, increasing the pressure for similar policies in other countries.

Exit strategies

The subsidy-and-recharge policy is designed for use at the current, early stage of the steel transition, where the challenge at hand is the first deployment of near-zero emission technologies. Although there is no reason in principle why it could not function indefinitely, exit strategies include contracts-for-difference that become zero subsidy when technology costs fall and/or clean steel becomes the price-setter in global markets, carbon contracts-for-difference that become zero subsidy when carbon prices rise high enough, and the eventual replacement of subsidies with regulations.

A policy design appropriate to each country

In this report, after first describing the general characteristics of a subsidy-and-recharge policy, we set out how different versions of the policy could be applied in China, India, the EU, Brazil, and the UK. The variations in design reflect differences in countries' industrial structures, resources and institutions. In the EU, for example, it could be embedded in the current EU ETS with a reformed CBAM. The concept common to each approach is that financial resources are drawn from a wide base and concentrated into targeted subsidies for the deployment of clean steel technologies, maximising their effectiveness in enabling investment.

1. The case for clean steel subsidy-and-recharge policies

The case for action on clean primary steel

Enabling investment in clean primary steel[3] is important for two reasons: to build industrial competitiveness in clean steel production methods, and to advance the transition to a near-zero emission steel sector.

Competitiveness

A transformation of the global steel sector towards near-zero emission technologies is implied by the economy-wide targets of net zero emissions or carbon neutrality that have been set by governments of almost all major economies. Industry investment is already moving in this direction, with clean primary steel plants under development in countries including China, Germany, Sweden, South Korea, the Netherlands, France, Finland, and Spain.

Competitiveness in this new context will depend on many factors, including natural resources, and cannot be entirely assured by any government policy. However, for any given country, early investment in the technologies and supply chains of clean primary steel production is more likely than late investment to increase the chances of its steel industry being competitive in this future global market.

This reality has been obscured by perceptions that moving first to clean steel technologies, with their higher costs than conventional steel production, must involve serious competitiveness risks. In this report we show that with well-designed policies, first-mover risks can be greatly reduced, opening up the opportunities of first-mover competitive advantage.

Emissions

Primary (ore-based) steelmaking accounts for around 75% of global steel production and around 85–90% of the sector's emissions at present.[4] Its share of production may fall in future as the volume of steel recycling increases, but given limits on the availability of scrap steel, ore-based production is typically expected to meet around half of global steel demand by 2050.

The goal of carbon neutrality in the steel sector cannot be met through a simple sequence: first recycle, later deploy clean primary steel. Existing assets have long lifetimes, new assets have significant build-times, and the technologies and supply chains of clean primary steel production will take time to develop and mature. Consequently, near-term investment is needed to meet long-term goals. The IEA estimates that over 100 Mtpa of near-zero emission primary steel production capacity is needed globally by 2030 to be consistent with a 2050 net zero scenario, compared with less than 1 Mtpa of such capacity operating in 2024.[5] For the world to be close to that pathway, substantial investment in clean primary steel production capacity needs to be taking place now. The alternative – continued investment in new coal-based production capacity – risks locking capital into assets that are inconsistent with governments' long-term policy goals.[6]

The distinction between primary (ore-based) and secondary (scrap-based) steel production is likely to become less clear in future, as electric arc furnaces increasingly blend inputs of scrap steel and primary iron. Nevertheless, there is a clear need to build near-zero emission iron production to meet the demand that scrap steel cannot supply, and to eventually eliminate all unabated coal-based production capacity.

3. In this paper, 'clean primary steel', refers to steel that is made with near-zero emission methods (achieving 90% emissions reduction compared to a typical BF-BOF plant), in a process that starts with iron ore and ends with crude steel. We distinguish between this as primary steel, and secondary (recycled) steel which uses scrap steel as its sole metallic input, avoiding the iron production stage and its associated emissions.

4. Morrisroe, J. et al. (2025). Making clean steel competitive in international trade: a positive-sum agenda for policy and diplomacy. S-Curve Economics CIC. https://www.scurveeconomics.org/publications/making-clean-steel-competitive-in-international-trade/

5. IEA and UN Climate Change High Level Champions. (2024). Breakthrough Agenda Report 2024. IEA. https://www.iea.org/reports/breakthrough-agenda-report-2024

6. Blast furnaces account for approximately half the new iron production capacity announced and under construction globally. Global Iron and Steel Tracker, June 2026. Available at: https://globalenergymonitor.org/projects/global-iron-steel-tracker

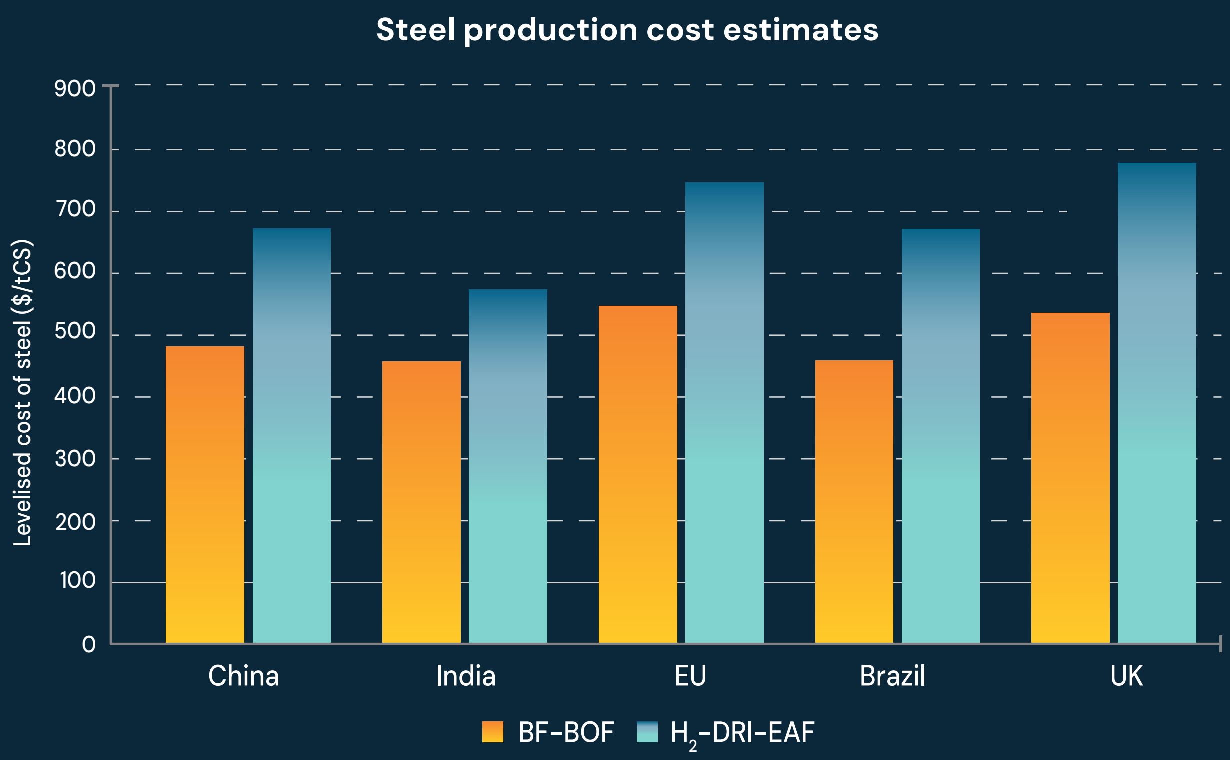
The need for policy

Policy is needed to enable investment in clean primary steel production principally because of its higher cost compared to conventional steel production. In the countries and regions covered in this discussion paper, we estimate the additional cost of steel produced with near-zero emissions through the hydrogen direct reduced iron – electric arc furnace (H_2-DRI-EAF) route to range between 26% and 47% compared to that of the blast furnace – basic oxygen furnace (BF-BOF) route (see Figure 1). The alternative clean primary steel production route of BF-BOF with carbon capture and storage (BF-BOF-CCS) has similarly high cost, less technological maturity, and more complex needs for new infrastructure. Other emerging technology options are yet to be proven at commercial scale. The clean primary steel plants already under development have generally been supported with subsidies[7] and in several cases also with carbon pricing; some have also benefitted from low-cost energy inputs and offtake agreements from buyers willing to pay a premium.

A review of clean steel technology options is beyond the scope of this report. Throughout the report, we use the H_2-DRI-EAF route to illustrate the cost implications of clean steel production and associated policies (this being a route for which many cost estimates are available), while recognising that other technology routes are possible.

The significant additional cost of clean primary steel through any technology route so far demonstrated makes it too risky for companies to invest in such plants in the absence of appropriate supporting policies.

Figure 1: Conventional and clean steel production costs for our set of countries. Primary steel production is modelled at 20% scrap charge in all cases except in India, where lower scrap availability results in a typical scrap charge of 9% for conventional BF-BOF production and expected 13% for DRI-EAF[8], and UK where H_2-DRI-EAF is expected at 50% scrap charge due to high scrap availability.[9] See Technical Appendix for the further details on cost assumptions.



[7] Morrisroe, J. et al. (2025). Making clean steel competitive in international trade: a positive-sum agenda for policy and diplomacy. S-Curve Economics CIC. https://www.scurveeconomics.org/publications/making-clean-steel-competitive-in-international-trade/

[8] Council on Energy, Environment and Water (2023). How can India decarbonise for a net-zero steel industry? CEEW. https://www.ceew.in/publications/how-can-india-decarbonise-for-net-zero-steel-industry

[9] Department for Business and Trade (2025). UK primary steelmaking review 2025. DBT. https://assets.publishing.service.gov.uk/media/690b868714b040dfe829237d/uk-primary-steelmaking-review-2025.pdf

Carbon pricing: useful but not sufficient

Many governments use, or intend to use, carbon pricing as a policy tool to support industrial decarbonisation. The EU and UK have implemented an emissions trading system (ETS), in which steel is one of the sectors covered, since 2005. China expanded its national ETS to include the steel sector earlier this year. Brazil is in the early stages of developing an ETS, and India has announced its Carbon Credits Trading Scheme which includes the steel sector.

Uses

Carbon pricing can be useful in the steel transition for several purposes:

- Incentivising marginal improvements in the emissions intensity of existing steel plants. This can include increased use of scrap steel inputs, co-firing of blast furnaces with biomass or hydrogen, and efficiency improvements, leading to reduced emissions.
- Influencing expectations and investment decisions. Industry can be influenced to invest in lower emission technologies, such as natural gas-DRI-EAF or scrap-EAF plants, instead of BF-BOF plants. The extent of this effect will depend on the level of the carbon price, expectations of its future level, and its interactions with other policies relevant to competition and trade.
- Encouraging material efficiency and circularity, through the increased price of steel.
- Forcing the retirement or replacement of the most emissions intensive steel plants. This may be achieved with a high carbon price or (in an ETS) a hard cap on emissions.

Carbon pricing can also raise revenues that may be used to support the transition in other ways.

Limitations

> Carbon pricing alone is unlikely to be sufficient to enable investment in clean primary steel.

This is due to several factors. First, it is difficult to set carbon prices high enough to make clean primary steel cost-competitive against conventional steel, due to concerns around competitiveness (see 'competitiveness risks' section below). Second, even a high carbon price may not give industry the necessary confidence to invest in clean primary steel. The level of carbon price within an ETS is uncertain, and any carbon pricing policy can be changed as a result of a change of government or of political priorities. Third, a steel company can respond to carbon pricing in ways that are lower risk than investment in clean primary steel production, such as by passing the costs through to consumers, increasing efficiency, or improving emissions intensity in any of the ways described above.

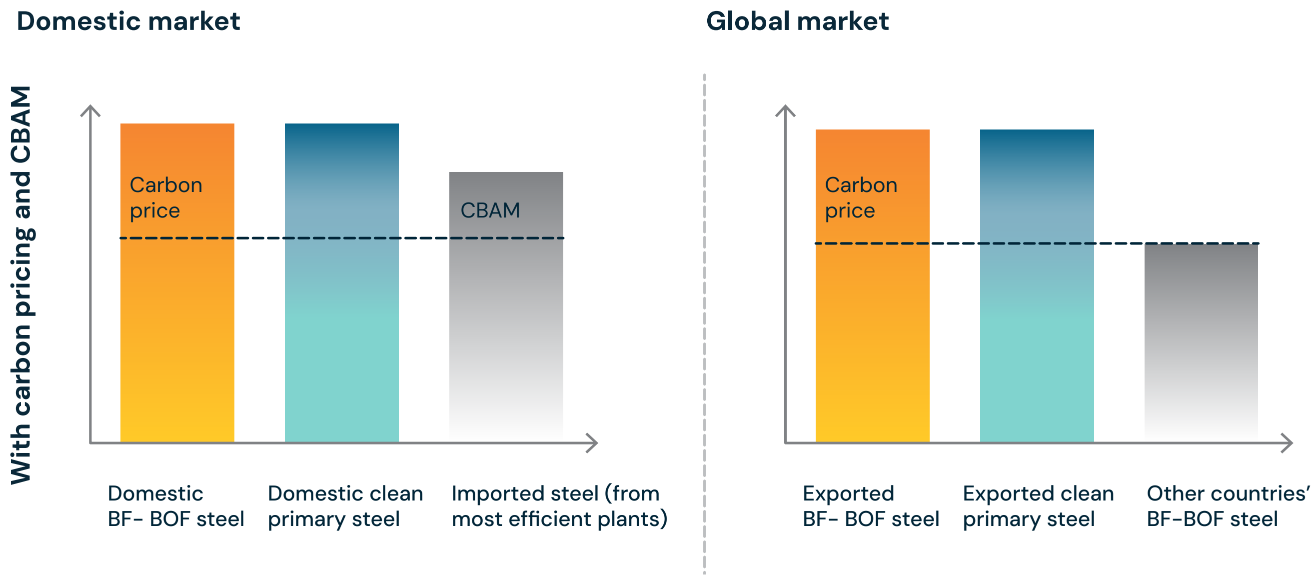
Competitiveness risks

Carbon pricing at the level needed to make near-zero emission primary steel cost-competitive is likely to add significantly to the cost of steel production, at least in the near term (see Table 1). In the absence of coordinated carbon pricing implemented by all major steel-producing countries, this creates competitiveness risks for industry that cannot be fully managed through a carbon border adjustment mechanism (CBAM), at least not by a CBAM of the kind traditionally envisaged and currently implemented in the EU, based on production-specific values. (Proposals for a reformed EU CBAM using standardised values, analogous to the 'recharge' approach discussed below, are set out in the EU chapter of this report). These include:

- Risks to steel production in the domestic market. Domestic steel producers cannot instantaneously change their production methods – they have fixed assets, financial constraints, and project lead-times. Steel producers in other countries can change where they sell their products without necessarily making new investments, and may choose to send their cleanest production to the country where carbon pricing is being implemented. This means domestic steel producers may be undercut by imports of cleaner steel, even when a CBAM is working entirely as intended.
- Risks to the competitiveness of steel exports. Steel exports on which a carbon price has been paid may become uncompetitive in their destination markets. The compatibility of carbon pricing export rebates with WTO law is contested, and the legal justification is thought likely to be weaker in the case of an ETS than in the case of a carbon tax.[10]
- Risks to downstream industries. Preventing carbon pricing from negatively affecting the competitiveness of downstream industries in the domestic market would require a CBAM to be extended to cover all steel-containing products. Reliably establishing the emissions associated with the production of the steel contained in all such products would be highly complex and administratively difficult. Downstream industries would also face export competitiveness risks similar to those faced by steel producers.

The first two of these risks are illustrated in Figure 2.

Figure 2: Risks to steel industry competitiveness arising from carbon pricing are only partially managed by a carbon border adjustment mechanism, in the domestic market and the global market.



[10] Leonelli, G.C. (2022). Export rebates and the EU carbon border adjustment mechanism: WTO law and environmental objections. Journal of World Trade 46(6). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4169900

Table 1: Carbon prices currently in place and required to close the cost gap between BF-BOF and H_2-DRI-EAF steel in China, India, Brazil, the EU and UK. The level required to close the cost gap is estimated using the national average BF-BOF emissions intensities and the production costs shown in Figure 1. *Effective carbon prices for typical BF-BOF plant, taking into account free allocation.

	Current effective level ($/$tCO_2$)[11]	Estimated level required to close cost gap between BF-BOF and H_2-DRI-EAF ($/$tCO_2$)
European Union	28[12]*	116
United Kingdom	17[13]*	155
China	~10	105
India	[0][14]	53
Brazil	[0]	105

The EU and the UK are already exposed to these competitiveness risks due to their being early implementers of industrial carbon pricing at substantial levels. To date, these risks have been managed through the free allocation of emissions permits, allowing steel producers to pay a much lower effective carbon price than the nominal price in the ETS. This is an unsatisfactory solution since it undermines the effectiveness of the policy.
India has a relatively high national average emissions intensity of BF-BOF steel production (at 2.4 tCO_2/t-steel compared to 1.8 tCO_2/t-steel in the EU)[15] and so would be more strongly affected than most countries by a high carbon price. Brazil has less emissions intensive production and good options for cleaner production including biochar and scrap-EAF with clean electricity, but could nevertheless be exposed to competition from steel producers without national carbon prices such as the US.

11. Throughout this report, we refer to 2026 USD, unless otherwise specified.

12. Average auction price in 2025: https://icapcarbonaction.com/en/ets/eu-emissions-trading-system-eu-ets. Effective carbon price estimated for BF-BOF with emissions intensity of 1.87 tCO_2/tCS, with free allocation of benchmark of 1.248 tCO_2/hot metal.

13. 2026 scheme year price. https://www.gov.uk/government/publications/determinations-of-the-uk-ets-carbon-price/uk-ets-carbon-price-for-use-in-civil-penalties-2026. Effective carbon price estimated for BF-BOF with emissions intensity of 1.86 tCO_2/tCS, with free allocation of benchmark of 1.288tCO_2/t hot metal.

14. The CCTS will have floor and ceiling prices; these are yet to be finalised and approved. https://cercind.gov.in/regulations/GZ-205.pdf

15. Elango, S. et al. (2023). Evaluating net-zero for the Indian steel industry: marginal abatement cost curves of carbon mitigation technologies. Council on Energy, Environment and Water.

Targeted support measures will be needed

Targeted subsidies will almost certainly be needed to enable the deployment of clean primary steel production. They can be effective by reducing the risks of clean steel investment to an acceptable level, as well as the costs. The level of subsidy can be fixed in a legally-binding contract, giving a steel company assurance (subject to the robustness of the legal environment) that the support cannot be withdrawn without compensation. The contract duration can be matched to the lifetime of the plant, or at least to the time required to make a return on investment.

Subsidies can be targeted to apply only to near-zero emission primary production, ensuring they support the deployment of new technologies and the development of new supply chains, and do not reward marginal changes to existing production methods. Auctions for subsidy contracts can be used to drive competition and cost reduction, and avoid overcompensation. The amount of subsidy awarded can either be fixed (e.g. per tonne of steel output) or varied in relation to a reference value such as a market price for steel or a carbon price in an ETS.

Clean technology subsidies have been used by many countries in the power sector and road transport transitions, and have been highly effective in enabling the early deployment of solar and wind power and electric vehicles.[16] Industry surveys[17] and modelling studies[18] support the view that they are likely to be needed in the steel sector.

Unlike the general subsidies that many governments give to their steel industries to help them stay competitive, clean technology subsidies can be seen as a payment for public goods: avoided emissions, and clean technology innovation.

Several countries are already implementing, or have implemented, subsidies that support clean steel production. While most of these policies have yet to be implemented in a way that enables ongoing commercial clean primary steel production, they illustrate the different ways in which subsidies can be applied. These include:

- Input subsidies: for hydrogen production, as in the US (Biden administration), UK (under development), Japan, India and China; or for the use of CCS (US, Biden administration; UK, under development).
- Capital subsidies: for investment in new plant, as in Germany, Japan, Sweden, the Netherlands, and Spain.
- Production subsidies: for clean steel, as in Germany's carbon contracts-for-difference.
- Use subsidies: for the use of clean steel in downstream sectors, as in Japan's subsidies for clean steel used in the automotive sector.[19]

At this early stage of the steel transition, these different forms of subsidy are not likely to be equal in their effectiveness. Input subsidies not tied to use the steel industry may be taken advantage of by other sectors. Subsidies for clean steel use in downstream sectors may be too diffuse to provide confidence for investment in a single clean steel plant. Steel companies can receive capital grants and then later change their investment plans, leaving public policy objectives unmet. Production subsidies for clean steel that are committed long-term but paid based on actual performance are most likely to be effective in enabling the first wave of investment in clean primary steel plants.

16. Grubb, M. et al. (2021). The new economics of innovation and transition: evaluating opportunities and risks. EEIST. https://eeist.co.uk/eeist-reports/the-new-economics-of-innovation-and-transition-evaluating-opportunities-and-risks/

17. World Business Council for Sustainable Development (WBSCD). (2025). Business Breakthrough Barometer 2025. https://www.wbcsd.org/resources/business-breakthrough-barometer-2025/

18. Dayal, S. et al. (2025). Towards near-zero emissions steel: modelling-based policy insights for major producers. https://eeist.co.uk/wp-content/uploads/Towards-Near-Zero-Emissions-Steel-Modelling-Based-Policy-Insights.pdf

19. Morrisroe et al. (2025).

Subsidy-and-recharge: a revenue neutral policy that creates no competitiveness risks

> A clean steel subsidy policy does not need to impose unmanageable costs on government budgets. In fact, it can be done at no cost to the government at all.

Revenue neutral for governments

A clean steel subsidy-and-recharge policy has two parts. First, subsidies are given for clean steel production. As described above, these are most likely to be effective if they are given in the form of long-term contracts, which may be allocated by auction, and if they are based on an appropriately stringent standard so that they support the deployment of clean primary steel technologies. Using an emissions standard as the basis for eligibility can allow for competition between alternative clean steel production technologies.[20]

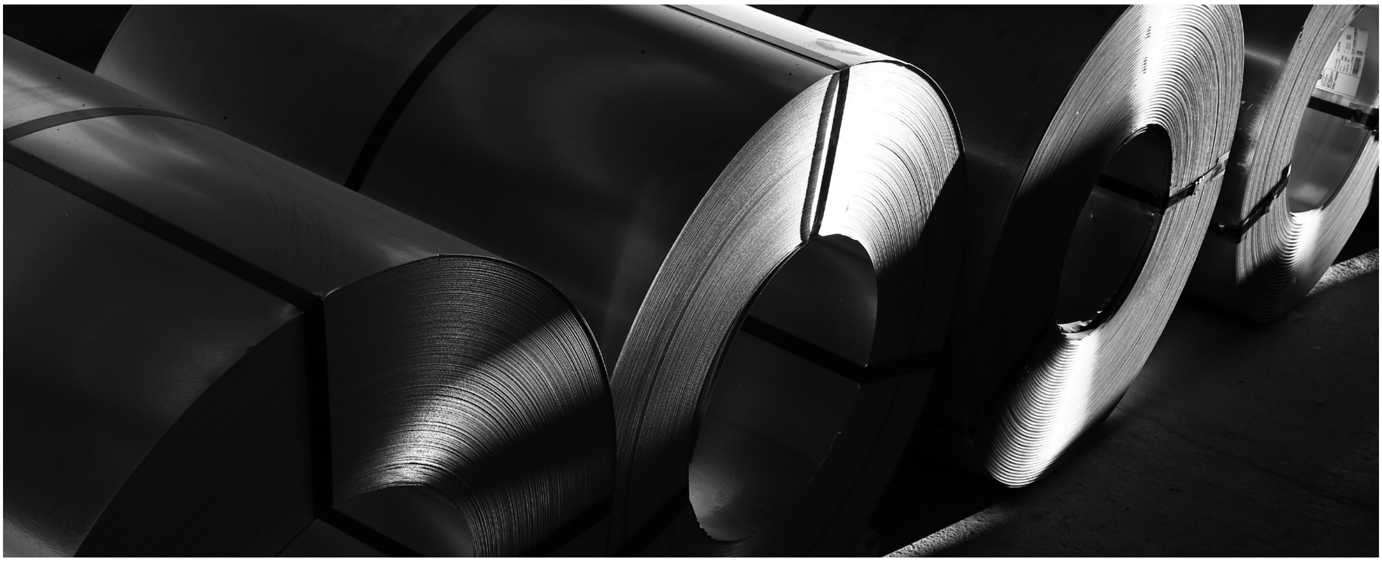
Second, in each year, the total cost of the clean steel subsidies is recouped by the government from the steel sector by a 'recharge'. The recharge is a levy on all steel domestically produced or imported (and with an exemption for exported steel), at an equal value per tonne of steel regardless of emissions or production process. The recharge simply divides up the cost of the subsidies, making the policy revenue neutral for government in every year of implementation.

No competitiveness risks created for industry

The subsidy-and-recharge policy can in principle create no international competitiveness risks for industry. In the domestic market, clean primary steel is made cost-competitive by the targeted subsidies. Since the recharge is applied equally to every tonne of imported steel as well as to domestic production, it does not cause any domestic steel producers to become less competitive in relation to imports.

