5 Steel industry net-zero tracker

For primary steelmaking clean hydrogen-based DRI-EAF has emerged as the main decarbonization pathway, whereas secondary steel needs to switch to clean power sources.

Key emissions data[202, 203, 204, 205]

8%
Contribution to global energy related GHG emissions

3.7 $gtCO_2e$
Scope 1 and 2 emissions

1.41 tCO_2
Emissions intensity (per tonne of steel, 2022)

22%
Reduced emission production

>85%
Fossil fuels in the fuel mix (2022)

1.4 times
Expected demand increase by 2050

<1%
Current low-emission production

Readiness key takeaways

Technology
Primary steel[206] can use both clean hydrogen and CCUS for decarbonization. Secondary steel[207] can use EAF with renewable electricity. However, costs are 40-70%[208] higher than traditional methods.

Infrastructure
Inadequate infrastructure requires $1.8-2.4 trillion[209] for clean hydrogen and clean power development. Regions with steel capacity and access to affordable renewables and CO_2 storage should be prioritized.

Demand
Near-zero-emission steel held less than 1% of the market in 2022. A B2B green premium of 40-70% may be necessary, with about 1-2% affecting consumers.[210] However, this remains untested at scale.

Policy
Early-stage steel decarbonization policies are needed especially in Asia-Pacific (with 70% global steel production). Policies should focus on clean power, hydrogen, R&D and green procurement for low-emission steel.

Capital
$372 billion[213] is required by 2050, with 60% directed towards retrofitting existing assets. However, the business case remains weak, given 8.5% industry profit margin and 10.1% WACC.[214]

Stated energy transition goals

- The industry targets a 45% reduction in intensity for primary steel and a 65% reduction for secondary steel by 2030, and net-zero emissions by 2050.[211]
- 70%[212] of large publicly traded steel companies consider climate change in their decision-making processes.

Emission focus areas for tracker

Steel emissions can be divided into two main categories:

1. **Energy-related emissions** are primarily due to coal use in the blast furnace-basic oxygen furnace (BF-BOF) and EAF processes to produce molten steel for primary steel production.
2. **Process-related emissions** emanate from the use of coke or natural gas as a reducing agent to convert iron ore into iron for primary steel production.

Sector priorities

Existing assets
Reduce near-term emissions intensity by:
- Deploying energy efficiency improvement techniques
- Shifting to transitional technologies such as DRI-EAF in regions where natural gas is affordable and available
- Switching to clean power sources for secondary steel production, where cost competitive renewables are feasible.

Next generation assets
Accelerate infrastructure development to drive absolute emissions reduction by:
- Investing in clean hydrogen generation capacity to support transition for primary steelmaking
- Retrofitting assets with CCUS where access to CO_2 transport and storage is economical
- Enabling access to grid-based clean power for secondary steel.

Ecosystem
Enabling access to grid-based clean power for secondary steel by:
- Implementing a blend of policies, principally product standards and incentivizing low-emission production
- Reducing near-zero-emission production costs through an increased number of clean hydrogen projects
- Enabling shared infrastructure and supply chain stability through strategic partnerships.