Similarly, clean steel can be exported competitively as a result of the targeted subsidies. All exported steel is exempt from the recharge, so that its competitiveness is unaffected. This can be done in compliance with WTO rules, since the recharge functions as an excise duty.[21]

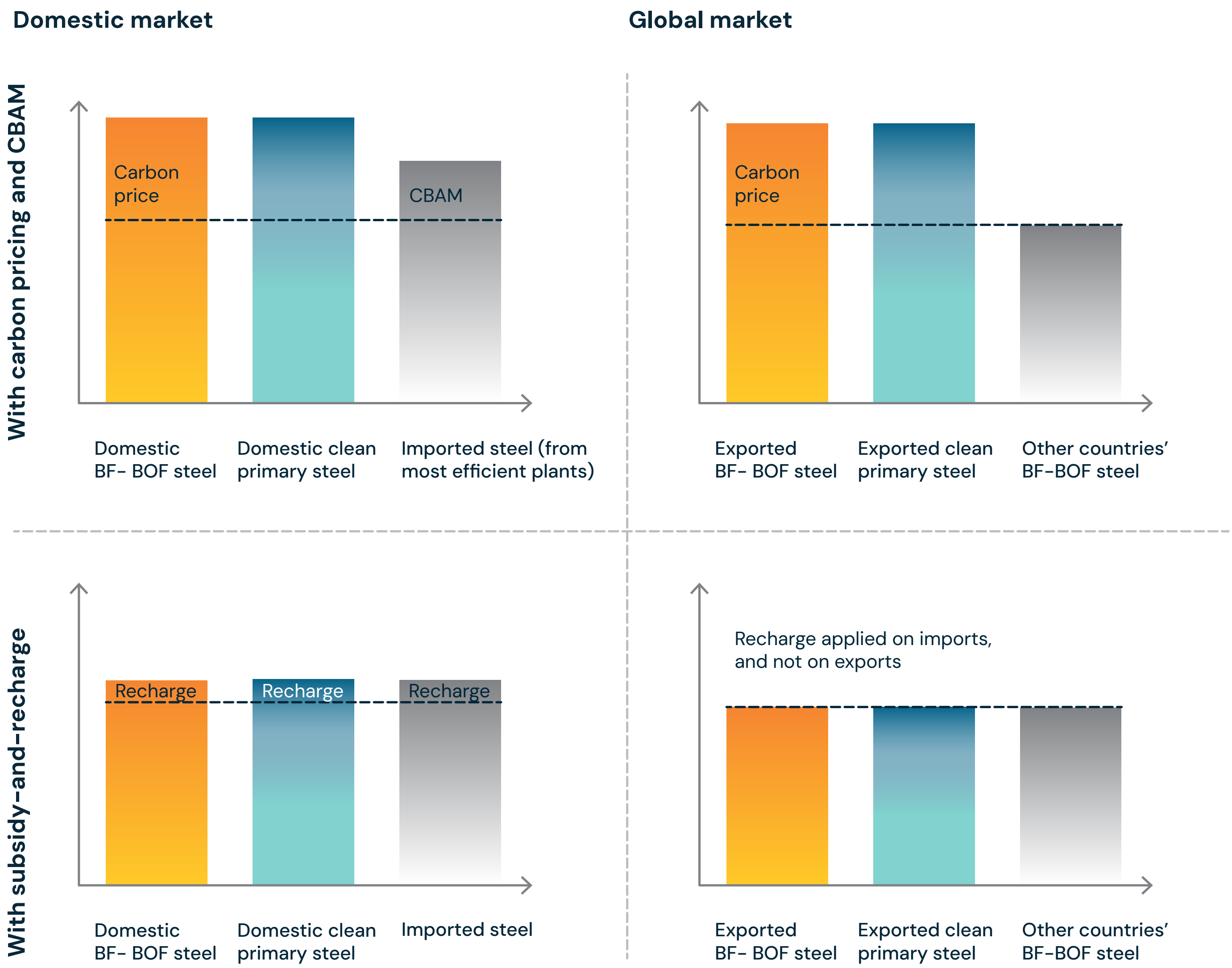
The lack of competitiveness risks to the steel industry created by the subsidy-and-recharge policy is compared to the effects of carbon pricing with a CBAM in Figure 3.



20. The standard may need to reflect the scrap share of input as well as emissions, to ensure the subsidies support clean primary steelmaking as intended. An additional design option is to have separate auctions to support more and less mature clean steel technologies, an approach that has been successfully used by some countries in the power sector to bring new clean technologies into the market.

21. Neuhoff, K et al. (2025). Industrial decarbonisation in a fragmented world: an effective carbon price with a 'climate contribution'. LSE and Grantham Institute. https://www.lse.ac.uk/granthaminstitute/publication/industrial-decarbonisation-in-a-fragmented-world-an-effective-carbon-price-with-a-climate-contribution/

Figure 3: Comparison of the effects on steel industry competitiveness of carbon pricing with CBAM and subsidy-and-recharge policies.



The imposition of the recharge on imported steel and the exemption for exported steel can be extended to steel embedded in traded products, avoiding competitiveness risks to downstream industries. This is far simpler to administer than a CBAM similarly extended to cover downstream products because it does not require the measurement and tracking of the emissions embedded in each tonne of steel.

While the subsidy-and-recharge policy does not create any immediate international competitiveness risks for industry, its design could have important implications for competitiveness over the long-term. As the main energy source for ironmaking shifts from coal to renewable electricity (for either hydrogen-based or direct electrolysis routes), countries with abundant high-quality renewable energy resources are likely to become the lowest-cost producers of iron. Subsidy policies that only support domestic production in countries with high energy costs may risk locking in higher production costs for the long-term. This can be addressed by allocating subsidies for clean primary steel production while allowing steelmakers the flexibility to use either domestically produced or imported green iron. The trade-offs involved in this design choice are discussed in the chapter on the UK.

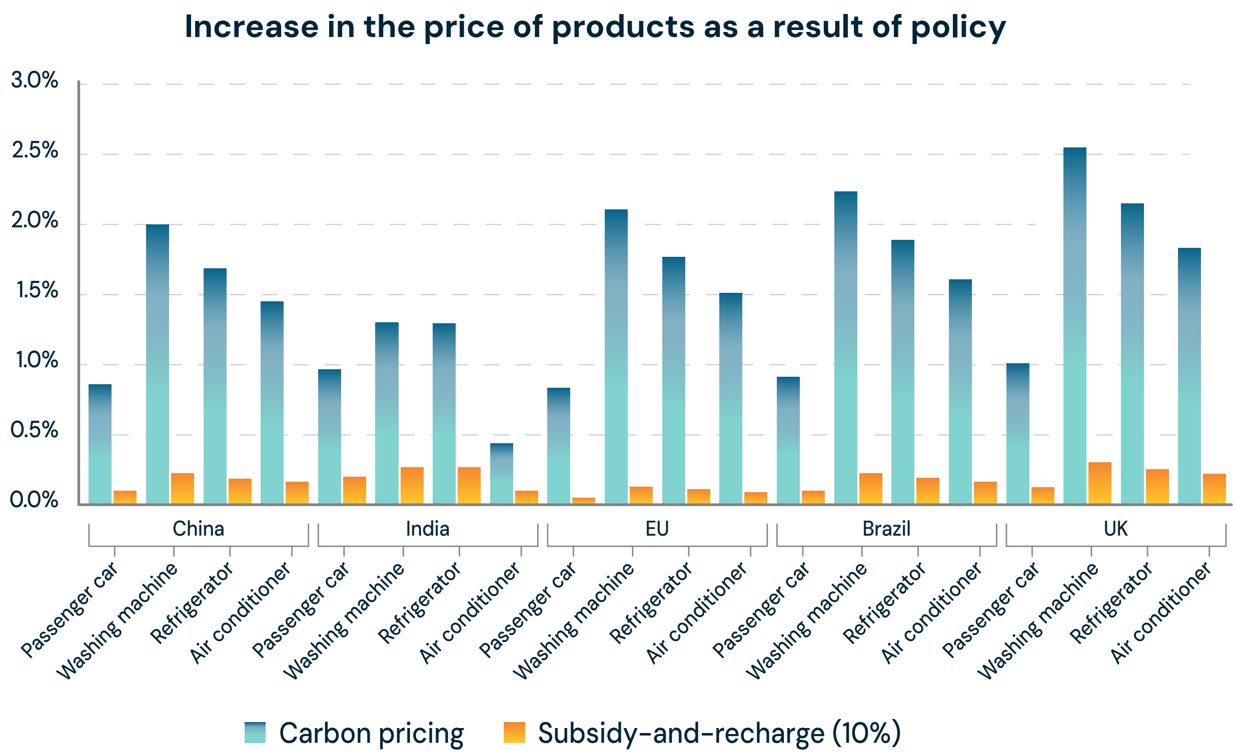
Trivial cost to consumers

If the steel sector is to be decarbonised, as governments' economy-wide targets imply that it will be, then any additional costs of clean steel production must eventually fall either to consumers or to taxpayers.

Previous studies have shown that even if the additional costs of clean steel production are high, the fractional addition to the cost of a final product such as a car or a building is very low, typically around 1%.[22]

With a subsidy-and-recharge policy, the costs to consumers are even lower, early in the transition. This is because the cost of subsidising a relatively small number of clean steel plants is spread across the whole sector, meaning that the recharge is very small. Figure 4 illustrates this by showing the change in prices of consumer goods as a result of the subsidy-and-recharge policy at a point where clean primary steel has reached a 10% share of the market, with the equivalent values of a carbon pricing policy shown for comparison. At small fractions of a percent, the additional cost of the subsidy-and-recharge policy is unlikely to be noticed by consumers.

Figure 4: Estimated effect on the price of consumer products as a result of the subsidy-and-recharge policy and of carbon pricing. Notes: Subsidy-and-recharge (10%) denotes subsidy-and-recharge policy when clean primary steel is 10% of national production, and the subsidy is recharged to steel consumption. For the UK, subsidy-and-recharge is for the case of 1 Mtpa of DRI production. Recharge costs estimated as $22.6/tCS in China, $25.2/tCS in India, $22.3/tCS in Brazil, $11.5/tCS in the EU, and $30.5/tCS in the UK. CP = carbon pricing at a level equivalent to the subsidy in its effect on the relative cost of H_2-DRI-EAF and BF-BOF steel in each country/region, using values given in Table 1.

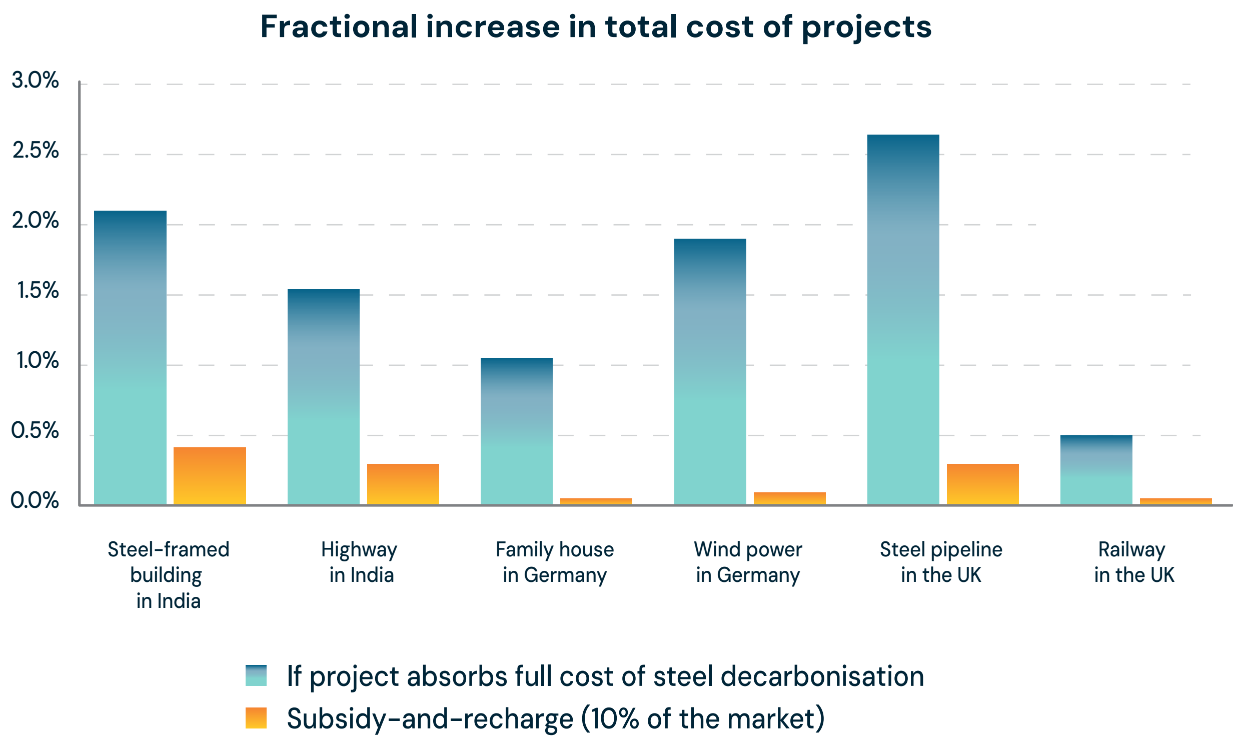


[22] Energy Transitions Commission (2018). Mission Possible: Reaching net-zero carbon emissions from harder-to-abate sectors. https://www.energy-transitions.org/publications/mission-possible/

The additional costs to consumers of the subsidy-and-recharge policy at the end of the transition, when all steel production is near-zero emission, would be the same as the additional costs imposed by a carbon pricing policy. As shown in Figure 4, these are in the region of 1–2% with current technology costs. With any technological progress, the actual costs at the end of the transition would be lower.

A significant share of all steel produced is used in the construction and infrastructure sectors (52% globally[23]). Even for steel-intensive projects in these sectors, using clean steel generally adds a very small fraction to the total cost, due to the large contributions to total costs of other factors such as land, labour, finance, and design and engineering. The additional cost early in the transition is even lower if a subsidy-and-recharge policy is used to spread the cost of the first wave of clean steel plants across all steel consumed, for the same reasons as described above. Figure 5 shows some illustrative examples.

Figure 5: Estimated effect on the cost of buildings and infrastructure as a result of the subsidy-and-recharge policy and of carbon pricing, using similar assumptions as in Figure 4. Percent cost increases are estimated based on the volume of steel used divided by the total construction cost.



[23] World Steel. (2024). World Steel in Figures 2024. https://worldsteel.org/data/world-steel-in-figures/world-steel-in-figures-2024/

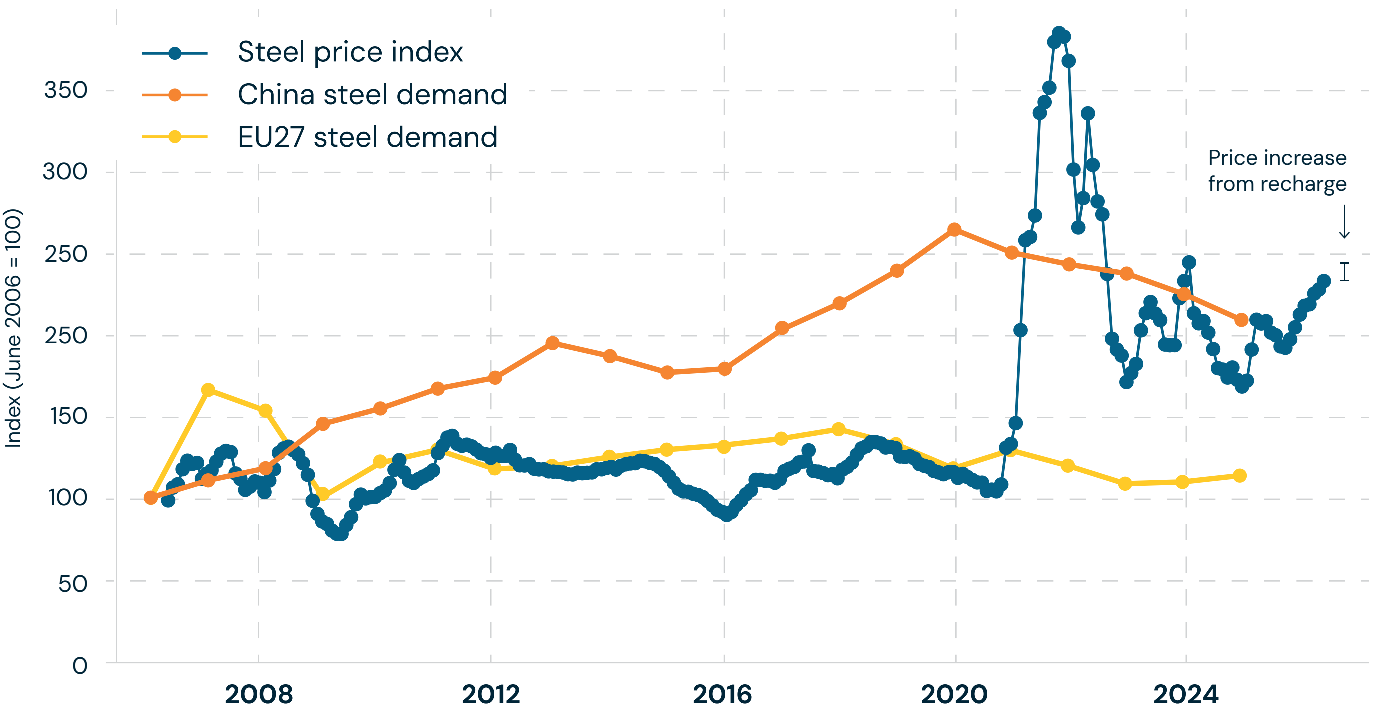
Unlikely to affect steel demand or steel industry profitability

The subsidy-and-recharge policy is unlikely to affect demand for steel, for several reasons. The price elasticity of demand for steel is generally estimated to be low, in the region of -0.07[24] , reflecting the foundational nature of its use in the economy and the limited options for material substitution. This means that with all else being equal, an increase of around 4% in the cost of steel – as could arise from the subsidy-and-recharge policy when clean primary steel accounts for 10% of steel production – would be expected to result in a decrease of 0.3% in steel demand.

In reality, any effect is likely to be smaller even than this. Steel demand has historically experienced long periods of growth or stagnation in particular regions, driven by structural economic change, with these trends being persistent despite price volatility. For example, steel demand in China increased from 378 Mtpa in 2006 to 1,009 Mtpa in 2020, reflecting China's urbanisation and industrialisation. Whereas in Europe, steel demand has remained largely consistent over the last two decades[25]. The 4% increase in the cost of steel production implied by the subsidy-and-recharge policy (at 10% clean steel market share) is small compared to the fluctuations in global steel prices seen in recent years and decades (see Figure 6). After the major global supply chain disruptions of the Covid-19 pandemic, the price of cold rolled steel sheet was 250% higher in 2021 than in 2020. In the periods before (2006–2019) and after (2023–2026), the standard deviation of the monthly average of this price was respectively 11% and 9% of the mean, while over the entire period (2006–2026) it was 41% of the mean.[26]

In this context, a recharge applied equally to every tonne of steel consumed is likely to be almost completely passed through from steelmakers to consumers, with no appreciable effect on steel companies' profitability.

Figure 6: Monthly producer price index of Cold Rolled Steel Sheet and Strip, with steel demand in China and EU27. Sources: Steel price index data from U.S. Bureau of Labor Statistics, Producer Price Index by Commodity: Metals and Metal Products: Cold Rolled Steel Sheet and Strip [WPU101707], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/WPU101707, July 16, 2026; apparent steel use from World Steel in Figures annual reports.



24. Fernandez, V. (2018). 'Price and Income Elasticity of Demand for Mineral Commodities'. Resources Policy, 59, pp. 160–83.

25. Based on apparent steel use data from World Steel in Figures annual reports.

26. Based on monthly price index from: U.S. Bureau of Labor Statistics, Producer Price Index by Commodity: Metals and Metal Products: Cold Rolled Steel Sheet and Strip [WPU101707], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/WPU101707, July 16, 2026.

Positive global influence

The EU's CBAM has been credited with spurring the development of industrial carbon pricing policies in other countries, and its regulation of market access could influence steel industry investment decisions[27]. However, the limitations of carbon pricing in respect of incentivising investment in clean primary steel as described above are likely to apply even more when the policy is implemented in an export market, and not in a steel company's domestic market. For most major steel producing countries, only a small fraction of their steel output is exported to the EU rather than consumed domestically or exported elsewhere. For China, India and Brazil, the fractions are 0.5%, 1.5% and 0.5% respectively[28]. The presence of carbon pricing in the EU is highly unlikely to incentivise investment in clean primary steel plants in these countries, in the absence of strong domestic policies.

A clean steel subsidy-and-recharge policy would not regulate market access, but could exert influence on the global transition in a different way. By enabling investment in primary steel in one country, it could change industry expectations and increase the pressure for similar policies in other countries. Whereas currently industry expectations are dominated by the perception of first-mover risk in the transition, successful implementation of a clean steel deployment policy could shift perceptions towards late-mover risk.

Policy combinations, sequencing, and exit strategies

Since carbon pricing and clean steel subsidies play complementary roles in the transition, there is ample scope to use these policies together. Targeted subsidies can be used to enable investment in clean primary steel, while carbon pricing disincentivises investment in the most emissions-intensive technologies and incentivises near-term emissions reductions and material efficiency. Later in the transition, carbon pricing can be used to protect the competitiveness of existing near-zero emission production and eventually to remove emissions-intensive plants from the market.[29]

Targeted subsidies are most important early in the transition, when their purpose is to enable investment in the first wave of clean primary steel plants. There is no reason in principle why the subsidy-and-recharge policy could not continue to function indefinitely: even if it were used to support 100% of primary steel production, it could remain revenue neutral and avoid creating competitiveness risks to industry (subject in some countries to the design choice around iron imports, as discussed above) or significant costs to consumers. However, governments may consider other policies to be more appropriate at later stages of the transition, and several exit strategies from the subsidy-and-recharge policy are available. Subsidies given in the form of contracts for difference can become zero-subsidy when clean steel technology cost reduction and diffusion lead to convergence between clean steel production costs and global market prices. Carbon contracts for difference can become zero subsidy when carbon prices rise high enough to cover the cost difference between clean and conventional steel production. Subsidies can eventually be replaced with regulations that require all steel produced or imported to be near-zero emission (analogous to the endpoint of the EU's carbon intensity standards for vehicles).

> Other policies, whose discussion is beyond the scope of this report, can further strengthen the overall incentives and enabling conditions for the transition.

These include public procurement and clean steel mandates in downstream sectors to create demand for clean steel, investment in electricity grids, and the adoption of clear standards for low and near-zero emission steel. When policies to support the production of clean primary steel are in place, their effect may be amplified by policies that create demand.

---

27. Bahí, A., et al. (2026). Carbon pricing beyond borders: assessing climate policy spillovers from the EU carbon border adjustment mechanism. Bruegel. https://www.bruegel.org/working-paper/carbon-pricing-beyond-borders-assessing-climate-policy-spillovers-eu-carbon-border

28. Values for 2024. Steel production volumes from https://worldsteel.org/data/world-steel-in-figures/world-steel-in-figures-2025/, EU 27 import volumes from https://www.eurofer.eu/statistics/trade-statistics/imports.

29. Murphy, A. et al, 2025. First build, then break: a policy framework for accelerating zero carbon transitions. https://www.scurveeconomics.org/publications/first-build-then-break/

Country-specific variants of a subsidy-and-recharge policy

In the following sections we explore how a clean steel subsidy-and-recharge policy could be adapted and applied in each of China, India, Brazil, the EU and the UK. For each country/region, we outline how one or more versions of the policy could work as an effective policy to enable investment in clean primary steel production, considering its implications for government budgets, industrial competitiveness and consumer costs, as well as political economy and institutional factors.

Table 2: National and regional variations on the subsidy-and-recharge policy.
Notes: ETS = emissions trading system. CCfD = carbon contract for difference.

Country/ Region	Focus of subsidies	Source of funds	Unique characteristics
China	Clean primary steel production, defined by technology route	Recharge on steel production and imports	Requires a particularly small recharge to support first few clean steel plants, due to the large scale of the sector
India	Clean primary steel production, and marginal emissions reduction in all plants	Very low carbon tax on steel production	Uses emissions verification infrastructure established for CCTS. Manages political economy through dual subsidy structure
EU	Clean primary steel production, with subsidy given as CCfD	Recharge on steel production (and import) equal to the value of free allowances in the EU ETS	Fits closely into the structure of the EU ETS, preserving its integrity and enhancing its effectiveness
Brazil	Clean primary steel production, and other low emission production routes	Recharge on steel production, supplemented by concessional lending from national development bank	Contributes to developing the capacity for green iron exports, by establishing a domestic market
UK	Clean iron production or import (alternative options), to supply all domestic steel plants	Recharge on steel production and imports	Support for a single clean iron plant could meet the sector's needs, given small scale and high availability of scrap steel

The core concept that is common across these examples is that financial resources are drawn from a wide base, minimising impacts on industrial competitiveness and government budgets, and concentrated into targeted subsidies for the deployment clean steel technologies, maximising their effectiveness in enabling investment.