Performance

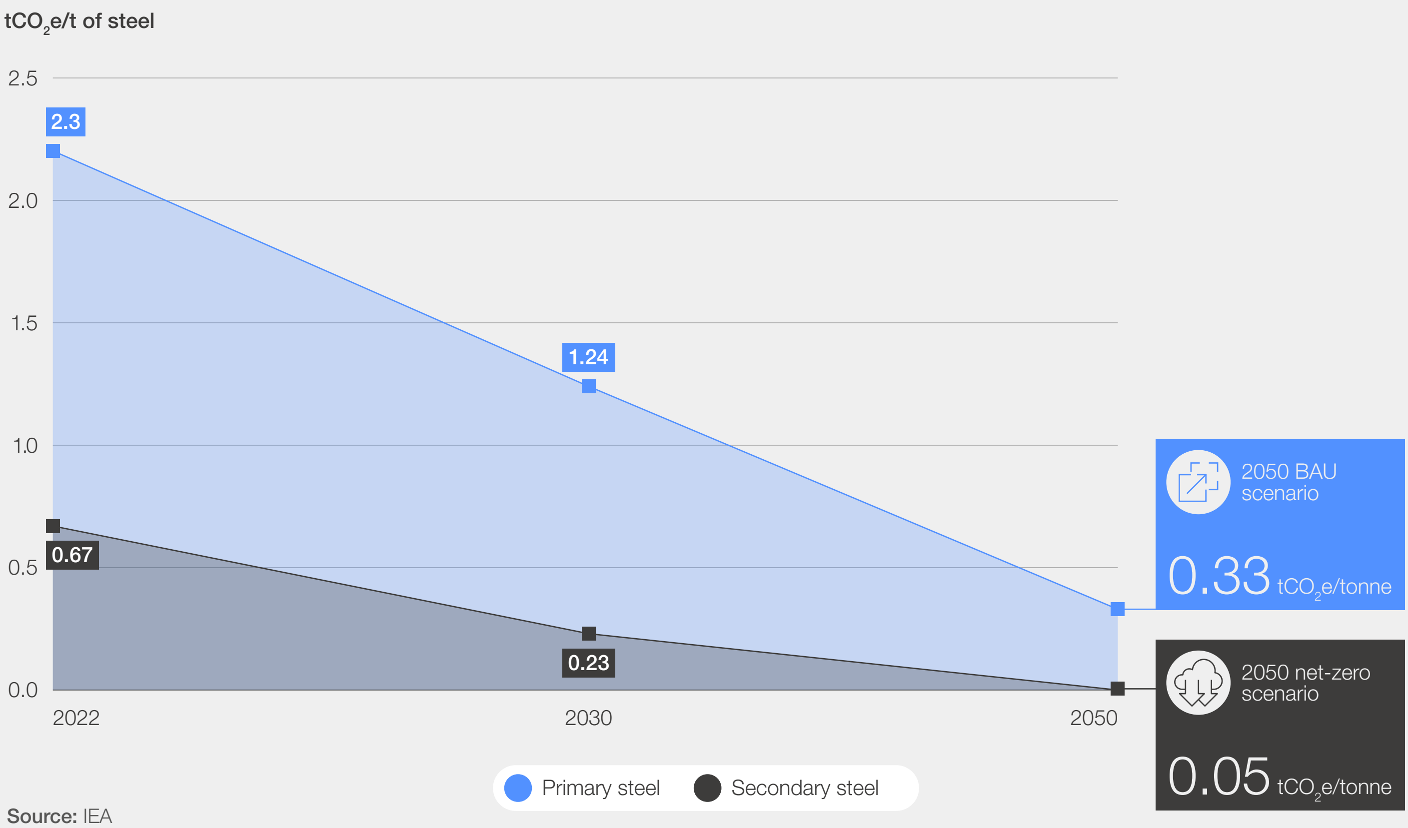
75%
of steel's fuel mix comes from coal

The production process of steel is energy intensive and generates high CO_2 emissions, accounting for up to 95% of its emissions. The current fuel mix heavily relies on fossil fuels, predominantly coal, occupying around a 75% share. The coal dependency has remained consistently between 70-75% over the decade,[215] substantially contributing to steel's absolute emissions.

Over the last decade, steel CO_2 emissions rose 2.5% annually, due to rising production driven by demand growth in emerging markets. Currently, 78%[216] of steel is produced using primary methods, while the remaining portion comes from secondary production. However, this distribution varies globally, with China predominantly using primary processes - mainly BF-BOF – for 90% of their steel, whereas North America relies on secondary processes for 70%[217] of its steel production. Other major steel-producing regions like India and the EU exhibit a more balanced distribution between primary and secondary steelmaking.