The variations in design reflect differences in the scale and composition of countries' steel industries, their current and expected future positions in global value chains, and the nature of existing policies and institutions relevant to the steel sector transition. Table 2 gives an overview of some of the main characteristics across the set of country-specific policy proposals.

2. A subsidy-and-recharge policy for China

Authors: Prof. Wang Pu, Lin Ziyue – Chinese Academy of Sciences

Context

China is the world's largest steel producer and consumer. In 2025, its crude steel output was about 968 Mt, accounting for more than half of global production.[30] The sector remains highly dependent on the blast furnace–basic oxygen furnace (BF-BOF) route. Around 90% of Chinese crude steel is produced through the BF-BOF route, while electric arc furnace (EAF) steel accounts for about 10%, well below the share in economies with more mature scrap systems, such as the United States and the European Union.[31] The sector is also one of China's largest sources of industrial carbon emissions. In 2024, China's steel industry emitted around 1.8 $GtCO_2$, equivalent to roughly 15% of national carbon emissions, with an average emissions intensity of about 1.8 tCO_2 per tonne of steel.[32] A production- and process-based proxy calculation gives a similar annual sectoral emissions range of around 1.8–2.0 $GtCO_2$.[33] Apparent steel use remains the highest in the world, although it has fallen from about 1,009 Mt in 2020 to 857 Mt in 2024 as construction and real estate demand weakened.[34] Manufacturing, renewable energy equipment, automobiles and exports have partly offset the decline in property-linked demand.

China's steel transition is distinctive because scale, technology structure and resource constraints are tightly interlinked. A large share of BF-BOF capacity remains within its operating life, creating significant path dependence. At the same time, China's scrap stock has accumulated later than in Europe and North America, and the collection, sorting and supply systems for high-quality scrap are still underdeveloped. These constraints limit how quickly secondary EAF production can substitute for primary BF-BOF production. As steel demand shifts from real estate and conventional infrastructure towards manufacturing, renewable energy equipment, automobiles, machinery and export-oriented sectors, the requirements on steel quality are also becoming more demanding. The core challenge for clean primary steel in China is therefore to maintain high-grade steel supply and industrial competitiveness while advancing decarbonisation routes, including hydrogen-based direct reduced iron (DRI), hydrogen-rich blast furnace operation, carbon capture, utilisation and storage (CCUS), EAF production and higher-quality scrap utilisation.

30. National Bureau of Statistics of China (2026). Statistical Communique of the People's Republic of China on the 2025 National Economic and Social Development, February 2026. https://www.stats.gov.cn/sj/zxfb/202602/t20260228_1962662.html

31. World Steel Association (2025). World Steel in Figures 2025, 'Crude steel production by process, 2024'; World Steel in Figures 2024 for 2023 process shares. https://worldsteel.org/data/world-steel-in-figures/world-steel-in-figures-2025/

32. Zhou Weifu (2025). Achievements of China's steel industry during the 14th Five-Year Plan and suggestions for high-quality development during the 15th Five-Year Plan. China Economic & Trade Herald 2025(9). http://gjs.cssn.cn/kydt/kydt_kycg/202506/t20250613_5879070.shtml

33. Rocky Mountain Institute (RMI) and China Electric Power Research Institute (2023). Demand-side flexibility series: overview of flexibility potential in the steel industry. https://rmi.org.cn/insights/industrial-dsf/

34. World Steel Association (2025). World Steel in Figures 2025, 'Apparent steel use, finished steel products'. https://worldsteel.org/data/world-steel-in-figures/world-steel-in-figures-2025/

Positive global influence

The current policy mix relies mainly on administrative regulation, energy-efficiency standards, pollution-control requirements, capacity controls and carbon-market development. At the central level, policy continues to restrict new steelmaking capacity, promote capacity replacement, support energy-saving and carbon-reduction retrofits, and accelerate ultra-low-emission retrofitting in steel plants.[35] On carbon pricing, steel was brought into China's national emissions trading system (ETS) in 2025.[36] The initial design is expected to rely mainly on free allocation and benchmark-based regulation, so the near-term cost signal is likely to be moderate. Even so, ETS coverage can help to build firm-level systems for carbon accounting, reporting, verification and compliance. Green finance, product carbon-footprint rules, green power trading, clean hydrogen applications in industry and catalogues of low-carbon technologies are also creating institutional foundations for later clean steel investment.

Clean primary steel deployment in China is still at the demonstration and early commercialisation stage. Leading steelmakers, including Baowu and HBIS, have launched projects involving hydrogen-based DRI, EAF melting, CCUS and low-carbon product certification. Baosteel Zhanjiang's million-tonne near-zero-carbon production line has formed an integrated hydrogen-based shaft furnace, EAF and rolling process, and has reported substantial emissions reductions from the hydrogen-based furnace stage.[37] However, major barriers remain. Green hydrogen is still costly and uncertain in supply; low-carbon electricity resources are not always well matched with steelmaking locations; high-grade iron ore and pellet supply may become a constraint for DRI; scrap quantity and quality cannot yet support rapid large-scale EAF growth; and weak steelmaker profitability, overcapacity and export pressures reduce firms' ability to absorb high upfront costs of low-carbon investment.

---

35. Key policy references include the State Council's Action Plan for Carbon Dioxide Peaking Before 2030; the Ministry of Industry and Information Technology and other departments' Guiding Opinions on Promoting High-Quality Development of the Iron and Steel Industry; the National Development and Reform Commission and other departments' Special Action Plan for Energy Conservation and Carbon Reduction in the Steel Industry; and the Ministry of Ecology and Environment and other departments' Opinions on Promoting Ultra-Low-Emission Transformation in the Steel Industry. https://www.mee.gov.cn/xxgk2018/xxgk/xxgk10/202202/t20220208_968879.html

36. Ministry of Ecology and Environment (2025). Notice on issuing the total allowance and allocation plan for the national carbon emissions trading market for the steel, cement and aluminium smelting industries for 2024 and 2025. https://www.mee.gov.cn/xxgk2018/xxgk/xxgk03/202511/t20251118_1134175.html

37. Xinhua Guangdong (2024). Million-tonne hydrogen-based shaft furnace cuts carbon emissions by 60% – Baosteel Zhanjiang Iron & Steel Co., Ltd. http://gd.news.cn/20240929/f0835245a13a4876818cfa1d0391a141/c.html

Proposed country-specific version of the subsidy-and-recharge policy

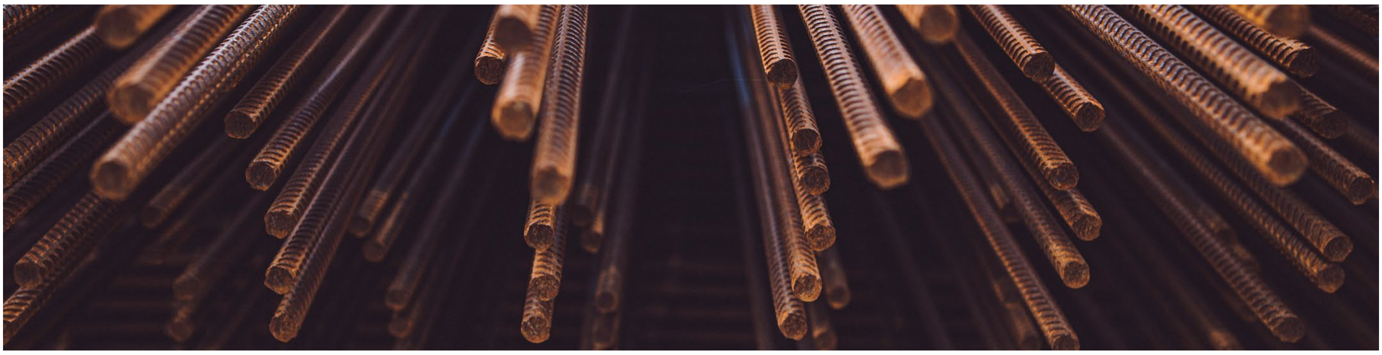
China could adopt a production-side subsidy mechanism for clean primary steel, financed mainly through a recharge on steel consumption. The government would provide a unit subsidy for eligible clean primary steel production, with priority given to near-zero emission routes such as H_2-DRI-EAF, so that these projects can compete on cost with conventional BF-BOF steel. The subsidy would be paid and administered through a dedicated Clean Steel Transition Fund. The fund's main revenue would come from a uniform recharge applied to steel consumed in the Chinese market, covering both domestically produced steel and imported steel, while exported steel would be exempt. This design would allow steel entering the Chinese market to bear the same transition charge while avoiding a direct cost increase for export steel. Since the steel sector is already covered by the national ETS, part of the revenue from auctioning allowances could also be channelled into the fund as a supplementary financing source, used to reduce the recharge, expand the subsidy envelope or support key inputs such as low-carbon hydrogen.

> Overall, the mechanism would spread the green premium of early near-zero emission primary steel across a broad steel consumption base and convert dispersed revenues into stable production-side support.

The mechanism would close the green premium by directly covering the cost difference between near-zero emission primary steel and conventional BF-BOF steel. Under the current cost assumptions used for this exercise, the levelised cost of steel is about $523 per tonne of crude steel (tCS) for BF-BOF and about $731/tCS for H_2-DRI-EAF, implying a cost gap of around $209/tCS. If the policy objective is to support H_2-DRI-EAF output equal to 10% of current primary steel production, the required annual subsidy would be about $19.4 billion. Spread across steel consumption through the recharge, this would correspond to around $22.6/tCS. Compared with relying on a carbon price to raise the cost of conventional steel, this approach directly reduces the revenue gap faced by clean primary steel projects and makes H_2-DRI-EAF commercially viable at prevailing market prices.

> For investors, the credibility and duration of support are as important as the subsidy level.

The subsidy could therefore be offered through multi-year production support, long-term contracts or a contract-for-difference style arrangement with transparent eligibility criteria, emissions thresholds, calculation methods and funding sources. This would turn policy support into a predictable cash flow that could underpin project finance, long-term green hydrogen procurement, EAF investment and deployment of direct reduction equipment. A stable mechanism would also reduce early-mover exposure to technology, input-price and market risks, making firms more confident that investment will not become uncompetitive because of weak green steel demand or volatility in conventional steel prices.



The impact on the competitiveness of the steel industry would be limited. Because the recharge would be applied to domestic steel consumption rather than steel production, and because exported steel would be exempt in principle, Chinese steel exports would not directly bear the additional policy cost. This avoids the competitiveness pressure that would arise if a high carbon price were applied directly to domestic production costs. In the domestic market, both domestic steel and imported steel would pay the same recharge when consumed in China, so imported steel would not gain a systematic advantage by avoiding the policy cost.

> For downstream sectors, the unit cost impact is small once the subsidy cost is spread across the full steel consumption base.

Automobiles, appliances, machinery, construction materials and renewable energy equipment would therefore experience only limited final-product cost increases. Residual risks mainly concern a future scenario in which ETS auctioning shares and carbon prices rise materially while imports do not face comparable carbon costs, and a second scenario in which some downstream exporters indirectly carry a small recharge cost. In the initial policy phase, however, a design centred on the recharge and supplemented by ETS revenue should keep these risks low.

The fiscal impact would be very small and close to revenue-neutral for the government. The main expenditure, namely the production subsidy for H_2-DRI-EAF and other eligible clean primary steel routes, would be recovered through a uniform recharge on domestic steel consumption. ETS allowance auctioning revenue from the steel sector could provide an additional source for the Clean Steel Transition Fund. With subsidy payments matched by recharge revenue, the mechanism would avoid a significant increase in general government expenditure and keep the net impact on public budgets close to zero.

The impact on consumer costs would also be limited, because the cost is distributed across the whole steel consumption system, and steel accounts for only part of the price of most final products. With a recharge of $22.6/tCS, full pass-through to consumers would still lead to small changes in typical steel-containing products: around $20.3 per passenger vehicle, or about 0.09%; around $0.48 per washing machine, or about 0.22%; around $0.77 per refrigerator, or about 0.18%; and around $0.67 per air conditioner, or about 0.16%. The cost impact would be more visible in steel-intensive sectors such as construction, machinery, and renewable energy equipment, but even there the effect per unit of output would be far lower than under a policy that relies mainly on a high carbon price to raise the cost of BF-BOF steel.

Operationally, the proposal would require clear definitions of eligible clean primary steel, reliable emissions-intensity thresholds, transparent subsidy formulas, and credible monitoring, reporting and verification (MRV). The recharge base should be defined around steel consumed in the domestic market, with mechanisms to cover imported steel and exempt exported steel. Administration could build on existing tax, customs, industrial statistics and ETS data systems, but data consistency would still matter. The Clean Steel Transition Fund would need rules on revenue collection, disbursement timing, project qualification, treatment of over- or under-recovery, and public disclosure. To reduce implementation risk, China could begin with a limited number of demonstration-scale clean primary steel projects and gradually expand coverage as emissions standards, product certification and MRV systems mature.

> The political economy is more favourable than for a pure carbon-pricing approach.

> Conventional high-emission steelmakers may resist a rising ETS auctioning share, but the fund's recycling of revenues back into the sector through targeted support can reduce opposition.

Leading steelmakers, hydrogen companies, renewable power suppliers and equipment manufacturers are likely to support the policy because it creates a predictable market for early H_2-DRI-EAF projects and low-carbon hydrogen supply. Downstream industries may be concerned about an additional steel cost, but the expected final-product price effects are small, leaving room for policy communication and sectoral coordination. Local governments may also see the mechanism as a way to attract low-carbon industrial investment while upgrading existing steel clusters.

The mechanism would also support secondary policy objectives. It could accelerate deep decarbonisation in China's steel industry, develop supply chains for H_2-DRI-EAF, low-carbon hydrogen, renewable power and direct reduction equipment, and improve the sector's preparedness for international low-carbon product standards, green procurement rules and carbon border adjustment measures. A uniform recharge could also provide a mild incentive for material efficiency, steel saving and recycling. These co-benefits would support industrial upgrading and green supply-chain development, although the policy design should avoid concentrating funding too narrowly among a small number of large state-owned enterprises or encouraging repetitive demonstration projects.

The proposal fits well with China's existing policy architecture. It can be linked with the expansion of the national ETS, the shift from energy-intensity controls towards carbon-emissions controls, green power trading, green finance and public green procurement. It can use existing systems to manage funds and track emissions outcomes while filling a gap that current policies do not fully address: the need for stable production-side revenue support for near-zero emission primary steel. In the early phase, the mechanism could support a small portfolio of demonstration projects. Over time, it could incorporate a larger share of ETS auctioning revenue and be integrated with green steel standards, public procurement and private clean steel purchasing commitments.

Key uncertainties

Key uncertainties fall into three groups. First, technology and cost uncertainty: near-zero emission steel production costs, low-carbon hydrogen supply costs and the pace of technology learning will determine the subsidy requirement. Second, market and financing uncertainty: domestic steel demand, recharge-rate adjustment and the long-term stability of the Clean Steel Transition Fund may affect policy durability. Third, institutional and external uncertainty: import coverage, alignment with international trade rules and the actual availability of ETS auctioning revenue will shape implementation feasibility. These factors should be reviewed regularly as demonstration projects generate better cost and performance data.

3. India: Subsidy-and-recharge policy options for clean primary steel

Authors: Sabarish Elango, Hemant Mallya
– Council on Energy, Environment and Water

Context

The Indian steel industry had an installed capacity of over 218 million tonnes per annum (Mtpa) as of December 2026 and produced 152 Mt of crude steel in 2024–25, making it the world's second-largest steel producer.[38] The draft National Steel Policy 2025 targets 300 Mtpa capacity by 2030 and 400 Mtpa by 2035, requiring investment of approximately $183 billion.[39] Steel consumption was approximately 136 Mt in 2023–24,[40] with construction (43%) and infrastructure (25%) together accounting for roughly 68% of demand.[41]

Technology mix and distinctive characteristics

> The technology mix in India is characterised as a wide variety of combinations.

The blast furnace–basic oxygen furnace (BF-BOF) route produces roughly 48% of output; coal direct reduced iron–induction furnace (coal-DRI-IF) 29%; coal DRI–electric arc furnace (coal-DRI-EAF) 12%; and gas-DRI-EAF 11% as of 2021–22.[42] The sector is fragmented across a range of plant sizes, from large integrated plants to small DRI-IF units. For comparison, India had 52 blast furnaces but over 300 DRI kilns in 2022.[43] The major steelmaking clusters are located in the states of Odisha, Jharkhand, Chhattisgarh and Karnataka around coal and iron ore mines.

Although coal is an abundantly available resource in India, the country does not produce sufficient quantities of metallurgical coking coal (used by BF plants) and higher grades of non-coking coal (used by DRI plants). Therefore, the Indian steel industry is highly import-dependent on Indonesia, South Africa, Australia, Russia and the USA for coal. Per our estimates, BF plants imported 80% of their coal needs and DRI plants imported 50% in 2021–22.[44] Natural gas is also primarily imported; high delivered gas prices (approximately $16/mmBtu[45]) have made the gas-DRI-EAF route unviable. However, adopting the gas-based route will enable a seamless transition to hydrogen DRI-EAF (H_2-DRI-EAF) for clean steelmaking. [46] India has abundant and cheap solar and wind energy resources. Although the installed capacity of solar and wind power as of 31 July 2026 amounted to 223 GW,[47] the overall potential could be over 24,000 GW.[48] Therefore, electrification of steelmaking (including transitioning to H_2-DRI-EAF) using renewable energy will be a viable pathway to support energy security considerations for the country while also cutting down on emissions.

---

38. Ministry of Steel (2026). Annual Report 2025–26. https://steel.gov.in/sites/default/files/2026-04/Final%20Annual%20Report%202025-26%20%28English%20Version%29.pdf; World Steel Association (2025). World Steel in Figures 2025. https://worldsteel.org/data/world-steel-in-figures/world-steel-in-figures-2025/

39. GMK Center (2026). India plans to reach a steel production capacity of 400 million tons by the 2035/2036 fiscal year. https://gmk.center/en/news/india-plans-to-reach-a-steel-production-capacity-of-400-million-tons-by-the-2035-2036-fiscal-year/

40. Joint Plant Committee (2024). Annual Statistics 2023–24. Ministry of Steel, Government of India.

41. Ministry of Finance (2025). Economic Survey 2024–25. Government of India; Gulia, J. et al. (2023). Steel decarbonisation in India. Institute for Energy Economics and Financial Analysis and JMK Research & Analytics. https://ieefa.org/sites/default/files/2023-09/Steel%20Decarbonisation%20in%20India_September%202023_2.pdf.

42. Elango, S. et al. (2023). Evaluating net-zero for the Indian steel industry: marginal abatement cost curves of carbon mitigation technologies. Council on Energy, Environment and Water. https://www.ceew.in/publications/how-can-india-decarbonise-for-net-zero-steel-industry.

43. Ibid.

44. Elango, S. et al. (2023).

45. Directorate General of Commercial Intelligence and Statistics (DGCI&S) (accessed 4 June 2026). Export-import data bank. Department of Commerce, Government of India. https://tradestat.commerce.gov.in/; Elango, S. et al. (2023).

46. Elango, S. et al. (2023).

47. Press Information Bureau (9 August 2026). India achieves landmark 300 GW non-fossil fuel power capacity. Ministry of New and Renewable Energy, Government of India. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2296782

48. Mallya, H. et al. (2023). Unlocking India's RE and green hydrogen potential: an assessment of land, water, and climate nexus. Council on Energy, Environment and Water. https://www.ceew.in/publications/how-can-india-unlock-renewable-energy-and-green-hydrogen-potential

Emissions

The sector emitted approximately 350 $MtCO_2e$ in 2023–24 at an average intensity of 2.40 tCO_2e per tonne of crude steel (tCS).[49] Emission intensities have a wide range; induction furnaces recycling scrap steel have an intensity of <1 tCO_2/tCS, while primary steel lies between 2 and 4 tCO_2/tCS. BF-BOF plants typically emit about 2.4–2.5 tCO_2/tCS, while DRI-IF plants emit >3 tCO_2/tCS.[50] As per the Government of India's draft targets for steel production and emission intensity, growth outpaces intensity improvements, and sector emissions could reach approximately 560 $MtCO_2$ by 2030.[51]

Current policy mix

The Carbon Credits Trading Scheme (CCTS) under the Bureau of Energy Efficiency (BEE), Ministry of Power, is the primary regulatory instrument, established under the Energy Conservation (Amendment) Act, 2022.[52] Draft greenhouse gas emission intensity targets have been published for 255 obligated steel entities.[53] India's Green Steel Taxonomy (2024) grades steel by emission intensity, and the National Institute of Secondary Steel Technology (NISST) issues certifications: as of July 2026, 15 units covering approximately 2.5 Mt of various types of steel (bars, rods, structural) have been certified, mostly from secondary producers.[54]

The National Green Hydrogen Mission (NGHM) targets 5 Mtpa of green hydrogen (GH_2) production by 2030 at approximately $2/kg, and provides subsidies, waivers and other policy support for indigenous production and exports of green hydrogen and derivatives.[55] India has achieved green hydrogen prices as low as $3/kg, partly owing to the subsidies provided under this mission.[56]

In its Union Budget 2026–27, the Government of India announced support for development and deployment of carbon capture, utilisation and storage amounting to over $2 billion over five years.[57] India has a sizeable underground CO_2 sequestration potential of 359 gigatonnes in saline aquifers, basalt formations, depleted oil and coal fields, making carbon capture and storage (CCS) a prominent pathway for emissions reduction.[58]

Progress and barriers

No near-zero emission primary steelmaking plant is currently operational in India. Based on the technology mix and policies, the two lead technology options are H_2-DRI-EAF and BF-BOF-CCS. AM/NS India has announced a 3 Mtpa greenfield H_2-DRI-EAF plant in Andhra Pradesh, but construction has not yet commenced.[59] Existing gas-DRI-EAF capacity (approximately 13 Mt/yr)[60] uses a mix of natural gas and reformed coke oven gas; there are no plans to shift to green hydrogen. The central barrier for H_2-DRI-EAF is the cost gap: it currently costs approximately $127/tCS more than BF-BOF at a green hydrogen price of $3.7/kg. For BF-BOF-CCS, gaps exist across costs, technology, infrastructure and policies. The lack of a dedicated carbon capture policy or a notable R&D ecosystem combined with high costs of CO_2 transportation and underground storage globally indicate that commercial-scale injection in suitable reservoirs could take over 15 years to commence.[61]

---

49. Bureau of Energy Efficiency (BEE) (2025). Carbon Credit Trading Scheme: baseline greenhouse gas emission intensity data, iron and steel sector, 2023–24. Ministry of Power, Government of India.

50. Ibid; Elango, S. et al. (2023).

51. GMK Center (2026).

52. Ministry of Power (28 June 2023). The Carbon Credit Trading Scheme, 2023. Gazette of India, Extraordinary, Part II, Section 3, Sub-section (ii), S.O. 2825(E).

53. Bureau of Energy Efficiency (BEE) (23 June 2025). Greenhouse gases emission intensity target rules, 2025 (draft notification, G.S.R. 405(E)). Ministry of Environment, Forest and Climate Change, Government of India. https://moef.gov.in/storage/tender/1750856052.pdf.

54. National Institute of Secondary Steel Technology (accessed 10 August 2026). List of companies/iron and steel producers having valid green steel certificates (as of July 31, 2026). Ministry of Steel, Government of India. https://nisst.org/wp-content/uploads/2026/08/12-Certificate-issued_31.07.2026.pdf

55. Ministry of New and Renewable Energy (MNRE) (accessed 4 June 2026). National Green Hydrogen Mission. Government of India. https://mnre.gov.in/en/national-green-hydrogen-mission/. Pal, R. et al. (2025). Augmenting the National Green Hydrogen Mission: assessing the potential financial support through policies in India. Council on Energy, Environment and Water. https://www.ceew.in/publications/augmenting-the-national-green-hydrogen-mission

56. Sethuraman, N. R. (7 August 2026). India seeks to boost domestic green ammonia supplies to fertiliser sector. Reuters https://www.reuters.com/business/energy/india-seeks-boost-domestic-green-ammonia-supplies-fertiliser-sector-2026-08-07/

57. Das, P. (1 February 2026). Budget 2026-27 sets aside Rs 20,000 crore to accelerate carbon capture in heavy industry. DownToEarth. https://www.downtoearth.org.in/climate-change/budget-2026-27-sets-aside-rs-20000-crore-to-accelerate-carbon-capture-in-heavy-industry

58. Bakshi, T. et al. (2023). Assessing India's CO□ storage potential: a critical analysis of what lies beyond the theoretical potential. Council on Energy, Environment and Water. https://www.ceew.in/publications/how-can-india-scale-carbon-capture-storage-projects-co2-storage-potential-sequestration

59. Leadership Group for Industry Transition (LeadIT) (accessed 4 June 2026). Green Steel Tracker, developed in collaboration with Lund University and Global Energy Monitor. https://www.industrytransition.org/trackers/green-steel-tracker/

60. Elango, S. et al. (2023).

61. Ibid.

In terms of carbon pricing, the CCTS is designed to achieve incremental emissions reductions and not to enable investment in near-zero emission plants. Being structured around emissions intensity targets rather than absolute emission caps with auctioned allowances, it is unlikely under its current design to generate high enough carbon prices. The notified targets amount to reductions of 5.6% by 2026–27 from the 2023–24 baseline, indicating that the scheme will mainly incentivise energy efficiency within coal-based production routes in its initial years. Effective prices above \$50/tCO_2 are required to incentivise near-zero primary steelmaking to account for the prevailing green premium estimates for H_2-DRI-EAF and BF-BOF-CCS. Even then, the policy's effectiveness in enabling investment in such plants would be uncertain, given the many factors that can influence a carbon price within an emissions trading system. At the same time, a carbon price of that level would have strongly negative effects on industrial competitiveness that both the government and industry would be likely to consider unacceptable.