Energy intensity in steel production has remained relatively stable, averaging between 19-20 gigajoules per tonne (GJ/t) of steel over the past 5 years,[218] due to improved energy efficiency and increased secondary steel production. Primary steel production is particularly energy-intensive due to the high temperatures required to melt iron. Both primary steel production methods, BF-BOF and DRI-EAF, require up to 25 GJ/t of energy. In contrast the secondary steel method (EAF), reduces energy intensity by 2.5 times, down to 10 GJ/t, as melting scrap steel requires much less energy.

FIGURE 35 **Emissions intensity trajectory for primary and secondary steel**



Source: IEA

Path forward

The industry targets a 45% reduction in intensity for primary steel and a 65% reduction for secondary steel by 2030.[219] The 2050 net-zero compliant fuel mix will require disconnecting steel emissions from the growth in market demand. This entails reducing non-abated fossil fuels from their current dominant share of 86% in the fuel mix to 30%,[220] which will require a substantial increase in CCUS deployment. For primary steel production, accelerated investments are needed, together with the commercialization of clean hydrogen fuels, coupled with implementation of CCUS-enabled technologies. In the case of secondary steel production, expediting the adoption of clean power through EAF processes is paramount.

FIGURE 36 | **2021 fuel mix**

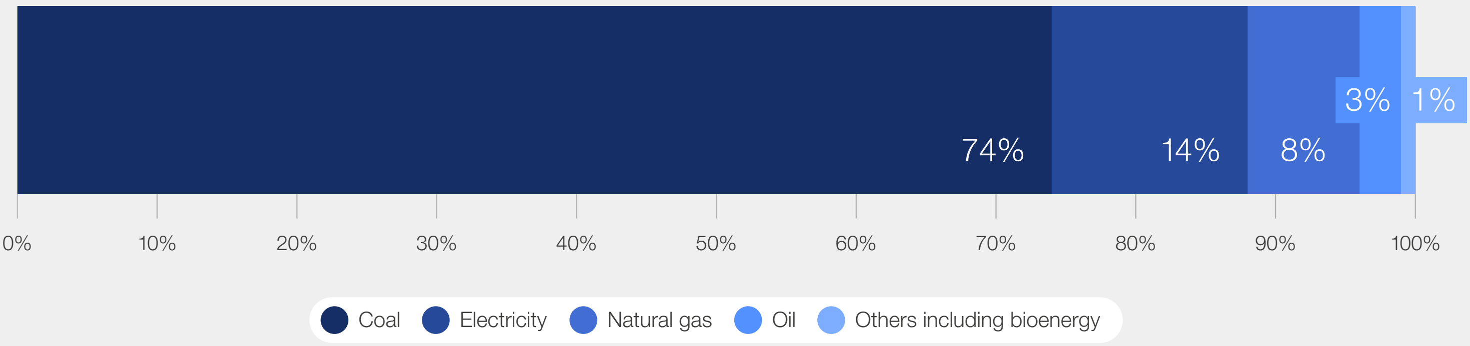
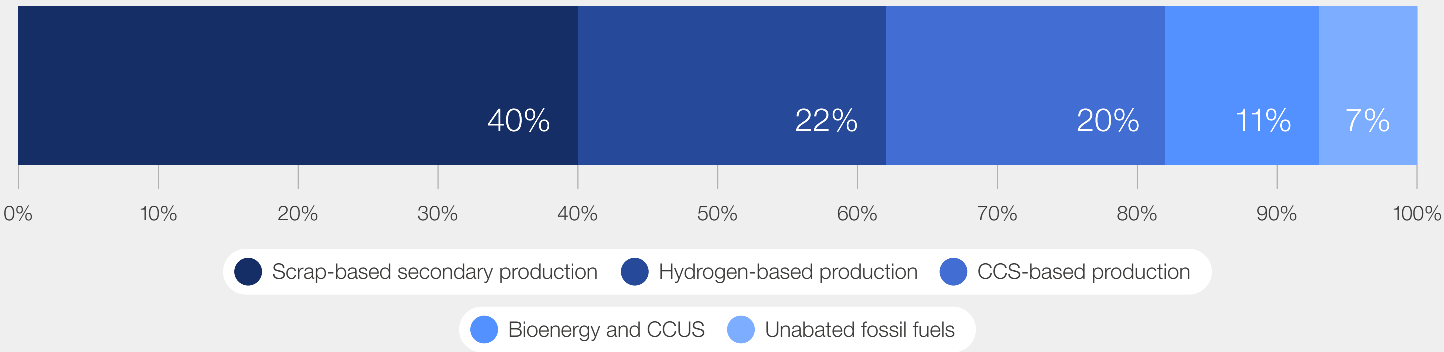


FIGURE 37 | **Estimated share of production in 2050**



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STEEL

2 Technology

Two leading decarbonization pathways have emerged for primary steel: clean hydrogen-based DRI-EAF is the most developed (TRL 6-8), and CCUS is rapidly developing (TRL 5-8). For secondary steel decarbonization, EAF-based production using 100% renewable electricity is a mature and available technology. Production costs for these technologies are 40-70% higher[221] than traditional steelmaking processes.

Process emissions abatement measures

Clean hydrogen potential for primary steel: Using clean hydrogen in production processes has the potential to reduce emissions by up to 97%,[222] however, it comes with an expected green premium of 35-70%[223] when compared to conventional BF-BOF processes. However, constraints around the capacity of EAFs in comparison to larger blast furnaces and deployment at smaller facilities impact the applicability of this technology.

CCUS technologies for primary steel: Most CCUS-based technologies are projected to become commercially available after 2028. These CCUS technologies have the potential to decrease emissions by up to 90%[224] compared to BF-BOF. Bioenergy carbon capture and storage (BECCS), a modified CCUS technology, can achieve up to negative emissions from BF-BOF, though results are dependent on the source of bioenergy. However, all CCUS technologies entail a significant green premium in the range of 65-120%.[225] Although DRI-EAF with CCUS is currently accessible, its carbon capture efficiency is limited. CCUS technology is most suited for decarbonizing BF-BOF assets, especially given the higher concentration of CO_2 in blast furnace gases.