As such, much of the planned capacity additions to the Indian steel industry are set to utilise the coal-based BF-BOF route, and the remainder through the coal-based DRI route. 26 Mtpa of BF capacity is already under construction, and about 166 Mtpa of capacity have been announced.[62] Therefore, policy action is imminently required to diversify the technology mix of the planned capacity additions away from coal to avoid the risk of a lock-in for the next 2–3 decades, especially considering the scale of capacity growth anticipated (152 Mtpa in 2025 to 400 Mtpa by 2035).

In the following sections, we present two versions of the subsidy-and-recharge policy for India. Both involve targeted subsidies for production of near-zero emission steel, funded by a very small carbon tax (the 'emissions intensity recharge') levied on the steel sector. The first version proposed also includes a small subsidy for incremental emissions reductions, linked to the CCTS. The alternative version replaces this with targeted public procurement of low emission steel. The main characteristics of these policy options are summarised and compared with the existing CCTS policy in Table 3.

[62] Global Energy Monitor (2026). Global iron and steel tracker, June 2026 (V1) release. https://globalenergymonitor.org/projects/global-iron-steel-tracker.

Summary of policy options

Table 3: Summary of policy options, compared with the existing CCTS.

Policy dimension	Carbon price (through the CCTS)	Proposed variant A: Emission-intensity recharge; dual-stream subsidy (CCTS performance-linked + FOAK–NOAK support)	Proposed variant B: Emission-intensity recharge; CfD green public procurement + FOAK–NOAK support
Description	CCTS-obligated steel producers face tighter targets. Based on CEEW analysis, effective ca rbon prices[63] above $50/tCO_2$ are needed to unlock RE switching for coal-DRI-IF routes and above $92/tCO_2$ to trigger BF-BOF-CCS. Together these address roughly 35% of sector emissions; decarbonisation of the remaining approximately 65% requires shadow prices at or significantly above $92/tCO_2$[64]. Actual carbon prices (nominal and effective) in the Indian CCTS are as yet unknown.	Alongside the CCTS, a per-tonne-CO_2 levy as low as $1.0/tCO_2$ (depending on the green premium) on verified plant-level emissions, collected on sale transactions. Fund is disbursed through two streams. **Stream 1:** CCTS performance-based sector-wide sliding-scale subsidy that pays for reductions per tonne of CO_2 post-facto (i.e. based on verified reductions in the next CCTS annual cycle). **Stream 2:** Targeted subsidy disbursed upfront to first-of-a-kind (FOAK) to nth-of-a-kind (NOAK) transformative clean steel plants (H_2-DRI-EAF or BF-BOF-CCS) through reverse auction on tendered capacity, covering differential green hydrogen or CCS costs to achieve BF-BOF cost parity for a fixed period decided by the company. The proportion of funds allocated to each stream can be determined based on the level of ambition.	Same recharge mechanism as variant A. Fund split between: **Stream 1:** A contracts-for-difference (CfD) green public procurement programme – government agencies procure steel certified 3-star and above under India's Green Steel Taxonomy based on greenness level; fund pays the strike price minus BF-BOF reference price on eligible contract volumes. **Stream 2:** Same as variant A.
Carbon price/ recharge rate	Effective prices of over $50/tCO_2$ would be required to incentivise clean steel.[65] Actual CCTS prices not yet established.	$10.5/tCO_2$ (5% of BF-BOF steel cost) at prevailing green hydrogen costs of ~$3.7/kg; as low as $1.0/tCO_2$ (0.4% of BF-BOF steel cost) with the projected decline in green hydrogen costs to $2.0/kg. Applicable to all CCTS-obligated entities (to subsidise 10% of total annual steel output).	Same as variant A.
Export premium ($/tCS)	~$127/tCS if fully passed through.[66] Significant export competitiveness risk, but steel is not a major export commodity for India presently.	Equivalent to recharge rate and prevailing emission intensity. Typically amounts to only 1% of BF-BOF steel cost for subsidising 10% of annual steel output. Partially offset by stream 1 for CCTS-compliant plants. H_2-DRI-EAF bears near-zero recharge.	Same as variant A.

63. Effective price across every unit of CO_2, i.e., average price across the entire industry's CO_2 emissions. In contrast, the nominal price is applied only on the traded volumes.

64. Elango, S. et al. (2023).

65. Based on CEEW estimates.

66. At the current emission intensity level of 2.4 tCO�/tCS and an estimated effective carbon price of $50/tCO_2$.

Policy dimension	Carbon price (through the CCTS)	Proposed variant A: Emission-intensity recharge; dual-stream subsidy (CCTS performance-linked + FOAK–NOAK support)	Proposed variant B: Emission-intensity recharge; CfD green public procurement + FOAK–NOAK support
Domestic market compet-itiveness	Risk of lower-emission imports undercutting domestic BF-BOF. No border adjustment mechanism.	Domestic producers pay recharge; imports are not subject to an equivalent levy. A carbon border adjustment mechanism (CBAM), calibrated to the recharge actually paid, would in principle be a WTO-compatible way to offset this, unlike a unilateral tariff increase, although probably not cost-effective at the current recharge rate. Net disadvantage modest; partially offset by stream 1.	Same as variant A.
Gov-ernment budget	No revenue. CCTS is baseline-and-credit with no permit auctions.	Self-financing. No net fiscal cost.	Self-financing (same fund size as variant A). Government procurement agencies pay strike prices for green steel; the CfD differential is reimbursed from the fund. No net fiscal cost, but procurement budgets absorb the gross strike price.
Steel cost premium; consumer impact	~$127/tCS (~24% above BF-BOF cost) if passed through. Significant impact on steel-intensive products.	Up to $25.2/tCS recharge if passed through (<0.1% of finished product prices). Stream 2 near-zero emission steel at BF-BOF cost parity during contract period.	Same recharge pass-through as A. Under stream 1, public contracts pay the strike price (green premium absorbed by fund, not final consumers). Private sector buyers face no additional cost from stream 1.
CO_2 abatement	~80 $MtCO_2$/yr at $50/$tCO_2$; marginal intensity reductions only (based on CEEW estimates).[67]	Stream 2: 40 $MtCO_2$/year at $10.5 down to $1/$tCO_2$ depending on the green premium. Near-zero primary steel at scale. Stream 1: Continuous intensity reduction incentive for all 255 CCTS entities.	Stream 2: Same as variant A. Stream 1: Supports ~11 Mt of gas-DRI-EAF (5-star rated at assumed 1.4 tCO_2/tCS) into public procurement by 2030. Less transformative than variant A stream 1 in the near term – intermediate rather than near-zero intensity.

[67] Estimated based on Elango, S. et al. (2023).

Proposed policy variant A: emission-intensity recharge with dual-stream subsidy

> India's CCTS is an intensity-based baseline-and-credit system with no auctioned allowances and no government revenue from carbon pricing.

The mechanism proposed here works within this structure by levying a modest charge on verified emissions and recycling the revenue into clean steel support.

Description

Recharge: Each CCTS-obligated plant pays a levy on its verified emission intensity for the preceding year. The levy can be adjusted annually depending on the prevailing premium for near-zero emission steel (which itself depends largely on the cost of green hydrogen in the case of H_2-DRI-EAF) to ensure that sufficient budget is available to meet the policy's objectives. This contrasts with other subsidy-and-recharge mechanisms described in this report that levy a flat rate per tonne of crude steel. This has the important advantage of alignment with the existing structure of the CCTS (discussed below) and reflects the large variation in emission intensity of production observed across CCTS-obligated entities in India.

The total levy per plant equals levy rate × emission intensity (tCO_2/tCS) × total steel sold (tCS), collected on all sale transactions of that plant. Based on the targeted steel production and emission intensity of over 250 MtCS and 2.2 tCO_2/tCS in 2030, and 340 MtCS and 2.0 tCO_2/tCS in 2035,[68] the recharge pool amounts to approximately $1.1 and $1.4 billion per year respectively at a rate of $2.0/$tCO_2$.

The recharge can be levied at the point of sale of steel from the steel plant for ease of application and tracking. In comparison, a levy on finished goods (such as automobiles, appliances, rebar etc.) sold to users and consumers is more challenging, owing to the requirement for product-wise data on steel use intensity and a monitoring, reporting and verification (MRV) framework to administer the product-specific charges.

In India, the recharge can take the form of a standalone central cess, similar to the model of the Sugar Development Fund under the Sugar Cess Act,[69] enacted through its own dedicated Act of Parliament rather than as an amendment to the goods and services tax (GST) framework.

Dedicated clean steel fund: All recharge revenue is credited to a dedicated, non-lapsable fund, ensuring its utilisation for the specified purpose. The fund is governed by an independent statutory board (with representation from industry stakeholders) with an explicit legislative mandate, transparent annual reporting, specific disbursal timelines and parliamentary oversight. This is in contrast with India's Clean Energy Cess (2010–17), less than a quarter of which reached its intended purpose before being subsumed into the GST Compensation Fund, among other such examples.[70]

---

68. GMK Center (2026).

69. Department of Food and Public Distribution (accessed 12 August 2026). Sugar Development Fund. Ministry of Consumer Affairs, Food and Public Distribution, Government of India. https://dfpd.gov.in/sugar-development-fund/en

70. Shekhar, S. et al. (2023). Decarbonizing energy system in India: a critical assessment of the performance of National Clean Energy and Environment Fund (NCEEF). Presentation, ADBI Virtual Workshop on Energy Transition from Coal to Low-Carbon Future. https://www.adb.org/sites/default/files/event/854126/files/s5-p101-presenter-bhagirath-behera-rev.pdf

Stream 1: CCTS performance-based sliding-scale subsidy: Part of the fund supports a sector-wide performance subsidy disbursed in the year following verified CCTS compliance. All obligated entities receive a subsidy per tonne of CO_2 reduced, calibrated on a sliding scale inversely proportional to emission intensity, weighting two factors equally: the intensity reduction achieved relative to the prior year, and the absolute emission level relative to the highest-emitting plant in the group. Cleaner plants receive more per tonne of CO_2 reduced; carbon-intensive plants receive less but remain eligible. This ensures that every entity receives a financial return, prevents the recharge from being perceived as a one-way levy, and creates a continuous incentive to reduce intensity beyond what CCTS targets alone require. It therefore creates less friction among entities paying the recharge and serves as a supporting mechanism to the CCTS itself. Table 4 shows an example of the stream 1 subsidy disbursement.

Table 4: Example working of how the stream 1 subsidy could function.

Item	Unit	Formula	Plant 1 (scrap-EAF/IF)	Plant 2 (natural gas-DRI-EAF)	Plant 3 (BF-BOF)	Plant 4 (coal-DRI-IF)	Total / *average*
Year 0 (when recharge is collected)							
a. Production	MtCS	Assumed	0.5	2.0	10.0	5.0	**17.5**
b. Intensity	tCO_2/tCS	Assumed	0.5	1.6	2.5	3.0	***2.5***
c. Emissions	$MtCO_2$	a × b	0.3	3.2	25.0	15.0	**43.5**
d. Emissions	% share	c/Σc	0.6%	7.4%	57.5%	34.5%	**100.0%**
e. Recharge collected	$ million	2 × c	0.5	6.4	50.0	30.0	**86.9**
f. Recharge collected	$/tCS	e/a	1.0	3.2	5.0	6.0	***5.0***
g. Stream 1 subsidy	$ million	Σe/2					**43.5**
Year 1 (when subsidy is disbursed)							
h. Production	MtCS	Assumed	0.6	2.5	12.5	6.3	**21.9**
i. Intensity	tCO_2/tCS	Assumed	0.5	1.5	2.2	2.7	***2.2***
j. Intensity change	tCO_2/tCS	b − i	0.0	0.1	0.3	0.3	***0.3***

Table 4: Continued

Item	Unit	Formula	Plant 1 (scrap-EAF/IF)	Plant 2 (natural gas-DRI-EAF)	Plant 3 (BF-BOF)	Plant 4 (coal-DRI-IF)	Total / *average*
k. Emissions	$MtCO_2$	h × i	0.3	3.8	27.5	16.9	**48.4**
l. Emissions normalised to base year production	$MtCO_2$	a × i	0.3	3.0	22.0	13.5	**38.8**
m. Reduction in normalised emissions	$MtCO_2$	l – c	0.0	0.2	3.0	1.5	**4.7**
n. Reduction in normalised emissions	% share	m/Σm	0.0%	4.3%	63.8%	31.9%	**100.0%**
Subsidy calculation							
o. Reduction-based subsidy	$ million	50% × g × n	0.0	0.9	13.9	6.9	**21.7**
p. Returned recharge	$ million	50% × g × d	0.1	1.6	12.5	7.5	**21.7**
q. Total subsidy	**$ million**	**o + p**	**0.1**	**2.5**	**26.4**	**14.4**	**43.5**
r. Net recharge paid	$ million	e – q	0.4	3.9	23.6	15.6	**43.5**
s. Net recharge paid	$/tCO_2$	2 – q/c	1.5	1.2	0.9	1.0	***1.0***
t. Net recharge paid	**$/tCS**	**s × i**	**0.8**	**1.8**	**2.1**	**2.8**	***2.2***

Note: All values have been rounded to the first decimal.

> The example plants in Table 4 represent four different steelmaking technologies through their sizes and emissions intensities: scrap-based EAF/IF, natural gas-based DRI-EAF, BF-BOF and coal-based DRI-IF. All plants pay a recharge of \$2.0/tCO_2; thus, the scrap-EAF/IF plant pays the lowest recharge per tonne of crude steel (\$1.0/tCS) while the coal-DRI-IF plant pays the highest (\$6.0/tCS).

In the subsequent year, all four plants achieve their emission intensity targets set under the CCTS. The scrap-EAF/IF plant has no change in its intensity as it is already low, and the BF-BOF and coal-DRI-IF achieve equal intensity reductions. Emission reductions are calculated as the difference between the normalised emissions in year 1 (i.e. the intensity in year 1 multiplied by the production in year 0) and the emissions in year 0.

The stream 1 subsidy is then disbursed as two substreams: the first based on the share of normalised emission reductions, and the second as a 'returned recharge' for meeting the CCTS targets. In the worked example, the scrap-EAF/IF plant effectively pays a net recharge of only \$0.8/tCS, while the coal-DRI-IF plant pays \$2.8/tCS at the end of year 1. This formulation ensures equitable distribution of the recharge while also incentivising both CCTS compliance and absolute emission reductions, but still keeping the recharge at a minimal level compared with the cost of steel itself.

Stream 2: FOAK–NOAK operating cost support: The remainder of the fund is allocated through a reverse auction to greenfield or brownfield plants committing to transformative decarbonisation: specifically H_2-DRI-EAF or BF-BOF with CCS. The subsidy covers the differential operating cost of green hydrogen (for H_2-DRI-EAF) or CCS (for BF-BOF-CCS), calibrated to achieve BF-BOF cost parity over a defined contract period chosen by the developer. The bidder who requires the lower subsidy amount per unit of steel for a predetermined volume and duration (specified in the tender) is awarded the subsidy. Up-front disbursement, conditional on construction and production commitments, or periodic disbursement via escrow against committed production volumes is permitted, with penalties for not meeting targets. This gives FOAK projects the revenue certainty required to reach financial closure while linking payment to demonstrated progress, with penalties for not meeting targets.

The H_2-DRI-EAF green premium is approximately \$127/tCS at a green hydrogen cost of \$3.7/kg (near present-day cost). If green hydrogen costs decline to \$2.0/kg (say, by 2035) through economies of scale and prevailing policy support for the green hydrogen value chain, the green premium will decline to just \$6/tCS. As green hydrogen costs and green premiums decline, the subsidy-and-recharge mechanism can support greater quantities of clean steel production. Even if only 50% of the recharge is allocated under stream 2, near-zero emission steel production equivalent to close to 10% of national production can be supported to achieve price parity with BF-BOF steel through this mechanism at varying recharge levels as shown in Table 5. The recharge can also be maintained at a flat level of, say, \$2.0/tCO_2 to maintain consistency across years and limit the effect on the steel costs, while still supporting substantial (~3 Mtpa) clean steel production every year (even if the target of 10% of total primary steel is not achieved in the initial years).

Table 5: Example of how the stream 2 subsidy functions.

Item	Unit	2025, 10% steel subsidised	2025, flat \$2.0/ tCO_2 recharge	2035, at \$2.0/kg green hydrogen
Steel output	MtCS	152.2	152.2	340.0
Emission intensity	tCO_2/tCS	2.4	2.4	2.0
Recharge	\$/tCO_2	10.5	2.0	1.0
	\$/tCS	25.2	4.8	2.0
	% of BF-BOF price	**5.1%**	**1.0%**	**0.4%**
	\$ million (2024 USD)	3,835.2	730.5	680.0
Green hydrogen cost	\$/kg	3.7	3.7	2.0
	\$/tCS	252.3	252.3	135.4
H_2-DRI-EAF steel cost	\$/tCS	623.8	623.8	507.0
Premium over BF-BOF	\$/tCS	127.0	127.0	10.1
Subsidy (stream 2)	\$ million (2024 USD)	1,917.6	365.3	340.0
Near-zero emission steel subsidised	**MtCS**	**15.1**	**2.9**	**33.6**
	% of total steel	10%	2%	10%

Impacts on industrial competitiveness

Steel industry: The recharge adds between \$2/tCS and \$25/tCS (based on the green premium and average emission intensity), amounting to between 0.4% and 5.1% of the cost of BF-BOF steel. As shown in Table 5, the recharge could be limited to lower values if the target of 10% clean primary steel is foregone in the initial years of the scheme. The stream 1 subsidy also partially offsets this cost for CCTS-compliant plants. The stream 2 subsidy could support over 30 Mtpa of near-zero steel production (2035 projections) at cost parity with BF-BOF steel, directly abating over 60 $MtCO_2$/year (about 35% of India's steel sector CO_2 emissions by 2035). The stream 1 subsidy will support additional reductions by making CCTS compliance more cost-effective for industries, and in turn promote stricter emission intensity targets to be set in successive years.

The large volume of annual near-zero steel production would make India among the first and largest clean steel producers in the world and could help establish markets for clean downstream products, both domestically and internationally. For example, India will be able to leverage the proposed India–EU free trade agreement-linked zero-duty quotas and avoiding rising CBAM costs (linked to the EU phase-out of emissions trading system allowances in the 2030s) to become a highly competitive exporter of green iron/steel to the EU.

Import competition: Imports are not subject to an equivalent levy, since the recharge functions as a carbon tax, and a flat levy applied to imports on that basis would not be a WTO-compatible option, unlike the flat per-tonne border levies proposed for other countries in this report. Domestic producers therefore face a small structural cost disadvantage relative to importers equivalent to the per-tonne recharge, but this would be relatively small: data show coking coal import unit prices in India rising by roughly 100% between 2020–21 and 2021–22, and by a further 50% into 2022–23, before falling back around 17% in 2023–24.[71] The average net annual change in retail prices for various steel products was about 5% annually from 2021–24,[72] fluctuations larger than the recharge's roughly 1% effect on production costs.

In principle, a border tax on carbon calibrated to the recharge actually paid would be a WTO-compatible way to offset any residual disadvantage, unlike a unilateral tariff increase. However, at a fixed $2.0/ t$CO_2$ recharge rate, the administrative cost of a dedicated border tax would be likely to exceed the competitiveness benefit; this would change if the CCTS evolves toward a materially higher effective carbon price in future, to which the recharge would add only a small increment. In practice, given India's existing competitiveness as a global steel producer and the small size of the recharge, a trade response of this kind is unlikely to be needed in the near term.

Downstream sectors: The recharge can be passed through to domestic buyers of steel, with effects so small that they are unlikely to be noticed. The costs of final products containing steel are unlikely to increase by more than 1% (Table 6).

Table 6: Cost increases to steel-containing products due to the steel recharge.

Item	Steel intensity	Cost	Cost increase	
			at \$10.5/tCO_2	2025, flat \$2.0/ tCO_2 recharge
Refrigerator (250 litre)	38 kg/unit	\$375	\$0.96 (0.26%)	\$0.18 (0.05%)
Compact passenger car	750 kg/unit	\$10,000	\$18.9 (0.19%)	\$3.6 (0.04%)
1,000 sq ft residen-tial apartment	4.5 kg/sq ft	\$27,000	\$113.4 (0.42%)	\$21.6 (0.08%)
Four-lane highway	160 t/km	\$1.3 million/km	\$4,032 (0.31%)	\$768 (0.06%)

> We note that steel procurement and usage are done in several upstream steps by various suppliers before being assembled into an end product.

The multitude of transactions and margins in the supply chain of a given product could mean that the calculation of the above effects is not as simplistic.

However, even a doubling or tripling of the above estimates due to these complexities would still limit the effect of the recharge to below 1.5% of the cost of a product or project. These impacts are within normal input cost variability and do not materially affect the price competitiveness of any downstream sector. Steel from stream 2 supported H_2-DRI-EAF plants is available to domestic buyers at BF-BOF cost parity during the contract period, so no green premium passes through to those buyers.

71. Joint Plant Committee (2024).
72. Ibid.

Impact on government budgets

> The mechanism is self-financing: total recharge collections equal total subsidy disbursements, with no net fiscal cost to government. The only outlay is the administrative cost of establishing and running the fund board and the stream 2 auction process. This is a significant advantage over a direct budget subsidy, which would require annual appropriation and compete with other fiscal priorities.

Exit strategy

The mechanism is explicitly transitional. The green premium for H_2-DRI-EAF declines as green hydrogen costs fall: from approximately $127/tCS in 2025 to $10/tCS by 2035 per our estimates. H_2-DRI-EAF reaches full cost parity with BF-BOF without subsidy when green hydrogen falls to approximately $1.90/kg at current other input costs. Analysts project that India-specific green hydrogen costs could reach $1.5–2.0/kg by 2035 under optimistic scenarios.[73] Once this threshold is sustained, stream 2 auction yields zero or near-zero subsidy bids. These may nevertheless contribute usefully to enabling investment by acting as a revenue-stabilisation mechanism, as international experience with renewable power CfDs has discovered. The fund can then be wound down over a two- to three-year glide path. Stream 1 may be retained at a reduced recharge rate as a CCTS complement or phased out in tandem.

Operational considerations

The mechanism builds on the CCTS's existing MRV infrastructure, requiring no new data collection: verified emission intensity and output data for all 255 obligated entities are already gathered annually. Incremental requirements are calculation of the per-plant recharge from existing MRV data; establishment of the statutory fund board through primary legislation; and design and operation of the stream 2 reverse auction, for which the Solar Energy Corporation of India (SECI) renewable energy auction model provides a proven template. The principal institutional risk is fund governance. The statutory ring-fenced recharge pool fund must withstand fiscal pressure, as the National Clean Energy and Environment Fund (NCEEF) failed to do.[74] Transparent accounting, fund disbursal within a specified timeframe, and an independent board with legislated powers are essential design features. The governance of this fund may be under the purview of the Ministry of Steel; as the CCTS is administered by the BEE under the Ministry of Power, facilitation of MRV data sharing is required between the two ministries, especially for the disbursement of the stream 1 subsidy.

Some additional considerations may be made for the design and formulation of the mechanism itself, such as:

- Applying the recharge distinctly between different plant groups based on, for example, production route or size.
- Whether scrap-based steel producers should be excluded for skewing the intensity distribution, restricting the overall subsidy-and-recharge mechanism to only primary steel producers.
- Whether the overall subsidy should be divided 50:50 between streams 1 and 2, or whether one of the streams should be given a larger share.
- Whether stream 1 should be subdivided 50:50 between the reductions-based subsidy and compliance-based recharge return, or whether one of the two should be prioritised.