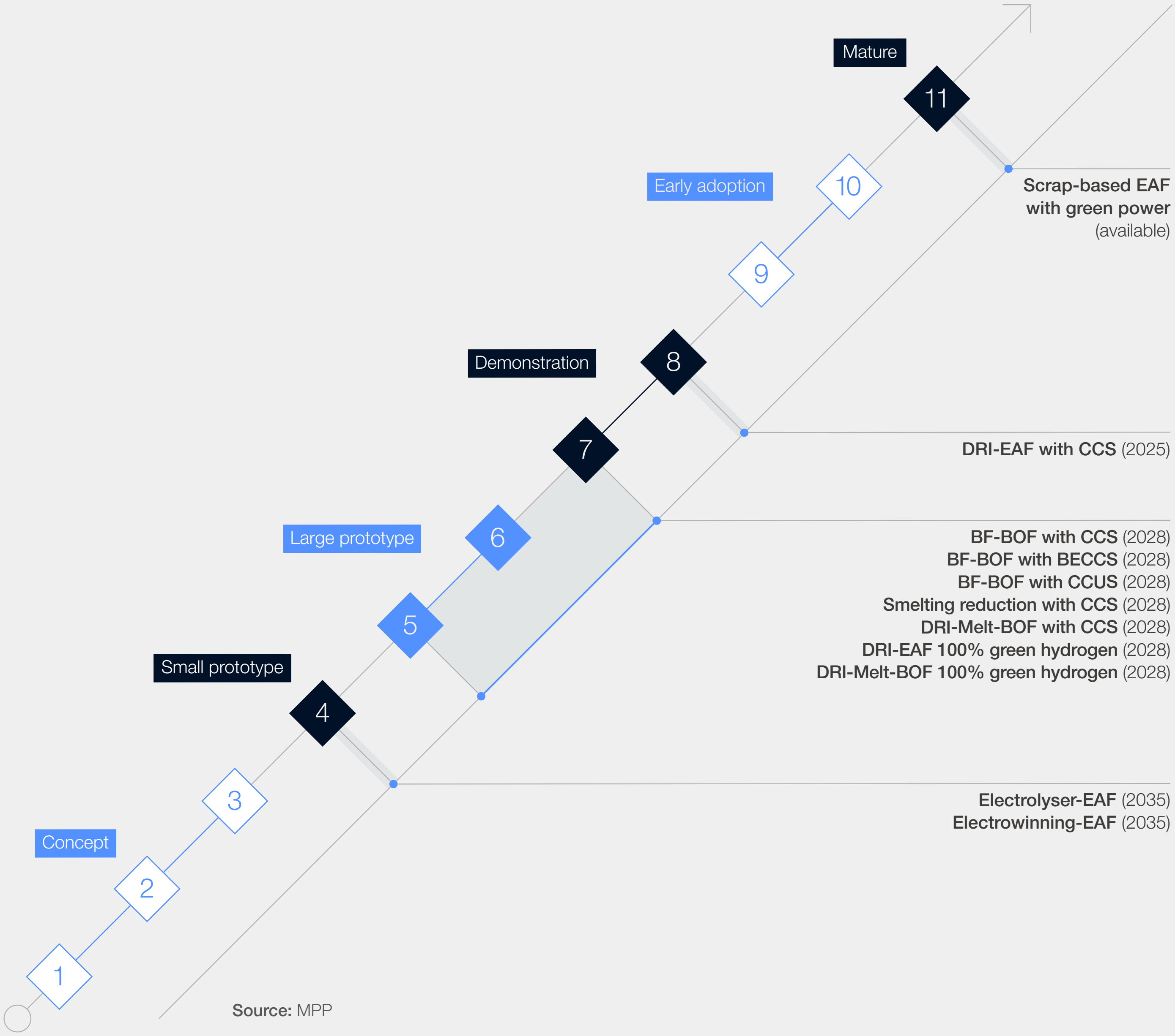
Energy emissions abatement measures

“ Steel decarbonisation is likely to be faster in regions where competitively priced clean power and scrap steel are readily available.

EAF-based secondary steel production: Powered by 100% renewable electricity, this method offers a promising pathway towards near-zero-emission steel at low cost. EAF technology can reduce emissions by 90-95% compared to BF-BOF, with only a marginal cost premium of 8-13%.[226] Yet, there are limits around the applications for secondary steel due to variances in the quality of available scrap. Adoption is likely to be faster in regions where competitively priced clean power and scrap steel are readily available. China, for instance, is expected to witness an estimated 70% growth in EAF production by 2050 compared to 2020 levels.[227] Additionally, SSAB, the largest steel manufacturer in Scandinavia, launched SSAB Zero™, produced from emission-free recycled steel. One of its main advantages is its near-zero-carbon emissions throughout the company's operations, contributing to an emission-free value chain for end-users. However, this sustainability comes at a higher cost due to the manufacturing process.[228]

Technology pathways

FIGURE 38 Estimated TRL and year of availability for key technology pathways



Source: MPP

STEEL

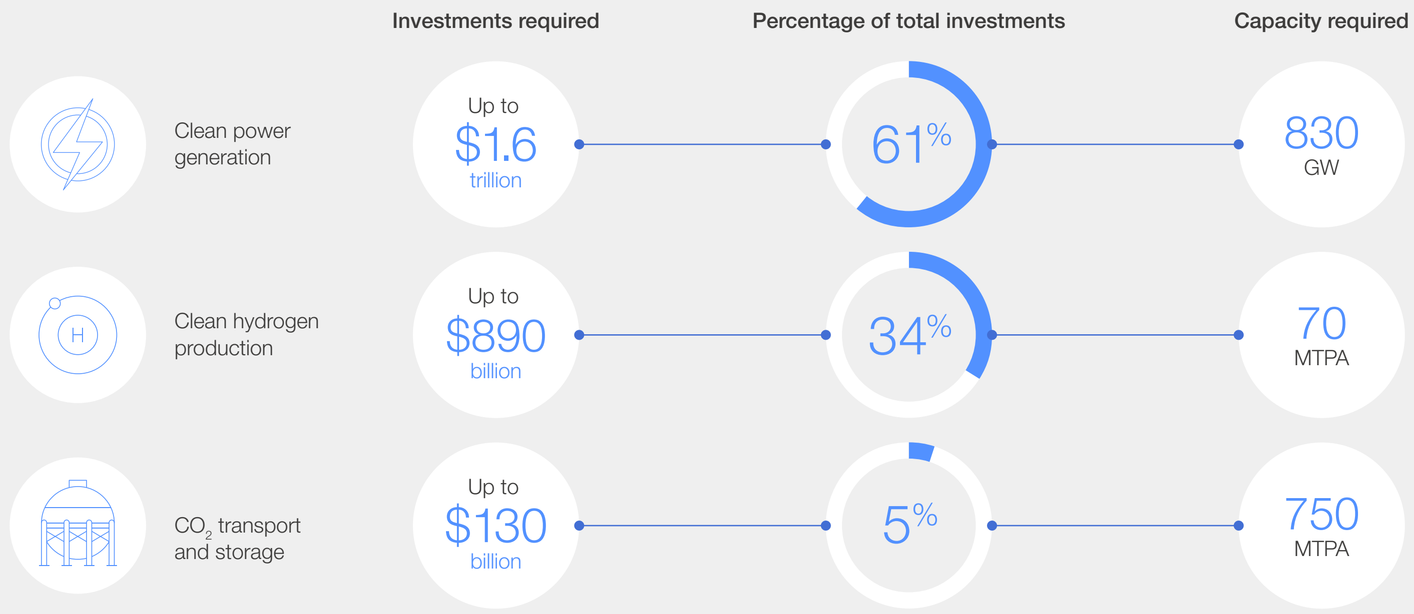
1 Infrastructure

Steel decarbonization relies on the availability of clean hydrogen, CCUS and EAF-based secondary steel production. Establishing infrastructure for near-zero-emission production requires significant investments, estimated between $1.8-2.6 trillion.[229] Of this, 90% should be directed towards creating clean hydrogen and clean power generation capacity, with the remainder for CO_2 transport and storage. Around 50%[230] of current steelmaking capacity is in regions with access to low-cost renewables or CO_2 storage and should be prioritized for transition.