---

73. Kowtham Raj, Pranav Lakhina, and Clay Stranger, Harnessing Green Hydrogen: Opportunities for Deep Decarbonisation in India (New Delhi: NITI Aayog; Boulder, CO: RMI, 2022), https://www.niti.gov.in/sites/default/files/2022-06/Harnessing_Green_Hydrogen_V21_DIGITAL_29062022.pdf; Sudheer Pal Singh, "Green Hydrogen Cost in India to Fall to $2 per kg by 2032: Mission Director," Business Standard, September 9, 2025, https://www.business-standard.com/industry/news/green-hydrogen-cost-in-india-to-fall-to-2-per-kg-by-2032-mission-director-125090901008_1.html; Asian News International, "India's Ambition to Achieve Green Hydrogen at $2/kg Is Not a Distant Dream Anymore: Amitabh Kant," Tribune India, March 5, 2026, https://www.tribuneindia.com/news/business/indias-ambition-to-achieve-green-hydrogen-at-2-kg-is-not-a-distant-dream-anymore-amitabh-kant/; RMI India (25 August 2025). Three considerations to make green hydrogen a reality in India. https://rmi.org/resources/three-considerations-to-make-green-hydrogen-a-reality-in-india/; Jindal, A. et al. (2024). At scale adoption of green hydrogen in Indian industry: costs, subsidies, and policies. Energy for Sustainable Development 82(2024): 101530; Gopika Nair, "India's Green Hydrogen Market May Surge 14x; Equirus Predicts 56% Cost Drop by 2030," Financial Express, July 22, 2026, https://www.financialexpress.com/business/industry-indias-green-hydrogen-market-may-surge-14x-equirus-predicts-56-cost-drop-by-2030-4299302/

74. Shekhar, S. et al. (2023).

Political economy

The recharge rate is unlikely to generate significant industry opposition as it amounts to only about 1% of the BF-BOF steel cost at a recharge of $2.0/tCO$_2$. Stream 1 also returns funds to every CCTS-obligated entity, preventing the mechanism from being perceived as a one-way levy. The open reverse auction for stream 2 creates a level playing field for private and public sector developers. Downstream industries face cost increases below 1% of product prices. The mechanism is consistent with proposed decarbonisation targets and the NGHM production goals, making it supportable across the Ministries of Steel, New and Renewable Energy, and Environment. The self-financing design addresses the Ministry of Finance's likely objection to an open-ended budget commitment.

The recharge could follow the model of the Sugar Cess Act, 1982, which funded the Sugar Development Fund to provide concessional loans to sugar industries for their own development over four decades.[75] The legislation can be enacted through a standalone Act of Parliament establishing a dedicated cess, rather than through an amendment to the GST framework itself. This distinction matters for political feasibility: A standalone cess Act does not require reopening or amending the GST framework and has a more established legislative track record in India, of which the Sugar Cess Act is an example. Securing legislative time and ministerial sponsorship for a new Act remains a genuine undertaking and competes with other legislative priorities in any given session, but the pathway itself is well-precedented. Potentially, the Act could allow for subsidy-and-recharge mechanisms to be set up for different industry sectors in addition to steel, such that all nodal authorities would then have the statutory provision to deploy the mechanism through a common Act established under a cross-cutting authority like the BEE or the Ministry of Finance.

Secondary objectives and fit with existing policies

> The mechanism complements rather than replaces the CCTS.

Stream 1 provides a direct financial reward for CCTS target compliance, strengthening the credibility of the carbon market without requiring a carbon price at the level needed for transformative change. Stream 2 creates large-scale demand for green hydrogen, directly supporting NGHM production targets. India's Green Steel Taxonomy and NISST certification infrastructure serve as the eligibility gateway for stream 2. The reverse auction builds domestic H_2-DRI-EAF deployment experience, positioning India's steel sector ahead of potential future carbon border measures from trading partners.

[75] Department of Food and Public Distribution (accessed 12 August 2026).

Proposed policy variant B: contracts-for-difference green public procurement as stream 1

How this variant functions

> This variant is identical to variant A in its recharge design and the stream 2 subsidy for near-zero emission steel production.

It replaces the stream 1 subsidy for incremental emissions reduction with a CfD programme for green public procurement. Under this arrangement, government agencies and public sector undertakings source steel certified at three-star or above (2.2 tCO_2/tonne finished steel or below) under India's Green Steel Taxonomy;[76] the fund pays each certified supplier the difference between a pre-agreed strike price and the prevailing BF-BOF reference price, on volumes delivered into eligible public contracts. With public sector steel demand at approximately 25 Mt in 2022–23,[77] a stream 1 allocation of $300 million could support approximately 2.5 Mt of H_2-DRI-EAF steel at a premium of $127/tCS.

Key differences from variant A

Effectiveness: Variant B supports lower-emission rather than near-zero emission primary steel in the near term, since no H_2-DRI-EAF capacity yet exists in India. This is a deliberate trade-off: supporting gas-DRI-EAF investment now diverts planned capacity away from the far higher-emission BF-BOF route, and gas-DRI-EAF plants are technically well-placed for later conversion to H_2-DRI-EAF, since the two routes share the same core shaft-furnace and EAF infrastructure and differ primarily in reductant source. This mitigates the risk of locking in fossil-gas-dependent capacity and aligns with stream 2 in supporting the establishment of gas-based DRI shaft furnace capacity. It becomes more effective as a complement to stream 2 once H_2-DRI-EAF plants are operating and can compete for public contracts. At that point, the criteria for the public procurement contracts could be tightened, or could continue operating with differentiated levels of subsidy support based on the greenness level or star rating of the steel as per the taxonomy.[78]

Uncertainty on strike price: No established green steel premium exists in India's market as of mid-2026: the approximately 12 Mt of certified green steel produced to date is largely from secondary producers and has not attracted a quantified market premium. Setting an appropriate strike price without market reference data introduces a risk that variant A's market-facing auction mechanism avoids. This risk could be reduced by structuring variant B's procurement contracts as an auction as well, with government setting only a reserve (maximum) price and the actual strike price discovered competitively, similar to stream 2. This would improve price discovery but may attract too few bidders to be effective while only a small, newly eligible pool of Green Steel Taxonomy-certified suppliers exists. An administratively set strike price, as originally proposed, is simpler and faster to implement but carries a greater risk of being set too high or too low relative to actual market conditions. However, if variant B is found to be more favourable, the mechanism can function as a simple parity-inducing subsidy in early years and then transition into a CfD based on the maturity of the market.

Competitiveness, government budget, consumer costs: These are unchanged from variant A. Under variant B, government procurement agencies (and indirectly, taxpayers) and not private consumers absorb the green premium, with the fund paying the CfD difference.

Political economy: Green public procurement is a well-understood policy tool. However, concentrating stream 1 support on suppliers winning public contracts may be perceived as less equitable than variant A's sector-wide approach, particularly by smaller DRI-IF producers who do not typically supply public tenders.

---

76. Ministry of Steel (12 December 2024). Taxonomy for green steel, notification G.S.R. 763(E). Government of India. https://egazette.gov.in/WriteReadData/2024/259382.pdf.

77. Ministry of Steel (2026). Annual Report 2025–26.

78. Ministry of Steel (2024).

Key uncertainties

> Five uncertainties bear most directly on the mechanism's design.

First, there is no mechanism to calculate split of the recharge between subsidy streams 1 and 2; this is largely discretionary. Second, CCTS MRV quality: the recharge is only as reliable as the underlying emission intensity data; the final gas emission intensity notification and MRV robustness are critical prerequisites. Third, fund governance: the statutory ring-fence must withstand fiscal pressure, and the legislative model must learn directly from the NCEEF failure. Fourth, import duties: whether India will be required to, and/or has the space to proportionally increase import duties is unknown; this depends on WTO limits and specific bilateral agreements. Fifth, whether there is sufficient legislative priority to secure passage of a standalone cess Act; while this is a well-precedented instrument in India (for example the Sugar Cess Act), it still requires dedicated legislative time and ministerial sponsorship.

79. Shekhar, S. et al. (2023).

4. From first-mover risk to late-mover risk in the steel transition: the European Union

Authors: Thibault Deletombe, Antonia Kurz, Prof. Karsten Neuhoff – German Institute for Economic Research (DIW Berlin)'

Context

Current state of the steel industry in the European Union

In 2025, the EU produced 125.8 Mt of crude steel, amounting to 6.9% of global production.[80] Coal-based blast furnace–basic oxygen furnace (BF-BOF) processes account for 54.2% of total production, while the remaining 45.8% comes from electric arc furnace (EAF) plants. The same year, the EU consumed 136 Mt of crude steel, positioning the region as a net importer. The construction sector is the largest steel consumer, responsible for 38.1% of total demand, followed by the automotive industry, responsible for 17.7% of total demand.

As a mature economy, the EU has a large stock of scrap embedded in products and buildings, currently recycled at an 85% rate.[81] In some modelling exercises, the scrap supply is increasing to equal European steel consumption by 2050.[82] However, scrap quality is the main bottleneck. In 2019, the share of scrap input into EU steelmaking was around 50%, while the rest of the production was based on iron ore.[83]

In the EU, the average emission intensity of BF-BOF plants is 1.8 tCO_2/t steel,[84] resulting in the emission of 145 Mt of CO_2 in 2023,[85] representing 4.3% of EU emissions.[86] The EU has committed to climate neutrality by 2050. This cannot be reached with incremental improvements of existing BF-BOF plants but requires a shift to near-zero emission production processes. Moreover, most BF-BOF plants reach the end of their operational lifetime or need to be relined before 2035.[87]

Steel producers active in Europe are thus facing the tough choice of either investing in near climate-neutral production processes to align with Europe's climate policy objectives, or not pursuing major investments and thus gradually retiring existing production capacities.

The 2019 Fit for 55 package of the EU Commission, targeting 55% emission reductions by 2030, has motivated steel producers across Europe to initiate near-climate-neutral steel projects. As a result, the majority of global low-carbon steel projects are currently concentrated in the EU.[88] Most of these European near-zero emission steel projects include the EAF technology, either in the hydrogen–direct reduced iron–electric arc furnace (H_2-DRI-EAF) primary production route or in the secondary scrap–EAF production route.

> While progress towards completion is steady with some of the projects, multiple factors are challenging both the business case for the new projects and the financial capacity of firms to pursue the investments.

---

[80] W EUROFER (2026). European steel in figures. https://www.eurofer.eu/assets/european-steel-in-figures-2026/Steel-in-Figures-SIF-Final_printer.pdf

[81] JRC (2022). Technologies to decarbonise the EU steel industry. https://publications.jrc.ec.europa.eu/repository/handle/JRC127468

[82] Material Economics (2019). Industrial transformation 2050 – pathways to net-zero emissions from EU heavy industry. CISL; Pauliuk, S. et al. (2013). The steel scrap age. Environmental Science & Technology 47(7). https://doi.org/10.1021/es303149z

[83] IEA (2020). Iron and steel technology roadmap – towards more sustainable steelmaking. https://www.iea.org/reports/iron-and-steel-technology-roadmap

[84] JRC (2026). Mapping the transition of the EU steel industry to carbon neutrality. https://setis.ec.europa.eu/publications-and-documents/industrial-decarbonisation-factsheets_en

[85] Choksey et al. (2025). The state of the European steel transition. https://eeb.org/wp-content/uploads/2025/03/State-of-Steel-Report.pdf

[86] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Greenhouse_gas_emission_footprints

[87] Choksey et al. (2025).

[88] https://www.industrytransition.org/trackers/green-steel-tracker/

First, the increasing competitive pressure from surplus production capacity in China, the US tariffs, and the recent energy crisis have all impacted European steel companies and contributed to economic uncertainty, which is impeding investments. Second, access to hydrogen infrastructure and to affordable, green electricity is uncertain. Finally, some design elements of certain EU climate policies also create challenges for investments in near-zero-emission processes

Current policies to decarbonise the sector

The EU is implementing several policy instruments that shape the investment framework of clean steel projects. The most prominent one is the EU emissions trading system (ETS), which puts a price on ~40% of EU greenhouse gas emissions,[89] including emissions from steel production. The EU ETS is complemented by a carbon border adjustment mechanism (CBAM). The CBAM's objective is to create an import tariff which prices carbon embedded in imports at a price equivalent to the EU ETS in order to level the playing field with domestic producers subject to the EU ETS. Additionally, the Industrial Accelerator Act aims to develop green lead markets, creating demand for near-zero emission steel.

This European regulatory framework is supplemented by various initiatives at the national level to fund or secure the incremental cost of green production. Either investment support or carbon contracts for difference (CCfDs) are granted through a competitive process to near-zero-emission processes.

Yet multiple barriers to the large-scale deployment of near-zero-emission technologies remain in Europe. The current architecture of the EU ETS and EU CBAM that targets production-specific emissions is subject to strong criticism:[90]

i) The lack of an export solution: alignment with WTO rules prohibits refunding carbon costs for exports within the current EU CBAM design. As a result, European steel exporters face a competitive disadvantage due to the EU ETS carbon price when selling into markets without such policies. At the same time, current policies do not provide a means for clean primary steel produced in Europe to be exported competitively.

ii) Opportunities for resource shuffling: following CBAM implementation, steel producers in other countries can sell their least emissions-intensive steel to the EU, undercutting European producers, while selling their more emissions-intensive steel elsewhere. Thus, foreign firms can simply redirect their trade flows to gain a competitive advantage in the EU market without actually decarbonising their production. Meanwhile, EU firms must comply with broader and more stringent decarbonisation constraints.

iii) Insufficient downstream coverage: the European Commission is consulting on proposals to expand the CBAM to cover around 180 downstream products. This could reduce the exposure of downstream industries, but its effectiveness is uncertain given the administrative difficulty of measuring, verifying and tracking the emissions embodied in the steel contained in each product.

To prevent potential carbon leakage risks not taken care of by the current EU CBAM, there is an extensive discussion to delay the phase-in of the CBAM and, in the meantime, maintain free allowance allocation, as carbon leakage protection is only reduced gradually. Free allocation or financial support for conventional production does, in principle, undermine investment incentives for near-zero-emission processes. To correct for this disadvantage, the EU committed to provide free allocation to plants using near-zero emission processes at the same scale per tonne of material produced (allowing them to earn revenues by selling the freely-acquired permits).

However, continuing free allowance allocation at the current scale for both conventional and clean production processes would gradually reduce

89. https://climate.ec.europa.eu/areas-action/carbon-markets/about-eu-ets_en

90. Neuhoff, K. et al. (2026). Industrial decarbonization in a fragmented world: carbon pricing with border adjustments using standardized values. Energy Policy 216 (September). https://doi.org/10.1016/j.enpol.2026.115405

the volume of allowances that are auctioned. This could trigger opposition from EU member states that currently obtain these allowances and use the auction-revenue, primarily to fund climate action. With the declining EU ETS cap, these auction volumes and their revenues would gradually decline and fully dry up in 2034. Then to maintain any ETS revenues either free allocation would need to be scaled back, or the EU ETS cap relaxed.

Against this background, in July 2026, the EU Commission published its long-awaited proposal for reform of the EU ETS. It slightly prolongs the amount of free allocation as well as relaxes the ETS cap. Also, a part of the CBAM revenue is proposed for a Temporary Decarbonisation Fund for providing additional compensation to producers of goods covered by the CBAM.[91] This re-balancing attempts to increase carbon leakage protection at the cost of reduced carbon pricing incentives, illustrating the challenge of the current production-specific CBAM that fails to fully align both objectives.

In order to also strengthen investment incentives, the new proposal envisages that firms receiving free allowances or support from the Temporary Decarbonisation Fund have to first, develop and comply with a transition plan, and second, demonstrate and report investment in decarbonisation at the scale of the value of the free allowance allocation and funding they obtain from Temporary Decarbonisation fund. The stronger role for transition plans has been broadly requested, as a push to implement clean production. It does depend, however, on adequate incentives to make the business case viable for such investments. For this business case, the requirement to invest the value of free allocation and support from the Temporary Decarbonisation Fund into decarbonisation projects is not sufficient, because the support is already required to cover incremental costs of production under the EU ETS compared to international competitors.

At the same time, the Commission has refreshed proposals to provide more direct support to low emission industrial production. These proposals include the use of 400 million EU ETS allowances in the period 2028–2031 to pay projects a fixed amount per tonne of avoided emissions, which the Commission estimates could support €30bn of investment; the use of competitively allocated CCfDs funded by EU ETS revenues to support clean industrial production from 2031 onwards, and a requirement for Member States to spend 50% of their EU ETS revenues on decarbonising sectors covered by the ETS.[92] These measures could in principle enable investment in clean primary steel production, but the scale at which they could do so is uncertain. The extension and increase of free allowances and the relaxation of the ETS cap will both tend to reduce ETS revenues, the former by reducing the volume of permits auctioned, and the latter by reducing the average permit price. Consequently, it is difficult to be confident that the revenues will be sufficient to support clean primary steel production at the scale needed for the transition (at the same time as supporting decarbonisation in other EU ETS sectors).

> Green lead markets are discussed as an alternative or a complementary instrument to support climate-neutral investments.

They include approaches based on product labelling and voluntary consumer choices. They also comprise the introduction of green requirements for public procurement or mandates for the private sector to use climate-friendly materials in production processes. However, the investment incentives that these instruments provide are limited as they suffer from multiple drawbacks: limited scale, uncertain willingness by consumers to pay the green premium, and lack of regulatory clarity.[93]

---

91. Only 27% of CN codes in the steel and iron sector are covered in the current preferred option of the Commission staff working document accompanying the document proposal for a regulation of the European Parliament and of the Council establishing the Temporary Decarbonisation Fund. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52026SC0067

92. European Commission (2026). Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC and Decision (EU) 2015/1814 as regards driving competitiveness and cost-effective decarbonisation, pp21, 88-93. https://eur-lex.europa.eu/resource.html?uri=cellar:757bd24a-8413-11f1-bf5e-01aa75ed71a1.0001.02/DOC_1&format=PDF

93. Deletombe, T. et al. (2026). Reforming carbon border adjustment mechanisms: European industry perspectives on a path forward. CETEX. https://cetex.org/wp-content/uploads/2026/06/Reforming-Carbon-Border-Adjustment-Mechanisms.pdf

CBAM with standardised values: a recharge-and-subsidy approach for the EU

Political economy

> The EU ETS is considered by most actors to be the EU's leading climate policy instrument and has been in place for over 20 years.

Therefore, our proposed approach is anchored in the existing EU ETS architecture, as developing a comprehensive alternative policy framework would take too long and create too much uncertainty for investments in climate-neutral production processes.

For these reasons, the approach we propose for the EU is one that is firmly embedded within the existing ETS and CBAM policies, and that addresses their deficiencies in relation to clean steel deployment and carbon leakage without creating any significant new administrative requirements or costs. This results in the proposed approach being one of 'recharge-and-subsidy' rather than 'subsidy-and-recharge', an important difference from the other country proposals presented in this report.

Policy description

The mechanism would raise funds by imposing a charge per tonne of steel produced or imported that is equivalent to the value of free allowances allocated through the EU ETS, and would use these funds to support clean primary steel production.[94]

The proposed reform would introduce standardised values to allow for the use of established effective border adjustment procedures in a WTO-compliant manner. This avoids the limitations of the current EU CBAM based on production-specific emission values, in particular for sectors with complex value chains. The proposed approach is based on a standardised liability imposed per tonne of steel produced or imported, analogous to the recharge system. The approach differs in that the liability is not calibrated to match the funding requirements of clean production processes, but to match the value of free allocation granted to conventional producers under the current EU ETS system. Thus, the approach reinstates the full carbon price incentives and revenues, while creating the basis for effective carbon leakage protection. The full carbon pricing revenues are then available to pay for emission savings of clean processes through CCfDs.

Such a reform to fill the carbon pricing gap while addressing carbon leakage concerns would ease the political economy of the instrument. It would anchor it within the current regulatory scheme and facilitate its appropriation by EU stakeholders and policymakers. It could be pursued within the EU ETS and CBAM reform processes and, as an environmental regulation, could be passed with qualified majority in the EU.[95]

Operational considerations

Shifting from the current CBAM design based on process-specific emissions towards standardised values comprises the following elements.[96] A standard liability per tonne of material is created for the domestic production of crude steel at the level of free allocation. The same liability also applies to the import of steel, including as part of products. Then, the liability can be passed to buyers of the steel and from there to buyers of intermediary products containing steel, in line with established duty suspension schemes. Because the liability is based on the weight of material irrespective of its geographic origin or its production process, it can be waived for exports within WTO rules. Firms selling to final users, or to firms that choose not to participate in the duty suspension scheme, pay the liability. Because all competitors in this market will have incurred the same liability, proportionally to the steel content of the product, the common cost can be reflected in product prices. Reporting by firms can be limited to a quarterly aggregate figure, because the approach of a duty suspension scheme without payouts limits fraud risks. Hence, firms only have to report quarterly on the amount of liability created or incurred from purchases from individual suppliers and imports, and on the amount of liability passed to individual firms or waived for exports. Each firm then pays for the liability it has incurred, and not passed to others, e.g. the liability for products sold to domestic users.

---

[94] Neuhoff, K. et al. (2026).

[95] Ismer, R. & Manuel, H. (2016). Inclusion of consumption into the EU ETS: the legal basis under European Union Law. Review of European, Comparative & International Environmental Law 25(1). https://doi.org/10.1111/reel.12131

[96] Neuhoff, K. et al. (2026).

Effectiveness of incentivising investments in climate-neutral primary steel production

Under the proposed reforms, revenues raised from the charge on all steel production and imports would be used to fund CCfDs for clean primary steel production. These contracts could close the remaining cost gap between clean primary steel and conventional BF-BOF steel and provide the long-term certainty that can enable investment.

The allocation of CCfDs would be determined by competitive auctions selecting the most cost-efficient projects under a volume constraint designed to encourage early movers. To ensure that the process incentivises clean primary steel, the subsidies would be allocated in proportion to the use of iron made with H_2-DRI produced in the EU.

Government revenues, incentives for climate-neutral primary steel investments and international climate action

At $90 per tonne of CO_2, such a mechanism applied to steel would generate approximately $28 billion per year in the steel sector.[97] This is more than the funding needed for the full transition of primary steel toward clean processes, estimated at $14.8 billion per year with the current set of assumptions.

> Additional revenue delivered by effective carbon prices, ultimately paid by users of materials, could be used for a combination of policies.

These might include international climate action or investments in transformation that directly benefit citizens, such as building retrofits or even lump-sum refunds. In theory, revenue could also be insufficient if carbon prices were to decline. Pre-commitments by governments through CCfDs reduce this risk.[98] With CCfDs, governments would bear the costs of reduced ETS and CBAM revenues instead of the firms having invested in clean production processes. Hence, governments have lower incentives to relax the EU ETS cap since this would lead to lower carbon prices and increase budgetary costs of CCfDs.

For example, allocating 20% of these revenues to decarbonisation projects in third countries could unlock $5.6 billion for global climate efforts and cover the incremental cost of 26 Mt of clean primary steel (assuming an incremental cost of $218 per tonne for clean steel produced abroad). Assuming that the current CBAM is fully effective and not subject to resource shuffling, it provides direct decarbonisation incentives abroad only to the primary steel imported into the EU, amounting to 23 Mt in 2025.[99]

Impact on incumbent steel industry and downstream firms

The mechanism would allow for the continuation of free allowance allocation to existing installations at the full benchmark established by the best available conventional technologies. The residual carbon cost above the benchmark that is not covered by the liability is low. For most steel firms, it represents less than 5.5% of their production cost.[100] In domestic markets, European firms thus compete on equal footing with foreign competitors whose products are subject to the standardised liability. The mechanism also levels the playing field for European firms in international markets because the liability can be waived for export. Additionally, because the liability is standardised and set irrespective of the production route, foreign firms cannot gain a competitive advantage over European firms by redirecting their least emission-intensive products to Europe. Thus, the main sources of carbon leakage risks under the EU ETS would be avoided.

Additionally, the integration of the mechanism within the existing EU ETS and CBAM regulation avoids additional administrative costs. Replacing the need for production-specific emission tracing and verification on imports with a duty suspension scheme based on standardised liabilities would instead be likely to reduce overall costs.

---

97. 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.

98. Chiappinelli, O. & Neuhoff, K. (2017). Time-consistent carbon pricing. SSRN Electronic Journal, ahead of print. https://doi.org/10.2139/ssrn.3100108

99. EUROFER (2026).

100. For four-fifths of conventional plants in the EU, less than 0.37 tCO_2/t-steel is not covered by the mechanism. At $90/$tCO_2$, this carbon cost represents 5.5% of the production cost. https://climate.ec.europa.eu/document/download/fd041819-e22e-4e77-a267-6ab4405328aa_en

Cost to consumers

Contrary to a CBAM targeting process-specific emissions, the standard liability is also embedded in products manufactured with secondary steel, yet the cost to the final consumer is limited. A $218 cost increase per tonne of primary and secondary steel results in a relative price increase of less than 2% for the following products: family houses, cars, washing machines, refrigerators, air conditioners, wind turbines and solar photovoltaic panels.

Secondary objectives

Because the liability is incurred with the production of basic materials, the full incentives for material efficiency and material choice along the value chain are preserved. The coverage of (residual) emissions of (clean) production processes under ETS ensures incentives for carbon-efficiency improvements for material production. It is envisaged that continued free allocation to conventional plants is conditioned on credible transition plans, ensuring an incentive for the shift to clean processes while facilitating coordination on the required infrastructure.

5. Brazilian subsidy-and-recharge mechanism for near-zero emission steel

Authors: Hugo Bolognesi, Simone Klein, João Abbud, Luisa Bianchet, Stefania Relva – E+ Energy Transition Institute

Context

Brazil hosts a medium-sized steel industry by global standards, producing 33.8 Mt of crude steel annually and accounting for around 1.8% of global production.[101] The sector combines integrated blast furnace–basic oxygen furnace (BF-BOF) routes, which represent roughly three-quarters of production, with electric arc furnace (EAF) routes that account for approximately one-quarter of output. Compared with many major producing regions, Brazil exhibits a relatively high share of secondary production through EAFs, reflecting both an established recycling industry and the structure of domestic demand.

The industry's emissions profile is heterogeneous. Conventional BF-BOF facilities remain the dominant source of emissions, but their carbon intensity varies across producers. Brazil also benefits from a predominantly renewable electricity system, providing a favourable starting point for the deployment of low-emissions technologies.

Brazil possesses several characteristics that differentiate its decarbonisation pathway. First, it is the only major steel-producing country with commercial experience in using charcoal as a reducing agent at scale. Second, the country combines abundant low-cost renewable resources with increasing interest in hydrogen hubs,[102] creating the potential to produce some of the world's lowest-cost renewable hydrogen over the coming decades.

Third, Brazil is a major producer of high-quality iron ore and maintains extensive logistics corridors connecting mining regions to export ports. Finally, although exports remain strategically important, the Brazilian steel industry is less export-dependent than many competitors, with domestic demand accounting for 66% of local production.[103]

Together, these factors suggest that Brazil can pursue a differentiated pathway toward low and near-zero emissions steel, combining short-term advantages in biomass and scrap with longer-term opportunities in electricity and hydrogen-based primary steelmaking.

[101] World Steel Association, World Steel in Figures 2025, 'Crude steel production by process, 2024'; World Steel in Figures 2024 for 2023 process shares.

[102] https://www.scielo.br/j/remi/a/YYnMgzH5prhKpWYBRwvmwcj/?lang=en

[103] Instituto Aço Brasil, Brazil Steel Databook 2026. Anu.Estat.,Rio de Janeiro, p.12, 2026.

Brazil currently lacks a policy framework specifically designed to decarbonise steel production. Nevertheless, important building blocks already exist (Table 7). These instruments remain fragmented, CAPEX-oriented and structurally insufficient for near-zero emissions of primary steel. Most hydrogen-based projects are still at feasibility stage,[104] and no commercial H_2-DRI-EAF plant has reached final investment decision (FID) in Brazil.

Table 7: Existing instruments and their limits for near-zero primary steel.

Instrument	Scale and function	Why it does not close the gap for primary steel
BNDES (Brazilian Development Bank)	Annual disbursements of $31 billion in 2025, a scale comparable to major MDBs,[105] and the delivery channel through which most federal climate finance reaches industry. Support is mostly repayable at market-based rates and a part at subsidised rates.	Repayable credit lowers the cost of capital, but it cannot absorb a recurring operating-cost premium, and the non-reimbursable window is both legally restricted and marginal in scale. Creating a CCfD capability would require a new legal mandate and a dedicated funding source.
National Climate Fund (Law 12.114/2009)	Main budgetary vehicle split into two windows with very different weights. The reimbursable window is operated by BNDES as financial agent, with concessional credit at 1% to 8% p.a. The non-reimbursable window is operated directly by the Ministry of Environment (MMA). The 2026 budget law provides around $7.9 billion (R$ 42.5 billion) to the fund, of which some $5.0 billion (R$ 27 billion) is BNDES lending capacity for the year.	The non-reimbursable window is three orders of magnitude smaller than the credit window and is directed at civil-society and public-sector projects rather than at industrial plants. On the credit side, direct support is capped at ~$93 million per economic group per 12 months; in July 2026 BNDES doubled the ceiling to ~$185 million for a defined list of segments that does not include steel. Even the doubled ceiling remains an order of magnitude below greenfield H_2-DRI-EAF CAPEX.
Eco Invest Brasil Program (Law 14.995/2024)	Treasury-led blended-finance and hedge platform funded by the Climate Fund. Catalytic capital is on-lent to accredited banks as repayable credit, auctioned on the leverage each bank commits to. Four auctions have mobilised over ~$26 billion in announced investment potential from a far smaller catalytic base: the fourth auction (May 2026) approved R$ 3.1 billion in catalytic capital against R$ 13.2 billion mobilised. The fifth auction (June 2026) seeds innovation funds seeds innovation funds on a two-to-one private leverage design.	Support is repayable and investment-linked, so it cannot cover an operating-cost premium. Low-emissions steel is not among the six strategic chains of the fifth auction, although adjacent chains are. Headline figures are mobilisation potential rather than disbursement. The thematic-auction format nonetheless offers a tested template for a future hard-to-abate round.

104. https://canalsolar.com.br/en/Axia-chalk-partnership-green-steel-hydrogen/

105. Multilateral Development Banks.

Table 7: Continued

Instrument	Scale and function	Why it does not close the gap for primary steel
Low-Carbon Hydrogen Development Program (PHBC – Law 14.990/2024)	~$3.4 billion in tax credits, allocated by competitive auction on the lowest credit per unit of hydrogen and covering up to 100% of the price gap against substitute goods. Support is non-repayable in nature (foregone tax revenue rather than credit) but applies only to transactions between 2030 and 2034 under the current wording of the law.	It can close the hydrogen price gap, not the steel one: even fully subsidised hydrogen leaves a residual premium on the finished tonne. Steel is named among the target sectors, and an H_2-DRI-EAF operator could claim credits as a buyer, but the first auction is only announced for 2026, and no credit can be used before 2030.
Brazilian emissions trading system (SBCE – Law 15.042/2024)	Cap-and-trade system managed by the Ministry of Finance. Article 28 earmarks at least 75% of system revenues to the Climate Fund, to finance decarbonisation of the regulated installations that generated them, alongside at least 15% for running the system and 5% for traditional communities.	Integrated steel mills enter monitoring, verification, and reporting (MRV) in the first wave (2027) and semi-integrated mills only in 2029, with full operation expected around 2030–31. Reporting applies above 10,000 tCO_2/yr and full obligations above 25,000; early free allocation limits auction revenue; steel competes with cement, chemicals, refining, aluminium, pulp and aviation for the same pool.

The main barriers, such as high capital requirements, regulatory uncertainty, the absence of demand-pull mechanisms, and the perceived risks of first-of-a-kind investment, are shared with other producing countries. What is specific to Brazil is the shape of the residual gap: capital support is available, while the remaining operating-cost premium is not addressed by any existing instrument. That gap motivates the mechanism proposed below.

Existing policies to close the cost gap for hydrogen-based steelmaking

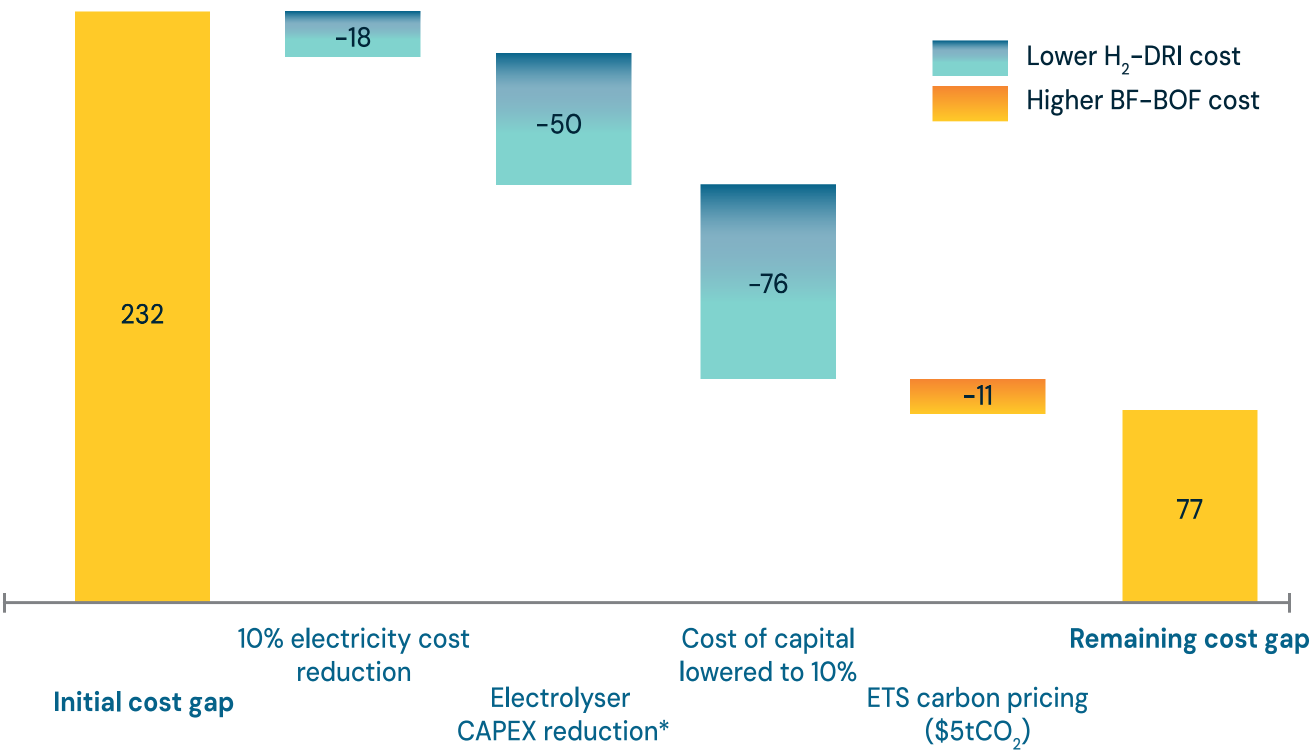
Brazil has significant opportunities to reduce the cost gap between conventional BF-BOF and near-zero emissions H_2-DRI-EAF through structural competitiveness measures. Under the baseline assumptions adopted in this analysis, H_2-DRI-EAF presents a production cost of approximately $730/t crude steel, compared with $498/t for conventional BF-BOF, resulting in an initial cost gap of approximately $232/t.

> A combination of structural measures could reduce this gap by more than half.

A weighted average cost of capital lowered from 15% to 10% rests on concessional lending, blended finance and guarantees from the Climate Fund, via Brazilian Development Bank (BNDES), and EcoInvest. Electrolyser capital costs at the levels currently observed in China ($1,100/kW) could be reached through the Low-Carbon Hydrogen Development Program (PHBC) National Policy on Low-emission Hydrogen (Law 14.948/2024), by accelerating deployment and scaling domestic supply chains. Renewable electricity at $45/MWh, against $50/MWh today, is achievable through long-term renewable power purchase agreements (PPAs). Finally, the gradual implementation of the SBCE, illustrated here with a carbon price of $5/$tCO_2$,[106] would increase the production cost of the BF-BOF route, as shown by Figure 7.

[106] Assuming an emissions intensity of 2.2 tCO_2/tCS.

Figure 7: H_2-DRI steel cost gap reduction through possible Brazilian policies, USD per tonne of crude steel. *Electrolyser CAPEX is assumed to decrease from USD 2,300/kW to USD 1,320/kW, corresponding to the currently observed electrolyser cost in China (USD 1,100/kW) plus 20% for taxes and logistics.



Together, these structural improvements reduce the cost gap from $232/t to approximately $77/t, representing a reduction of more than 65% without relying on direct production subsidies. Market-based mechanisms can further narrow the remaining gap before direct public subsidies are required. Green public procurement and voluntary green steel premiums from downstream sectors can monetise the environmental value of low-emission production. Under the assumptions adopted in this analysis, the remaining 15% green premium corresponds to approximately $35 per tonne of CO_2 avoided, creating demand-driven incentives while recovering a substantial share of the transition cost through the market. These reductions, however, are cumulative and conditional. They materialise if every lever performs as assumed at the same time: concessional costs of capital, electrolyser CAPEX at Chinese levels, low-cost renewable power and an operating carbon price. If one of these levers underperforms, the residual gap is correspondingly wider. The $77/t figure should therefore be read as an optimistic but attainable anchor rather than a central expectation, and the subsidy envelope should be sized against a plausible range around it rather than a single point estimate, so that funding remains adequate if input costs prove less favourable.

> Thus, rather than compensating the full difference between conventional and near-zero emissions steel, a new subsidy-and-recharge mechanism would bridge only this residual gap.

A Brazilian subsidy-and-recharge policy

> Conceptually, the subsidy-and-recharge approach separates two questions that are often conflated: who finances the green premium today, and who ultimately bears its cost.

The subsidy component covers the residual premium up front, through grants, concessional credit, or a carbon contract for difference (CCfD), allowing first-of-a-kind plants to reach FID before buyers are willing to pay a premium. The recharge component then recovers this cost from the market over time, making the mechanism fiscally neutral over its life cycle rather than a permanent budgetary obligation.

Impacts on industrial competitiveness, government budgets and consumers

The fiscal implications of such a mechanism are comparatively modest. Supporting production equivalent to 10% of Brazil's current primary steel output[107] would require approximately $193 million per year. However, a design choice concerns the point of incidence of the recharge. If the cost is recovered on the production side, for instance through carbon pricing applied to conventional routes, the burden falls on incumbent producers, raising competitiveness and carbon leakage concerns during the transition. If it is recovered on consumption, as is proposed under the recharge, the burden falls on domestic steel consumers and is diluted across the value chain. So two realistic routes emerge in the Brazilian context: recovery through the carbon market and recovery through a surcharge on domestic steel consumption.

Under a 10% deployment scenario of H_2-DRI-EAF, the required recharge would amount to only $7.4 per tonne of steel consumed in Brazil. This substantially reduces the burden on downstream industries compared with relying exclusively on carbon pricing, which would require a carbon price of approximately $35/t$CO_2$ to achieve cost parity. This route also fits the structure of the Brazilian market: in 2025, around two-thirds of all steel produced in Brazil was sold domestically. Spreading the recharge across downstream steel users results in only marginal impacts on final consumer products. Under this report's assumptions, the additional cost would increase the price of a typical passenger vehicle by approximately 0.03%, while white goods would experience price increases of less than 0.1%.

This snapshot, however, understates the mechanism's dynamics. As the share of near-zero emissions steel expands beyond the initial 10% deployment, the total subsidy requirement increases proportionally, resulting in a higher recharge per tonne of steel consumed. Over time, as near-zero emissions steel becomes more mainstream as a production route, the recharge gradually approaches the residual cost premium (~$77/t), unless continued technology learning, structural cost reductions, or green premiums further reduce the remaining cost gap. That convergence coincides with higher global carbon prices and a maturing CBAM, which raise the incumbent-route cost and shrink the premium the recharge must cover, so the burden peaks while low emission steel is still a minority and may ease thereafter.

For this reason, it is worth asking whether even a small charge could add to domestic inflation. The risk appears limited as the aggregate recharge totals under $200 million per year, and since steel is only one input among several in downstream goods, the pass-through effect is diluted well before reaching final prices. The more relevant risk is distributional rather than macroeconomic, which is to keep the recharge transparent and capped, as discussed above, so it does not accumulate into a lasting cost burden.

The consumption route also raises a question at the border. A recharge levied only on domestic production would create a direct incentive to import conventional steel that escapes the charge, so the base should be apparent consumption. On imports, the charge mirrors the domestic one: the same flat rate per tonne of steel ($7.4/t under the 10% deployment scenario), applied uniformly regardless of the carbon intensity or the origin of the imported tonne. Imported and domestic steel therefore bear an identical charge per tonne, and the only measurement the border requires is the steel content of the incoming good.

107. 2.5 Mtpa, which is equivalent to one DRI plant.

On exports, treatment differs by destination. Steel sold to markets without carbon pricing is rebated, so Brazilian exports compete abroad without carrying a domestic cost that no competitor bears. Steel bound for jurisdictions with a border carbon adjustment pays, instead of the flat recharge, a charge calibrated on its carbon intensity at the level of the destination's adjustment. There is no double payment, since the CBAM credits the carbon price effectively paid in the country of origin and the importer buys certificates only for the remaining difference. The exporter's total cost is unchanged, but the revenue stays in Brazil and is recycled into the subsidy windows. This depends on the destination recognising a carbon price applied only to exports, which the EU may resist. It is a negotiating position rather than a unilateral design choice, and its outcome does not affect the domestic recharge or the import charge.

Operational considerations

Such a charge cannot stand alone. On the import side, the flat rate keeps administration light: customs only needs to count the steel content of the incoming good, with no need to trace its origin or verify its embodied emissions. MRV is nonetheless essential domestically, where it underpins eligibility by certified emissions intensity and the calibration of the charge retained on exports to jurisdictions with border adjustments. The mechanism may also benefit from a public mandate, through procurement quotas for low-emissions steel, to create anchor demand before the recharge is diluted across consumption. Many of these institutional components are already being developed under the SBCE and emerging international standards for near-zero emissions steel, reducing implementation complexity. Finally, it requires an international commercial base designed as part of a green trade corridor, linking certification standards, traceability systems and regulated buyers' markets. This positions Brazil as a supplier of low-carbon intermediate goods rather than primary resources, and reduces the risk that the measure is read as an isolated tariff inviting retaliation.

Funding architecture

The subsidy side of the mechanism can operate through two windows, so that support reaches the whole steel industry rather than a handful of pioneer plants. The first window fosters CCfDs and concessional credit with transformative, first-of-a-kind projects, especially H_2-DRI-EAF, where the premium per tonne is largest and the investment case is weakest. The second window supports the existing asset base through grants for energy efficiency, for scrap-based EAF production and for the substitution of fossil carbon by sustainable biogenic carbon.

The recharge is the anchor source for both windows. Because it is levied on apparent consumption, dedicated to the sector and recycled back into it, it provides the multi-year predictability a CCfD requires. Two other sources complement it for reasons of timing rather than principle. Contracted payments to first-of-a-kind plants concentrate in the early years of operation, while recharge revenue accrues gradually as the levy is phased in, and raising the rate to front-load collection would defeat the purpose of keeping it at a level the market can absorb. Climate Fund resources, including the share of SBCE revenues already earmarked to it, and a defined share of oil and gas royalties can bridge that ramp-up gap.

A possible objection is that the sector would face two charges, a carbon price under the SBCE and a recharge on consumption. But the two instruments differ in nature: the SBCE prices emissions at installation level and its proceeds are pooled across all regulated sectors, while the recharge is a sectoral levy whose proceeds return in full to steel. The two are also unlikely to bind at the same time, since free allocation will keep effective SBCE exposure low in precisely the years when the recharge is being phased in, and a sector already financing its own transition through the recharge has a weaker case for being asked to carry the burden of auction revenue.

> Above all, the two-window design means that every producer, whether it builds a new route or improves an existing one, has access to a funding line financed by the levy it pays.

Using a recharge for exports

While the illustrative calculations assume deployment equivalent to 10% of Brazil's current primary steel production, Brazil's long-term opportunity extends beyond domestic demand. The country's abundant renewable electricity, high-quality iron ore, and emerging hydrogen industry position it to become a competitive exporter of low-emissions steel, direct reduced iron (DRI) and hot briquetted iron (HBI). Consequently, the mechanism should remain sufficiently flexible to support export-oriented projects where these contribute to domestic value creation, industrial competitiveness and strategic positioning in international low-carbon materials markets.

> At the macroeconomic level, an expanded export base in low-emissions steel and metallics would also enlarge the country's foreign exchange earnings. Stronger and more diversified export revenue tends to support the exchange rate, which moderates the domestic price of imported inputs, fuels and capital goods, and therefore contributes to lower inflation and to a less restrictive monetary stance.

This export orientation, however, is not fully captured by the consumption route, which works when new near-zero plants substitute conventional tonnes already consumed at home, but breaks down when new plants add capacity aimed at international niche markets. Projects oriented solely to export markets, whose tonnes fall largely outside the domestic recharge base, would therefore, in the short run, need to rely on the carbon-market route or on dedicated instruments, such as the EcoInvest's catalytic potential. One alternative option is to explore a support mechanism for renewable hydrogen combining long-term offtake contracts with counterpart obligations to supply part of the output to the domestic market, linking export competitiveness to domestic decarbonisation.

A related scope question is whether the mechanism should extend upstream to green iron. Brazil sits in the small group of countries, alongside Australia and South Africa, best placed to supply low-emissions iron to the main potential buyers in China, India and Europe, and it currently has no DRI capacity at all, so green iron is an opportunity to be built rather than an installed base to be converted. That places it on the export side, outside a recharge whose base is domestic consumption. The mechanism is therefore scoped to steel, with green iron belonging to the export routes discussed above. Neither of those subsidised export routes is proposed here, as both would require their own assessment, including assessment of compatibility with WTO subsidy disciplines.

Eligibility criteria for CCfD support

Eligibility should also reflect Brazil's existing production structure, following the same two-window logic. Charcoal-based routes already account for roughly 11% of national output and deliver proven reductions today, but they do not reach the near-zero thresholds emerging in international standards. They therefore belong in the second window, alongside scrap-based EAF and energy efficiency, where grants reward measured improvement against a route-specific benchmark. The first window is reserved for routes capable of meeting near-zero thresholds, where the premium per tonne and the technology risk are largest and only a long-term contract makes the investment case work. Within each window, eligibility should be defined by certified emissions intensity rather than by named technologies, so that any route meeting the relevant threshold qualifies. Matching the instrument to the abatement task avoids both discriminating against biogenic-carbon routes and paying first-of-a-kind support for improvements the market can already deliver.

Technology-neutral eligibility, however, need not mean uniform support, because the routes differ in the operating-cost gap they face. Scrap-based EAF is already broadly cost-competitive with BF-BOF, and charcoal-based BF-BOF operates at or near parity where sustainable planted-forest charcoal is available. Their binding constraints are biomass and land-use certification, biogenic-carbon accounting and demand recognition, rather than a large green premium. H_2-DRI-EAF faces the opposite problem, with a genuine operating-cost gap and first-of-a-kind technology risk.

The two windows therefore run in parallel from the outset, each matched to the constraint it addresses: certification, green public procurement and the recharge's demand-pull for the existing base, long-term contracts for the transformative route. Simultaneous support is affordable because a CCfD costs little at signature, with payments beginning only when the plant produces, so early recharge revenue can fund improvements across the existing base while new capacity is built. Sequencing would forfeit that window, since lead times of several years between investment decision and first production would push Brazil's first near-zero tonnes beyond the period in which international markets are being defined, and it would reserve support for a single future technology instead of letting producers already operating lower-carbon routes see value from the start.

Finally, since the SBCE has not yet been regulated, its detailed design may open alternatives to a standalone mechanism. One possibility would be a voluntary opt-in of near-zero steel projects into the SBCE. Its feasibility depends on regulatory choices still under discussion, such as whether the cap would be adjusted upon voluntary entry or maintained, and whether near-zero production could give rise to a tradable asset alongside allowances and verified emission reduction certificates. Depending on these choices, an opt-in structure could eventually deliver part of the revenue certainty that a subsidy-and-recharge mechanism seeks to provide. On current information, however, the standalone mechanism should remain the primary recommendation: these choices will not be settled before steel enters MRV in 2027, whereas first-of-a-kind projects need revenue certainty now. The opt-in is therefore best framed as a later-phase substitute that could take over as the SBCE matures, not a co-equal alternative that defers the decision.

Exit strategy

The mechanism is designed to expire. CCfD payments could narrow automatically as carbon prices rise and near-zero production costs fall, so the subsidy declines without discretionary intervention, and the recharge ends when the last contracted plant completes its term. Brazilian experience shows why this must be written into law rather than left to practice. The Energy Development Account (CDE), a charge embedded in electricity tariffs, financed genuine sectoral policy but gradually accumulated unrelated subsidies, becoming costly and difficult to unwind. The RenovaBio Program, by contrast, scaled an entire low-carbon industry by recharging costs onto fuel consumers, yet remains contested over how visibly the cost lands at the pump and over who captures the benefit. The lesson for steel is one of governance, since it would require a single statutory purpose, a ceiling on the rate, a sunset clause tied to contract expiry, an explicit prohibition on repurposing the revenue, and annual public reporting of what is collected and paid.

Analysis

> The proposed mechanism is intended to accelerate investment in new near-zero emissions production rather than penalise existing steelmakers.

Existing BF-BOF assets are expected to continue operating during the transition, particularly where recent investments have extended plant lifetimes. Consequently, the mechanism complements rather than replaces existing production, encouraging gradual portfolio diversification instead of premature asset retirement. EAF producers could also benefit indirectly through expanded renewable electricity infrastructure and increased availability of low-emissions iron feedstocks such as DRI and HBI.

Support for the mechanism is likely to depend on its recognition of existing decarbonisation efforts and its technology neutrality. Steelmakers that have already invested in lower-emission production routes, such as scrap-based EAF production or charcoal injection in BF-BOF operations, are likely to seek eligibility for financial support and recognition of the emissions reductions already achieved. At the same time, incumbent firms are expected to favour grant-based instruments that reduce investment risks for first-of-a-kind projects, while minimising repayment obligations and preserving international competitiveness during the transition.

The mechanism could also strengthen Brazil's position in emerging international markets for low-emissions steel. Differentiated export treatment, rebating tonnes sold to markets without carbon pricing and retaining a CBAM-equivalent charge on those bound for jurisdictions with border adjustments, would preserve competitiveness abroad while keeping the revenue in Brazil. Early deployment could therefore improve access to premium international supply chains and long-term offtake agreements.

Overall, the proposed subsidy-and-recharge mechanism should be viewed as a transitional industrial policy instrument rather than a permanent subsidy. In practice, the realistic path is to combine rather than choose: a consumption-based recharge for near-zero steel supplied to the domestic market, targeted public support for first-of-a-kind capacity, and a growing role for the SBCE as carbon prices rise and the system matures.

Both windows operate from the start rather than in sequence. Scrap-based EAF and charcoal-based BF-BOF rely on inputs and infrastructure already present in Brazil and can be scaled with comparatively lower technological risk, which makes them immediately addressable through the second window. H_2-DRI-EAF, by contrast, has lead times of several years between investment decision and first production, so early contracting through the first window is what determines whether Brazil has near-zero capacity when international markets are defined. The design question is which instrument each route needs, not which route comes first.