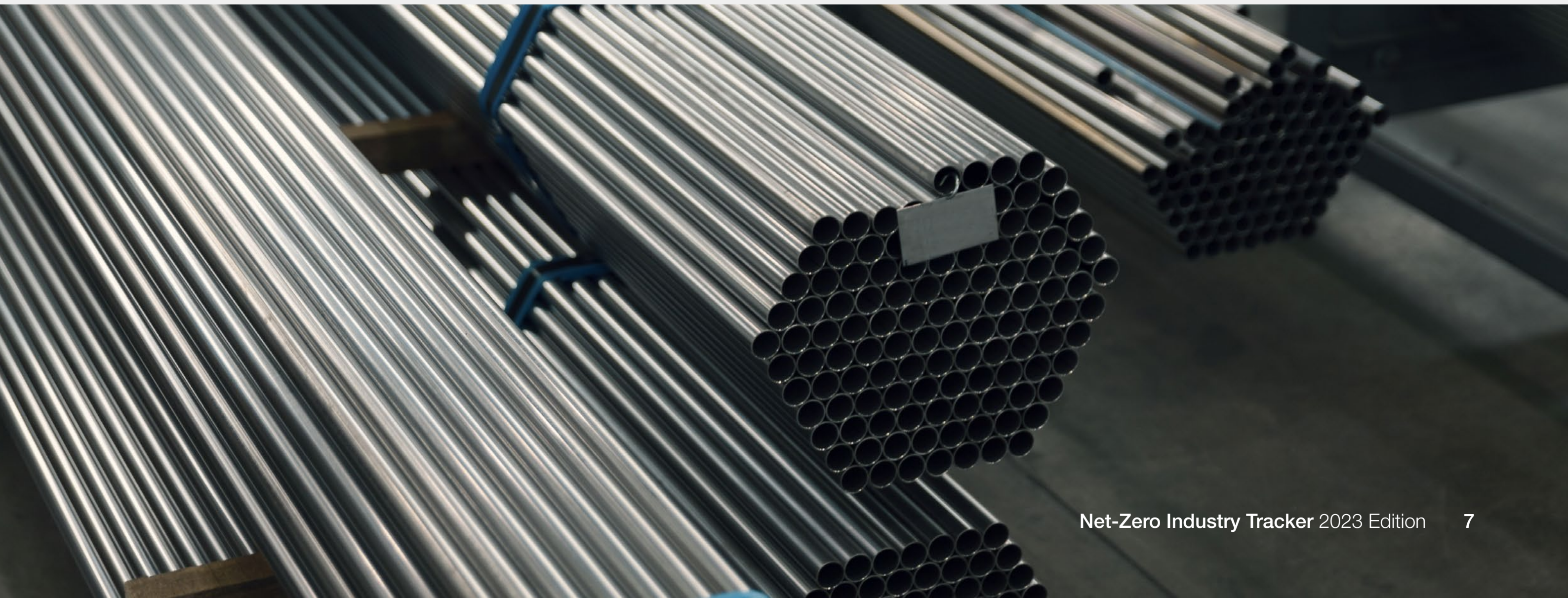
Meeting the steel industry's clean hydrogen demand would require substantial investments ranging from $200-$890 billion[231] for additional capacity. Regions with affordable natural gas and clean power are well-suited for near-term adoption of clean hydrogen. CCUS technologies are advantageous in settings with CO_2 storage availability or proximity to industrial clusters where captured carbon can be used as feedstock. United States Steel Corporation and CarbonFree Chemicals Holdings have signed a non-binding MoU to collaborate on capturing CO_2 emissions from US Steel's Gary Works plant. They will deploy CarbonFree's SkyCycle technology with the goal of capturing and mineralizing approximately 50,000 tonnes of CO_2 annually, equivalent to offsetting the carbon emissions of nearly 11,000 passenger cars each year.[232]

Clean power generation will be a priority in regions where the role of EAF production is expected to increase, such as China and North America.

FIGURE 39 **Investments required for enabling infrastructure**



Source: Accenture analysis based on multiple data sources including IEA IRENA BNEF and Global CCS Insititute



3

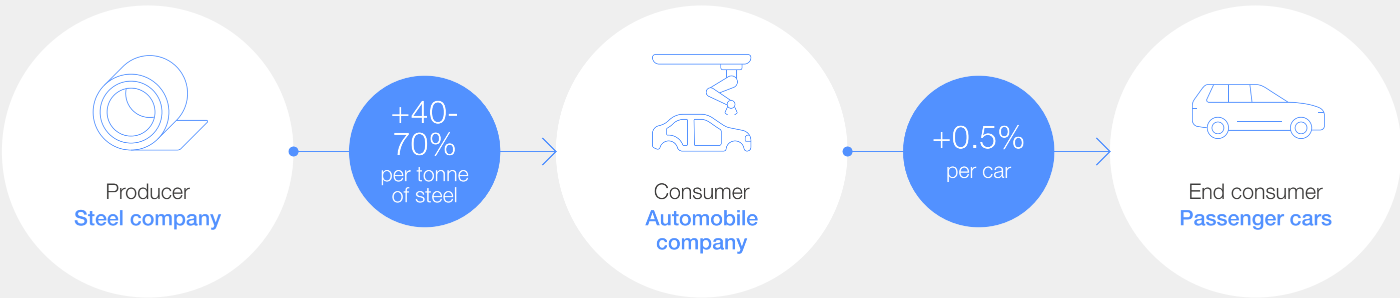
STEEL

Demand

The ability of customers to absorb a green premium of 40-70% per tonne[233] is untested beyond prototype projects as low-emission steel represents less than 1% of global supply.