Beyond reducing emissions from primary steel production, the mechanism contributes to several broader industrial policy objectives. These include accelerating the deployment of renewable hydrogen infrastructure, stimulating domestic manufacturing of electrolysers and associated equipment, expanding renewable electricity investments, promoting sustainable forestry for biomass supply where applicable, increasing 212value addition to Brazil's iron ore resources through domestic DRI and HBI production, and strengthening innovation capabilities across emerging low-carbon industrial value chains.

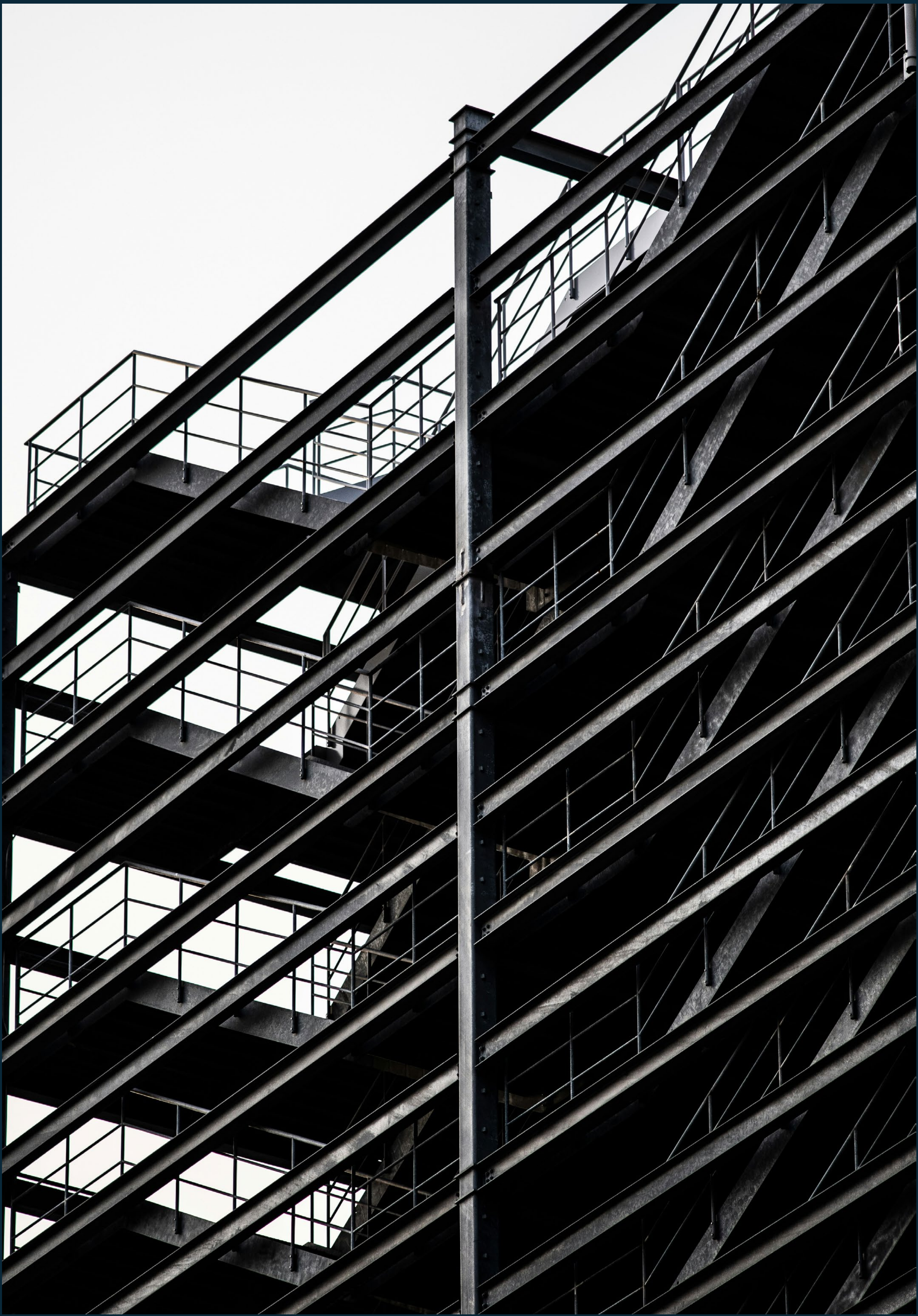
Key uncertainties

Several uncertainties will ultimately shape the effectiveness and scale of a subsidy-and-recharge mechanism in Brazil. The first relates to technology and input costs, particularly the future trajectory of renewable hydrogen prices, the pace at which electrolysis costs decline, and Brazil's ability to maintain competitively priced renewable electricity while expanding transmission infrastructure. The availability and cost of other strategic feedstocks, including direct reduction-grade pellets and high-quality scrap, will also influence the level of support required. A second set of uncertainties concerns market dynamics: the future growth of domestic steel demand, Brazil's ability to capture emerging export opportunities for near-zero emissions steel and HBI, and the extent to which downstream sectors can absorb or pass through modest increases in steel prices.

A third uncertainty concerns Brazil's fiscal position. Public debt and the primary deficit remain under scrutiny, and the fiscal framework introduced in 2023 constrains the growth of discretionary spending, of which climate and industrial programs form only a small part. While the recharge is designed to limit dependence on general budget expenditure, the subsidy component still requires upfront public resources, whether through Climate Fund grants, BNDES concessional credit or royalty-based financing, and these compete with other fiscal priorities in a constrained environment.

A related uncertainty concerns institutional continuity. Much of the policy architecture described above rests on administrative decisions and annual budget cycles rather than on legislation that binds future governments. Industrial policy priorities have historically shifted with changes in administration in Brazil, and there is no guarantee that support for near-zero emissions steel would survive a change in government committed to different fiscal or industrial priorities. Anchoring the mechanism's core parameters, eligibility criteria, and funding commitments in statute, rather than leaving them to discretionary budget allocation, would reduce this risk and provide the multi-year certainty that first-of-a-kind investment decisions require.

> As demonstration projects advance and better information becomes available, these assumptions should be periodically revisited to ensure that policy design remains aligned with technological progress, market realities and Brazil's evolving industrial ambitions.



6. Subsidy-and-recharge proposals for the United Kingdom

Authors: Maude Gibbins, Joe Morrisroe, Simon Sharpe – S-Curve Economics

Context

> The UK steel sector is undergoing a transition to low emission steelmaking amid a difficult economic context.

Production currently comes from six companies with a total capacity of 8.4 Mtpa. Five of these sites have electric arc furnaces (EAFs, including a 3.2 Mtpa facility in construction) accounting for 5.9 Mtpa of production capacity.[108] The UK's last blast furnace–basic oxygen furnace (BF-BOF) sites, Scunthorpe and Port Talbot, struggled to be profitable in recent years, caught between high costs and low steel prices. Tata Steel closed the blast furnaces at Port Talbot in 2024 and is constructing an EAF with financial support from the government. The remaining two blast furnaces at the Scunthorpe site owned by British Steel account for 2.5 Mtpa of capacity.[109] In July 2026, the government nationalised British Steel to prevent the closure of the remaining blast furnaces, placing all remaining UK iron production under public ownership.[110]

Demand for iron in the UK is changing as a result of this transition. With the good availability of high-quality scrap steel in the UK, and advances in EAF production technology over recent decades, the UK Primary Steelmaking Review finds that all major steel products can be made in EAFs to meet even the highest quality standards with as little as 50% primary iron. The total requirement for primary iron across the mix of steel products produced in the UK is estimated to be about 1 Mtpa at present, growing to 1.3–3.1 Mtpa by 2035.[111] Fully decarbonising the UK's steel industry can therefore be achieved by a relatively modest amount of near-zero emission iron – an amount that can be produced by just one or two direct reduced iron (DRI) furnaces.

Where the sector will source its iron after the blast furnaces at Scunthorpe close, and how emissions-intensive that iron will be, remains uncertain. The UK Primary Steelmaking Review recognises DRI (with natural gas, but 'hydrogen-ready') as the most viable current means of production domestically and recommends a feasibility study for a hydrogen-ready 2 Mtpa DRI plant that could be operational by 2028.[112] At the same time, the Department for Business and Trade notes that the UK's future iron demand can be met through "imports of pig iron or DRI products from established market routes" and that "to achieve Net Zero and remain competitive in global green steel markets, primary iron should come from DRI plants powered by natural gas, with a planned transition to hydrogen".[113] The timeline for this transition in either scenario is unstated.

The case for early action on green iron

If the UK industry used pig iron or DRI produced with natural gas together with a high scrap share in EAFs, it is likely that much of its steel would meet the basic or mid-tier 'low emission' thresholds of widely discussed international standards, but not the most stringent low or 'near-zero emission' thresholds (see Table 8).[114] Products made with a high proportion of iron (e.g. 50%) would be less likely to meet these thresholds than high-scrap-based products, or would do so at higher cost.

---

108. Department for Business and Trade (2026a).The UK Steel Strategy. https://www.gov.uk/government/publications/steel-strategy/the-uk-steel-strategy-web-version

109. Department for Business and Trade (2026a).

110. Department for Business and Trade (2026b). Government brings British Steel into public ownership to protect UK steelmaking. https://www.gov.uk/government/news/government-brings-british-steel-into-public-ownership-to-protect-uk-steelmaking

111. Materials Processing Institute (2025). UK Primary Steelmaking Review 2025. https://assets.publishing.service.gov.uk/media/690b868714b040dfe829237d/uk-primary-steelmaking-review-2025.pdf

112. Materials Processing Institute (2025).

113. https://questions-statements.parliament.uk/written-questions/detail/2026-06-17/10992

114. https://www.iea.org/reports/emissions-measurement-and-data-collection-for-a-net-zero-steel-industry/recommendations-for-the-g7

Table 8: Likely emission threshold achieved for EAF steel made with different inputs. Source: UK Primary Steelmaking Review modelling[115] compared with Responsible Steel Decarbonisation Scale[116] (authors' interpretation).

Input mix	Likely threshold achieved
Scrap and pig iron (50/50)	Level 1 (basic threshold) or 2
Scrap and gas DRI (50/50)	Level 2 or 3
Scrap and green iron (50/50)	Level 3 or 4 (near-zero)

The move to green (near-zero emission) iron would make a relatively small contribution to overall emissions reduction – perhaps in the range of 0.6–1.7 $MtCO_2e$/year, equivalent to around 1.3–3.9% of the economy-wide emissions cuts that must be found between the Fourth Carbon Budget (2023–2027) and Fifth Carbon Budget (2028–2032).[117] This could be delayed for one or two decades, while other countries do the work of enabling investment in clean iron production and making it cost-competitive in the global market. But there are reasons why a more proactive approach would be in the UK's interests, both to improve its industrial competitiveness and to meet its climate goals.

Industrial competitiveness

> An earlier move to green iron could have advantages for the competitiveness of UK steel production, in three ways.

The move to green iron could allow the UK to use more stringent climate policies against high-emission steel, including imports. In the domestic market, decarbonisation policies can be applied to imported steel in the same way as to domestic production, in compliance with WTO law. With the UK steel sector fully decarbonised, a carbon price and carbon border adjustment mechanism (CBAM), as currently implemented across energy-intensive industrial sectors through the UK Emissions Trading Scheme (ETS), could remain in place, potentially with the carbon price rising over time, increasing the price of all imported steel that was not produced with near-zero emissions. If green iron is used in the UK at cost-parity with conventional pig iron – as we explain below that it can be – the carbon pricing policies would give domestically produced clean steel a cost advantage compared with imported conventional steel. The advantage would remain until other countries moved further in decarbonising their own steel production. This would contribute to the government's objective of increasing the share of domestically produced steel in the UK's steel consumption from its current level of 30% to 40–50%.[118] An even stronger policy option would be a regulation requiring all steel produced or imported to meet a near-zero emission standard – analogous to the endpoint of the UK's Zero Emission Vehicle Mandate.

115. (pp. 39–40) https://assets.publishing.service.gov.uk/media/690b868714b040dfe829237d/uk-primary-steelmaking-review-2025.pdf

116. https://www.responsiblesteel.org/steel-decarbonisation-scale

117. This emissions savings is estimated as the difference for 1 Mtpa of DRI-equivalent made via blast furnace (pig iron) or natural gas-DRI, compared with H_2-DRI, assuming zero emission electricity is used, compared with a 45 $MtCO_2e$/year annual emissions reduction implied between the Fifth Carbon Budget (1,725 $MtCO_2e$) and the Fourth (1,950 $MtCO_2e$).

118. Department for Business and Trade (2026a).

> In export markets where carbon pricing is present, there could be a similar competitive advantage for UK clean steel that is enabled by policy to be produced at cost-parity with conventional steel.

With the current level of carbon pricing in the EU ETS, assuming full application of the CBAM, the cost of UK steel exported to the EU could be reduced by around 2–15% through avoided carbon pricing due to moving from pig iron or gas-DRI to clean iron.[119] This would be valuable given that the EU is the destination of 67% of the UK's steel exports.[120] An important uncertainty, however, exists around how countries will judge the fairness of their trading partners' clean steel subsidies – a matter on which WTO rules are disputed and no steel-specific principles have been agreed.[121]

As early movers to near-zero emission production, UK steel companies could gain a lead over competitors in establishing relationships with customers that have a specific demand for near-zero emission steel (due to their own customers' preferences, or to lifecycle emissions regulation in their own sectors). Although this demand would be largely voluntary from the private sector early on, it could grow into a more considerable market in future as other countries implement climate policies across a broader range of sectors. There are already signs of such demand emerging in the automotive and construction sectors in Europe. The British Constructional Steelwork Association has argued that if UK steel is not decarbonised, it will be substituted by low carbon imports.[122] In Sweden, green steel producer Stegra has signed offtake agreements with Mercedes-Benz, Porsche, Volvo Group and IKEA.[123]

Climate change objectives

The risks of climate change to the UK depend on global emissions, not national emissions.[124] The low carbon transition in the UK only contributes to reducing climate risks to the UK to the extent that it influences the global transition.

The UK could strongly influence the pace of the global steel transition by demonstrating the potential to produce clean primary steel competitively. This would build on the efforts of other countries that are already having a global impact, including Sweden, which has demonstrated the viability of the H_2-DRI production route, and Namibia, which is demonstrating the potential for green iron production with international offtake agreements. Steel transition policymaking and industry decision-making internationally, currently dominated by perceptions of first-mover risk, could be transformed by the demonstration of an approach that gains first-mover advantage.

[119] The lower value of this range is the estimated emissions savings from the use of H_2-DRI compared with natural gas-DRI for steel produced from 25% ore-based inputs (0.24 tCO_2e/tCS), and the upper value is from the use of H_2-DRI compared with pig iron for steel produced from 50% ore-based inputs (1.14 tCO_2e/tCS). Cost impacts are calculated using an EU CBAM price of $85.82.

[120] Department for Business and Trade, (2026a).

[121] For discussion of this issue, see Morrisroe, J. et al. (2025). Making clean steel competitive in international trade: a positive-sum agenda for policy and diplomacy. S-Curve Economics CIC. https://www.scurveeconomics.org/publications/making-clean-steel-competitive-in-international-trade/

[122] https://committees.parliament.uk/writtenevidence/106490/pdf/

[123] https://buildcleannow.missionpossiblepartnership.org/bright-spot/stegra/

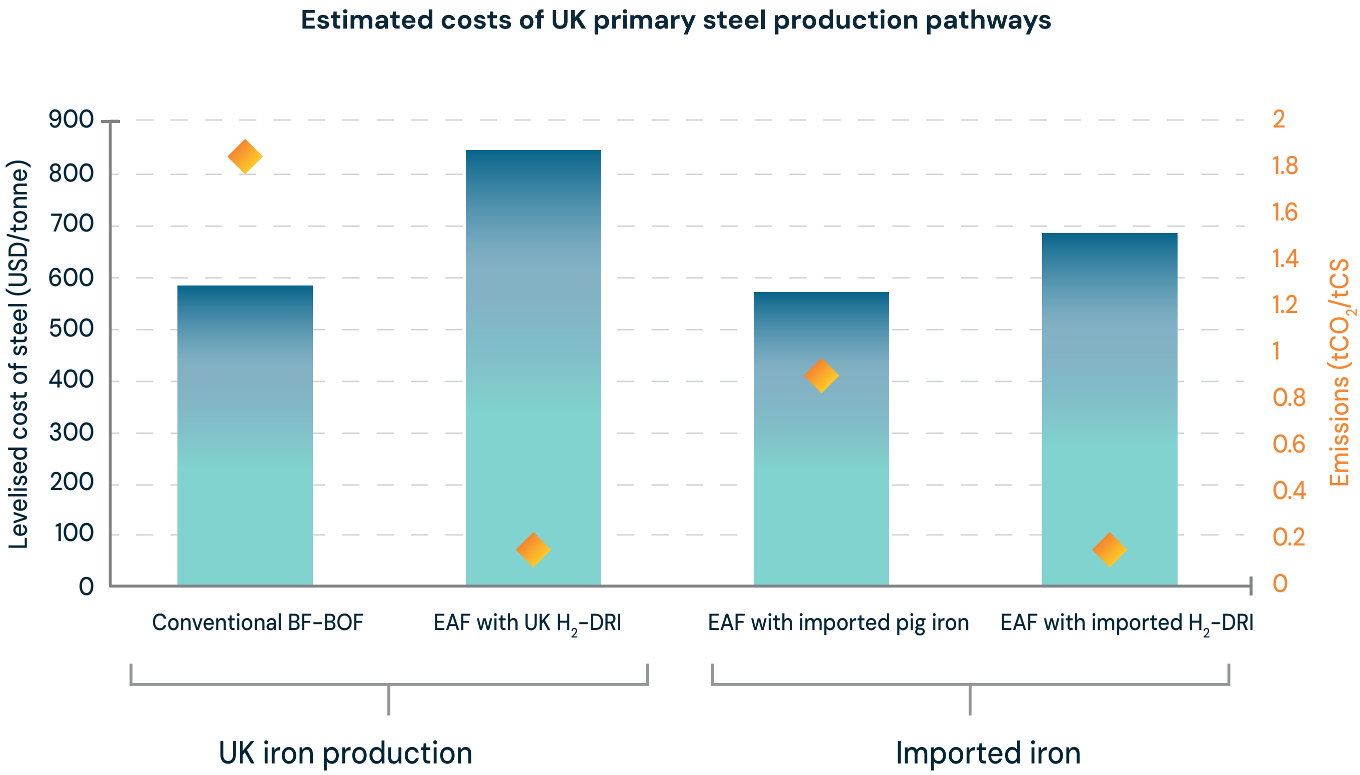
[124] Like all except five countries in the world, the UK accounts for less than 2% of current global emissions.

Existing policies to support clean steel production, and their limitations

The main policy relied upon in the UK to achieve industrial decarbonisation for the past 20 years has been the ETS, first within the EU ETS, and more recently as a separate UK ETS. The UK ETS puts a price on carbon by requiring industry and power sector producers to buy allowances for each tonne of CO_2 they emit, the supply of which is capped and declining over time. The UK is also introducing a CBAM similar to that of the EU from 1 January 2027, applying a carbon price to steel imports at the same level as the UK ETS.[125]

The UK's ETS price today fluctuates at a nominal value of around £60/tCO_2 ($80/t$CO_2$),[126] but we estimate the effective carbon price faced by steel after free allowances are taken into account to be around £12/tCO_2 or $17/t$CO_2$.[127] This compares with an estimated breakeven carbon price for domestically produced H_2-DRI-EAF steel versus conventional BF-BOF steel of £119/tCO_2 ($156/t$CO_2$), and a similar breakeven carbon price for H_2-DRI-EAF steel produced with imported green iron instead of imported pig iron.[128] For the reasons of cost and risk described in the opening chapter, it is clear that carbon pricing is not sufficient to enable near-zero emission steel production in the UK.

Figure 8: Estimated levelised cost of production for UK primary steel production. Scrap charge is modelled as 20% for BF-BOF production and 50% for EAF production. Further assumptions used for estimating production costs are given in the Technical Appendix.



[125] https://www.gov.uk/government/publications/factsheet-carbon-border-adjustment-mechanism-cbam/factsheet-carbon-border-adjustment-mechanism

[126] https://www.purelyenergy.co.uk/tools/carbon/uk-ets

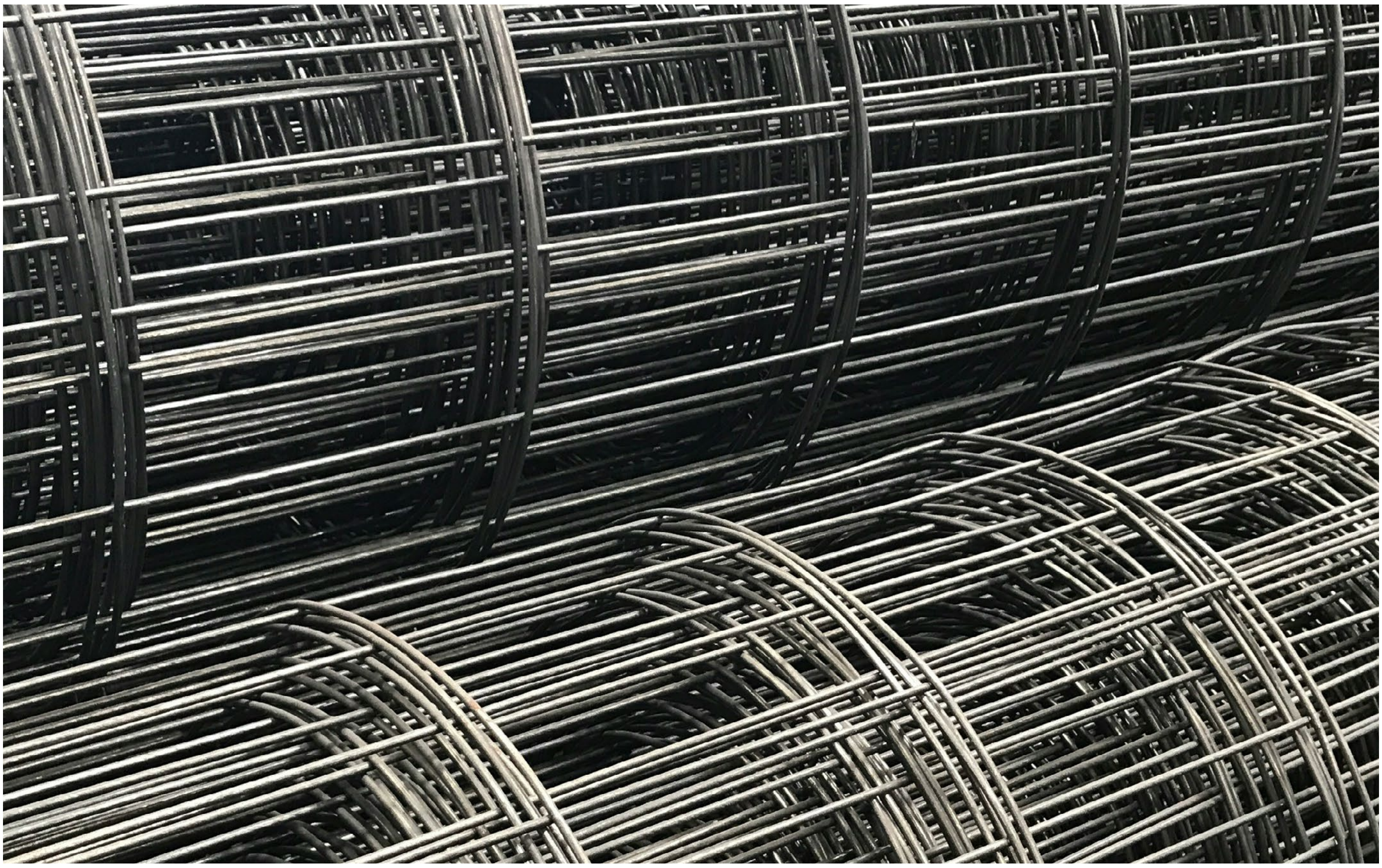
[127] Based on estimated BF-BOF emissions of 1.86 tCO_2/tCS, with 100% free allowance to the benchmark of 1.288 tCO_2/t hot metal.

[128] This breakeven carbon price is estimated by comparing UK BF-BOF production at 20% scrap charge at an estimated cost of $583/tCS and specific emissions of 1.87tCO_2/tCS, compared to EAF production at 50% scrap charge with UK H_2-DRI ($848/tCS, 0.17 t$CO_2$/tCS), imported pig iron ($572/tCS, 0.91 t$CO_2$/tCS), and imported H_2-DRI ($688/tCS, 0.17 t$CO_2$/tCS).

There are also policies in place aimed at reducing the input costs for clean industrial technologies. Relevant to hydrogen-based steelmaking are measures to reduce electricity prices paid by steel producers,[129] and subsidies for hydrogen producers under the Hydrogen Production Business Model.[130]

The hydrogen subsidies provide revenue support to low carbon hydrogen through contracts for difference (CfDs) with 15 years duration. Under the CfD, the government pays the hydrogen producer the difference between the agreed strike price (discovered through a bilateral negotiation process) and the higher of (i) the contracted selling price that the hydrogen producer achieves, or (ii) the natural gas reference price (multiplied by a factor of 1.2 if the hydrogen is used as a feedstock).[131] The government awarded contracts for production capacity of 125 MW in the first allocation round,[132] has shortlisted 765 MW of production capacity in the second round and has targeted 5 GW capacity in total by 2030. Although the subsidies are given on the hydrogen supply side and are not tied to use in any specific sectors, the government has historically suggested that the steel sector could be one of those where the hydrogen is used,[133] and has funded a feasibility study under its hydrogen accelerator programme.[134]

The government's planned funding mechanism for the hydrogen subsidies is the Gas Shipper Obligation (GSO).[135] This would pass on the costs to gas shippers – companies that buy and sell all the natural gas used in the UK gas network – via either a levy per-volume of gas or per-meter point. This cost would be expected to be directly passed on to gas consumers, since there would be no sources of gas not subject to the levy.



129. Electricity price support mechanisms include the British Industry Supercharger scheme and the Network Charging Compensation Scheme, expected to reduce electricity prices for steel producers from £168/MWh to £86/MWh, according to the UK Steel Strategy (2026).

130. https://www.gov.uk/government/publications/hydrogen-production-business-model-net-zero-hydrogen-fund-shortlisted-projects/hydrogen-production-business-model-net-zero-hydrogen-fund-har1-successful-projects

131. https://www.gov.uk/government/collections/hydrogen-allocation-rounds

132. Since these subsidy allocations were announced, two projects have been cancelled, leaving 107 MW remaining at the time of writing. https://energynews.biz/green-hydrogen-faces-structural-setbacks-as-scottishpower-suspends-uk-projects

133. https://assets.publishing.service.gov.uk/media/64c7e8bad8b1a70011b05e38/UK-Hydrogen-Strategy_web.pdf

134. https://www.gov.uk/government/publications/industrial-hydrogen-accelerator-programme-successful-projects/industrial-hydrogen-accelerator-programme-stream-2a-successful-projects--2

135. https://www.gov.uk/government/consultations/funding-mechanism-for-the-hydrogen-production-business-model-proposed-design-of-the-gas-shipper-obligation

Effectiveness

It is far from clear that these existing policies will be effective in enabling investment in clean primary iron or steel production.

The design of the hydrogen subsidy policy effectively creates a floor price at which low carbon hydrogen can be purchased for use in iron production, equivalent to the price of natural gas multiplied by a factor of 1.2. This could significantly reduce the cost of H_2-DRI production, but we estimate that about a third of the cost premium compared with BF-BOF would remain – around $100 per tonne of steel – assuming current prices of electricity, coal and gas.[136] Absent any carbon pricing, this higher-cost production would be even less competitive against foreign conventional steel than current domestic BF-BOF production, and would be more expensive than both foreign gas-DRI and H_2-DRI production.

A carbon price and CBAM could provide some protection against fossil-based competition, but this would not be enough to give prospective investors the necessary confidence to invest in clean iron or steel production. We estimate that it would take a carbon price of \$143/tCO_2e to make subsidised H_2-DRI production in the UK cost-competitive with coal-based imports, and a higher carbon price of \$177/tCO_2e to make it cost-competitive with gas-DRI imports.[137] It is difficult to envisage how such high carbon prices (as effective, not just nominal carbon prices) would be plausible, given the significant competitiveness risks that they would create. The CBAM would not help at all with the lack of competitiveness against near-zero emission iron or steel imports, nor would it help with the lack of UK producers' competitiveness in export markets.

Even if material input and carbon prices change such that domestic H_2-DRI production with subsidised hydrogen inputs does achieve cost parity with most fossil-based iron imports, the viability of investment in a H_2-DRI plant would remain vulnerable to two price uncertainties. One is in the future of the carbon price, which could either increase or decrease over time, as technological change reduces demand for permits in parallel to the emissions cap reducing supply. The other is the difference between coal and gas prices. The hydrogen subsidy is tied to the cost of natural gas, but the dominant fuel for ironmaking globally is coal, making this difference important to the plant's competitiveness.

Finally, the availability of hydrogen production subsidies does not itself guarantee the availability of hydrogen to a green iron plant at the required scale and subsidy floor price, as we have assumed above. Instead, aligning investment in hydrogen production with concurrent investment in green iron production represents a significant hurdle, with all parties needing to maintain confidence and availability of funds throughout the tender process for the Hydrogen Business Model and negotiation of a contract between the hydrogen supplier and iron producer. These negotiations would occur in the context of other producers and consumers of electrolytic hydrogen competing for the same limited production subsidies and hydrogen supply. There is the further limitation that the current hydrogen subsidies cover just a 15-year period, whereas a steel plant would probably need confidence in competitive hydrogen prices for a 25-year lifetime.

Impact on industrial competitiveness

> Clean steel produced in the UK under these existing policies would struggle to be competitive for the reasons discussed above.

A further consideration is that by subsidising the input of low carbon hydrogen rather than the output of clean steel, this approach has no flexibility to support either alternative clean steel technology routes or the option of using imported green iron, with potential implications for competitiveness that are discussed further below. At the same time, the reliance on carbon pricing to close part of the cost gap would mean that UK-produced clean steel would not be cost-competitive against conventional steel in any export markets where carbon prices equivalent to the UK's were not in place.

More broadly, increases to gas, electricity, and hydrogen prices as a result of the GSO, although very modest, would have a negative effect on competitiveness across all UK industry. In contrast to the effect of a steel recharge, trade-exposed, energy-intensive industries would not be exempt from these extra costs when producing products for export. Neither would they be protected against competition in the domestic market from imports not subject to similar policy costs.

136. There may be no remaining BF-BOF steel production in the UK if this policy is successfully implemented, but the cost gap remains relevant because UK-produced H_2-DRI-EAF steel would need to compete against imported BF-BOF steel. The cost of imported BF-BOF steel would be raised by the CBAM, in line with the domestic ETS carbon price.

137. For steel produced with a 50% scrap charge, assuming emissions of 0.91 tCO_2/tCS and cost of \$572/tCS for steel produced from imported pig iron, and emissions of 0.5 tCO_2/tCS and cost of \$619/tCS for steel produced from imported gas-DRI.

Impact on consumers

In order to subsidise the hydrogen needed for 1 Mtpa of H_2-DRI, we estimate a cost of $308 million/year,[138] which would raise the wholesale cost of gas by $0.50/MWh, or 0.7%, when funded by the GSO. Because this levy would apply to all gas, including that used for electricity generation, this would have a knock-on effect on electricity prices, potentially raising wholesale electricity prices by around $0.50/MWh.[139] Together, these cost increases would cost energy consumers a total of $389 million/year, adding around $7.10, or 0.3% to the energy bill of a typical dual-fuel household.

> The effect of the recharge through the GSO would change over time, as the energy landscape evolves.

There is considerable uncertainty around the shape of the UK's energy transition, but plausible scenarios include a 70% reduction in total gas consumption by 2050,[140] as well as a dramatic reduction in the strength of the link between gas and electricity prices.[141] These changes would more than triple the per-unit levy on gas, and either increase or decrease the effect of the policy on electricity prices, depending on the relative change of each factor. Because electricity and low carbon hydrogen consumption are expected to rise, displacing gas in heating and industry as well as displacing oil in road, ship, and air transport, both the total cost to energy consumers and the distribution of those costs could change significantly.[142]

Feasibility of implementation

Operationally, the GSO is straightforward to administer. Gas shippers could easily report volumes sold and pay the obligation with minimal overhead.

Political economy

Although the immediate impact on energy prices arising from the use of the GSO to fund hydrogen subsidies in the steel sector alone would be extremely small, it could still represent a significant political challenge. The government is currently putting considerable effort into reducing energy costs, and additional levies that increase these costs would be counter to these efforts. This issue is highly contentious in current debates, so implementing a policy that increases energy costs, even if only by a little, could come at a high political cost. In aggregate, and in the long term, the cost impacts could be more substantial. If electrolytic hydrogen subsidies are delivered at the full targeted scale for 2030 (for use in all sectors), using the GSO to fund this could raise the cost of gas by up to 50% in 2045,[143] a price rise that would be highly visible to consumers.

---

138. Based on a hydrogen subsidy that changes the cost of hydrogen from $7.84/kg to $1.60/kg, and 27.3 kg H_2/tCS, this equates to an effective subsidy of $170/tCS, or $308/tDRI at 0.553 tDRI/tCS.

139. Based on a total annual gas consumption of 610 TWh/year (Digest of UK Energy Statistics Annual Data for UK, 2024). The thermal efficiency of a gas power station is about 60%, and gas-powered electricity sets the market price around 60% of the time. https://www.gov.uk/government/news/decisive-action-to-break-influence-of-gas-on-electricity-prices

140. NESO (2025). Future energy scenarios. 'Holistic transition' scenario. https://www.neso.energy/document/364541/download

141. https://www.gov.uk/government/news/decisive-action-to-break-influence-of-gas-on-electricity-prices

142. Some forecasts suggest that blue hydrogen production will account for around half of all gas consumption by 2050, and electricity production will account for a further 20%. In these scenarios, just 30% of the levy would be passed directly to gas consumers, with the remaining 70% borne by the low carbon hydrogen and electricity sectors and their industrial and other users.

143. Assuming 5 GW of electrolytic hydrogen subsidised at today's prices, and a 70% reduction in gas consumption.

Alternative policy options

In the following sections, we discuss two alternative policy options that can close the cost gap for clean primary steel in the UK. Firstly, we propose a subsidy-and-recharge policy in which subsidies support a H_2-DRI plant in the UK to be cost-competitive against conventional steel, with the costs recharged via a levy on steel consumption. We then present an alternative option in which clean steel production in the UK is enabled by imported green iron (and iron is not necessarily produced domestically), with the cost gap covered by a subsidy-and-recharge policy. We do not attempt to resolve the strategic choice between domestic iron production and reliance on imports: although we set out some of the risks and opportunities of each approach, a full assessment is beyond the scope of this report. Instead, our aim is to show that with either approach, a subsidy-and-recharge policy could be used to enable clean steel to be produced competitively in the UK, at no cost to government and at trivial cost to consumers.

The domestic green iron option

> The main argument for keeping some ironmaking capacity in the UK is one of strategic resilience.

No primary steelmaking process in the UK can be entirely reliant on domestic resources: either the iron products, or the ore, must be imported. However, iron ore is a highly traded commodity with around 68% of global output traded internationally (1,712 Mt), compared with pig iron and DRI where less than 1% (11 Mt) and 10% (13 Mt) of global output respectively is traded internationally.[144] Retaining domestic iron production capacity would preserve the ability to make primary steel if pig iron or DRI supply chains were disrupted.

A second argument is the retention of expertise, skills and jobs throughout the iron and steelmaking value chain, which could be difficult to rebuild once lost. Most jobs are in the steelmaking process, downstream from ironmaking. It is estimated that around 200 jobs could be retained in the UK through a domestic H_2-DRI plant.[145] Although not a large number, these jobs are highly concentrated in specific regions, and important socially and politically. A full consideration of these issues is beyond the scope of this report, and we provide the main counterargument and the policy option that follows from it below.

Given the expectation for relatively small proportions of primary iron needed to make various steel grades across multiple EAFs, a subsidy allocated for near-zero emission DRI production in a single plant, whose output would be available to all EAF steelmakers, could enable near full decarbonisation of the UK steel industry.[146] The subsidy could be allocated as a CfD, awarded against a reference price of conventional pig iron to ensure cost-competitiveness, and with a contract length sufficient to justify the investment.

This subsidy could be funded by a recharge to all steel consumed in the UK, as a flat fee per tonne of steel, making it entirely revenue-neutral for the government. This would include steel produced in the UK, both fully recycled and with primary iron, and imported steel. The recharge would not be levied on steel exported or used for exported products.

In order to fully cover the cost gap between conventional BF iron production and H_2-DRI, for a 1 Mtpa plant, we estimate a subsidy needed of $479 million/year.[147] Recharged to the UK annual steel consumption of 15.7 Mtpa,[148] this would result in a recharge of $30.5/tonne of steel, or about a 5.2% increase in the total cost of crude steel (Figure 9).

144. https://www.ippr.org/articles/partner-to-scale-international-collaboration

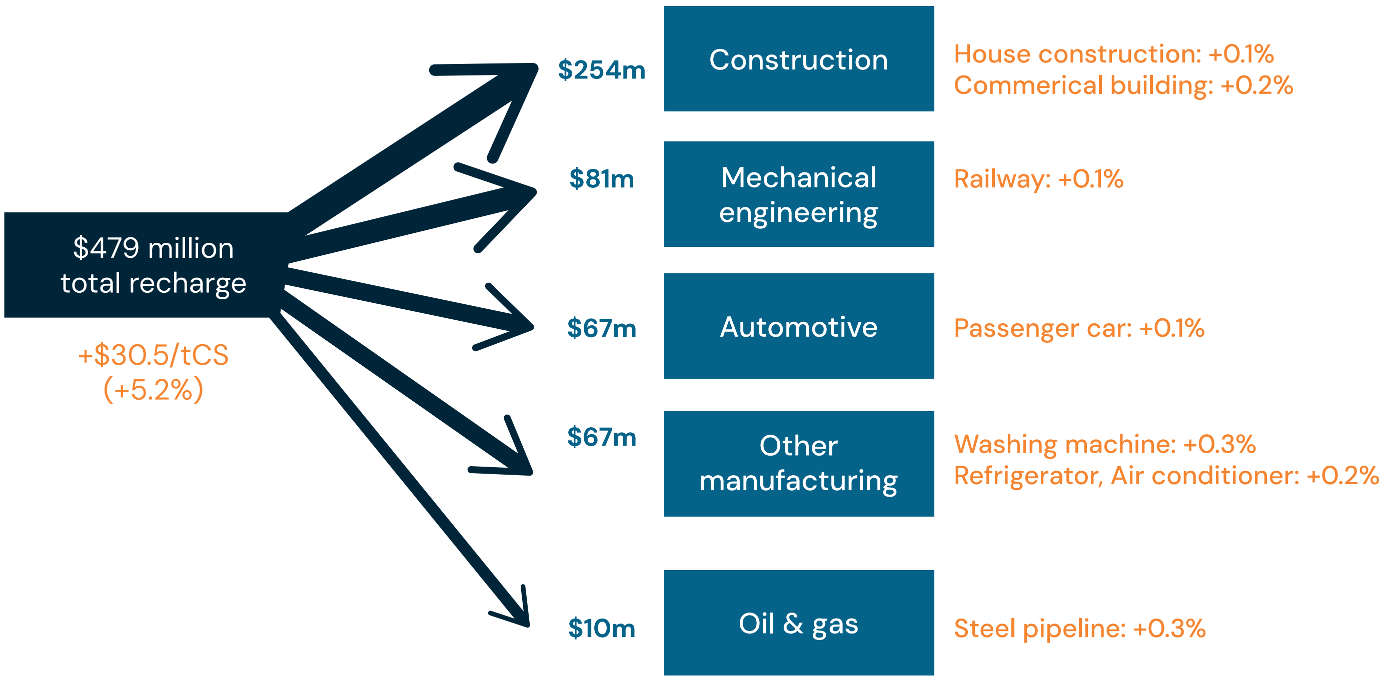
145. https://www.tatasteeluk.com/corporate/news/tata-steel-transformation-plan-faqs

146. According to the IEA, it is likely to be technically and economically very challenging to entirely eliminate emissions from industrial production; 'near-zero' emission materials are the likely 'net zero compatible' endpoint for industrial sectors, while other sectors will reach negative emissions to achieve net zero emissions for the energy system as a whole.
https://iea.blob.core.windows.net/assets/0910c4ff-4008-48f5-a3ec-c52996ed694d/Definitionsfornear-zeroandlow-emissionssteelandcementandunderlyingemissionsmeasurementmethodologies.pdf

147. Estimated based on a production cost premium of $264/tCS, or an equivalent of $479/tDRI, assuming 0.553 tDRI/tCS (50%, after losses in EAF production). See Technical Appendix for further assumptions used for estimating production costs.

148. UK Steel (2025). Key Statistics Guide 2025.

Figure 9: Estimated annual recharge, and impact on downstream products, for a recharge administered as a flat fee per tonne of steel for UK steel consumption. Sectoral consumption data from UK Steel – Key Statistics Guide 2025.



Impact on industrial competitiveness

> Because all steel consumed in the UK would be subject to the recharge, but not steel exported, UK steel production would face no change to its competitiveness in either domestic or international markets due to this policy.

However, other countries' existing conventional steel production, and future clean steel production, would probably continue to be lower-cost than UK-produced steel as it is at present – the policy would not address all the factors that currently make UK steel uncompetitive. An increasing carbon price and CBAM, used in conjunction with this policy, could help to improve UK competitiveness relative to imported steel in the short to medium term (see below). However, if steel production in other countries makes the transition to near-zero emission production, in the longer term, the UK could remain at a competitive disadvantage.

Extending the recharge to steel embedded in imported products, and having an equivalent exemption to the recharge for steel embedded in exported products, would avoid the policy creating any competitiveness risks for downstream industries.

Impact on consumer costs

The downstream impacts on consumer products would be extremely small – just a 0.1% increase in the cost of a passenger car, and a 0.2% increase in the price of a refrigerator. These are negligible compared with choices between brands, the prices offered by different dealerships, or inflation, and are unlikely to be noticed by consumers. Small increases in the cost of crude steel of $30.5/tonne of steel could be expected to have only minimal impacts on downstream demand and material substitution when compared with typical, cyclical fluctuations in steel prices.[149]

[149] The decarbonisation of other industrial sectors would also add to the cost of end products, but generally by similarly small fractions. The additional cost with the subsidy-and-recharge approach is significantly less than the additional cost under carbon pricing.

Feasibility of implementation

A steel recharge would require a new reporting system. All imports and exports of steel and steel-containing products would need to report their steel content and either pay the charge or receive a refund. However, in comparison with a CBAM similarly extended to cover downstream sectors, this represents a relatively light reporting requirement and a less difficult administrative challenge. The extended CBAM would require measurement, reporting and verification of the emissions embedded in all relevant imported goods, requiring knowledge of both the materials included in the product, and the emissions embedded in the materials. In contrast, the recharge extended to downstream sectors requires measurement and verification only of the material (steel) content, and not of the embedded emissions.

> The main practical challenge associated with the deployment of a H_2-DRI iron plant in the UK could be access to electricity on the scale required.

The UK electricity grid is already constrained, with new large-scale consumers facing waits of up to 15 years for a connection, although the process for requesting and allocating grid connections is under reform.[150]
A single 1 Mt plant using 300 MW of power would be the equivalent in demand of 730,000 UK homes each using 3,600 kWh of electricity a year.

Finally, a decision would need to be taken on the best location for a H_2-DRI plant. This could involve a process of inviting bids for the contract from interested companies. Scunthorpe would represent a good option to manage the transition from jobs at the existing blast furnaces to new ones created by investment in a DRI plant. It is also well positioned owing to its port access and proximity to other existing industrial sites. However, this would have to be compared with the costs of construction on a greenfield site. The choice could also be influenced by the prospect of locational pricing featuring in future electricity market reforms.

Political economy

One potential concern is that the provision of a subsidy for green iron production could be seen as market distorting. In reality, there should be no direct impact on competition between steel producers in the UK because the subsidy would only affect iron production, of which there is only a single facility left in the UK with a limited remaining lifespan. After its closure, the subsidy would ensure ironmaking continues in the UK. A second challenge is that any steel company provided with a subsidy may not be willing to sell green iron to other steelmakers in the UK with low margins. Consumer-funded subsidies could be seen as supporting the profitability of individual steel companies, whose interests differ from the government's, although a strong case could be made for the public interest in the transition. A nationally owned ironmaking company, or conditionalities on the subsidies provided, could potentially resolve both these challenges at once.

Compatibility with existing and future policies

With the green iron subsidy-and-recharge policy being used to enable clean primary steel production in the UK, the existing ETS and CBAM policies could continue to play complementary roles. The full decarbonisation of the UK steel sector would mean that the carbon price generated by the (multi-sector) ETS would have no impact on the cost of domestic steel production. But the CBAM would continue to increase the cost of any imported conventional steel, helping to prevent domestic clean steel production being undercut by more emission-intensive imports.

> In future, other policies such as public procurement of clean steel, or lifecycle emissions regulations in downstream sectors, could also further support the growth of near-zero emission steel supply chains in the UK.

150. https://www.gov.uk/government/news/government-to-tackle-speculative-demand-grid-connection-requests

The imported green iron option

The main argument against supporting ironmaking in the UK is that as the sector shifts towards clean technologies globally, ironmaking will be most competitive in regions with the lowest-cost renewable electricity generation – typically those with the highest solar irradiation.

An alternative route for UK clean primary steel production is therefore to import near-zero emission iron ('green iron') from other countries. In this case, a subsidy could be allocated to EAF steel producers in the UK, proportional to the volume of green iron that they use in their facility. This proportional allocation would prevent subsidies being used unnecessarily to support scrap-EAF production, which is already commercially viable and cost-effective. Steelmakers would then be free to source iron from either the UK or abroad.

Given the potential for lower-cost H_2-DRI production in other regions, the cost gap between imported green and conventional iron could be closed with a smaller subsidy than in the case of UK domestic production. For the same 1 Mtpa volume of green iron to be used in the UK steel industry, we estimate a total subsidy requirement of $210 million/year.[151] This cost could be recharged to steel consumed in the same way as described in the previous section.

Impact on industrial competitiveness

The policy itself would create no risks for industrial competitiveness, for the same reason as described above: the recharge creates no additional costs for UK steel producers or downstream manufacturers compared with those of other countries, in either domestic or global markets. However, the impacts of the choice not to support iron production in the UK could be significant. Primary steelmaking skills and expertise could be lost, but the use of low-cost green iron imports could strengthen the competitiveness of the UK steel industry over the long term. Lower-cost steel could enhance the competitiveness of manufacturing sectors. Additionally, reduced electricity demand for green iron production (a highly electricity-intensive process) could have the indirect benefit of lower electricity prices for other parts of the UK manufacturing ecosystem.

Impact on consumer costs

The impact on consumer costs of this policy would be even smaller than the already negligible impact described for the policy proposal above. The cost of a car would increase by around 0.05%, and that of a refrigerator by around 0.1%.[152]

Feasibility of implementation

The subsidy for steelmakers could be given in the form of a contract for difference with a 25-year period. This would enable UK steelmakers to arrange offtake agreements with green iron producers for a similar timescale, in turn giving green iron producers an assured market to justify the up-front cost of building a new plant.

An important uncertainty concerns the imbalance of risk: the risks are greater for an investor in a green iron plant than they are for any steel company committing to buy a portion of that plant's output. It may only be possible to reach the necessary level of confidence for investment in the green iron plant if several steelmakers have signed offtake agreements. Enabling investment in the first wave of green iron plants could require the establishment of arrangements for demand aggregation. Since these arrangements would operate internationally, they may require substantial diplomatic cooperation to establish, and if taking place in countries such as Brazil or South Africa, they may also require concessional finance and assistance. The commercial viability of the green iron plant could also be influenced by other policies in the producer country.

Political economy

The primary concern with relying purely on imported iron is likely to be the reduction of jobs, skills and expertise and elimination of ironmaking capability in the UK, and the subsidy could be framed by opponents as providing support to the industry of other countries. The counterargument would be that by supporting the use of lower-cost green iron inputs, the policy would enable the UK steel sector to meet a near-zero emissions standard at lower cost, increasing its competitiveness and safeguarding steelmaking jobs for the long term.

A second challenge is the political concern around supply chain security. This could be mitigated to some extent by seeking to establish green iron trade with countries with which the UK has strong bilateral relationships, potentially with commitments on long-term offtake contracts embedded within broader climate and trade cooperation agreements.[153]

---

151. Estimated based on a production cost premium of $116/tCS, or an equivalent of $210/tDRI, assuming 0.553 tDRI/tCS (50%, after losses in EAF production). See Technical Appendix for further assumptions used for estimating production costs.

152. Based on a recharge of $13.4/tCS.

Conclusion

The continuation and extension of existing policies for carbon pricing and hydrogen subsidies appears the least favourable option for enabling clean primary steelmaking in the UK. This approach is unlikely to be effective in enabling investment, creates competitiveness risks to the steel industry and to downstream industries, may be difficult to fund sustainably over the long term, and involves the political challenges of increasing energy prices for households and industry.

A domestic green iron subsidy and steel recharge would enable clean steel production in the UK at no cost to government, creating no immediate competitiveness risks, and at unnoticeably small cost to consumers. The choice to support iron production in the UK does, however, prioritise strategic resilience over the competitiveness of steel-using sectors and may not be the most competitive option for the UK steel industry in the long term.

The alternative approach of a clean steel subsidy-and-recharge with industry allowed to use imported green iron would involve the opposite strategic choice: prioritising long-term industrial competitiveness at the expense of strategic resilience. It would be similarly unnoticeable to consumers but may need further interventions in the form of demand aggregation and diplomacy to ensure its effectiveness in enabling investment in green iron production.

[153] https://www.ippr.org/articles/partner-to-scale-international-collaboration

CEEW

DIW BERLIN

s-curve economics