A 40-70% increase in the per tonne cost of steel translates into lower green premiums for end consumers. It can range from 0.5% for passenger cars to 2% for buildings.[234]

FIGURE 40 **Estimated B2B and B2C green premium**



Source: MPP

Circular economy models should be promoted where steel producers can recycle and reuse their own steel scrap.

The ability for the industry to pass along this premium, or to monetize near-zero-emission steel as a differentiating attribute depends on the target consumer segment (for example, passenger cars vs buildings), and geography (developed vs developing regions). The largest forecasted increases in steel consumption globally align with the markets with likely the lowest ability to absorb a significant green premium.

Currently, several major global players are taking proactive steps towards decarbonizing steel production. China Baowu Group, the world's largest steel producer, has signed an MoU with Rio Tinto to jointly explore green steel projects.[235] They've also established a Global Low-Carbon Metallurgical Innovation Alliance with partners from 15 countries, aimed at reducing GHG emissions in steelmaking.[236]

In the automotive industry, bilateral offtake agreements with steel producers are impacting the market,[237] offering convenient access to buyers who secure their supply in advance. For instance, Volkswagen Group and Salzgitter AG have signed an MoU to source near-zero-emission steel starting in late 2025.[238]

The Clean Energy Ministerial Industrial Deep Decarbonisation Initiative (IDDI)[239] is developing globally recognized targets for the public procurement of near-zero-emission steel. The IDDI is set to introduce standardized definitions, methodologies and guidelines across the industry. Additionally, Responsible Steel have implemented auditable to near-zero-emission steel production certifications, available to its members.[240] These initiatives signal a potential shift towards boosting demand and encouraging collective efforts towards near-zero-emission products, and ultimately driving a positive trajectory towards net-zero emissions.

Improving supply chain efficiency and promoting circularity is essential to accelerate secondary steel production in regions with limited access to scrap steel. In these areas, optimizing supply chains becomes paramount to ensure a consistent flow of recyclable materials. Implementing connected supply chain networks, supported by AI technology and blockchain, can enhance transparency and traceability, reducing waste and losses.[241] Moreover, promoting a circular economy model by encouraging steel producers to recycle and reuse their own steel scrap can reduce reliance on external sources. By integrating these strategies, regions facing scrap steel shortages can bolster their secondary steel production capabilities.

STEEL

2 Policy

Policy efforts to promote and support the decarbonization of the steel industry are still in their early stages, particularly in the Asia Pacific region, which produces 70% of the world's steel.[242]

Global steel production is highly concentrated, with the top five producing companies accounting for around 75% of production. Public policies should be aimed at:

- Supporting the development of clean power and clean hydrogen infrastructure
- Providing R&D support and market-based incentives to accelerate low-emission steel technologies, especially in their early stages
- Implementing demand-side interventions such as green public procurement and updated product codes to stimulate market demand for near-zero-emission steel.

While policy measures to facilitate decarbonization are beginning to emerge, they will require time to fully mature. Local regulations, such as Environmental Product Declarations (EPDs), often prioritize pollution control, life cycle assessments and performance standards but may not sufficiently address CO_2 emissions reduction. Currently, policy development is mainly driven by Europe and the US. However, it is crucial to strengthen policy initiatives in the Asia Pacific region, given its substantial contribution to global steel production.

As steel is a highly traded commodity, international collaboration on policy measures is essential to prevent the uneven application of policies that could lead to market distortions.

Existing policy landscape

TABLE 8 **Policy summary**

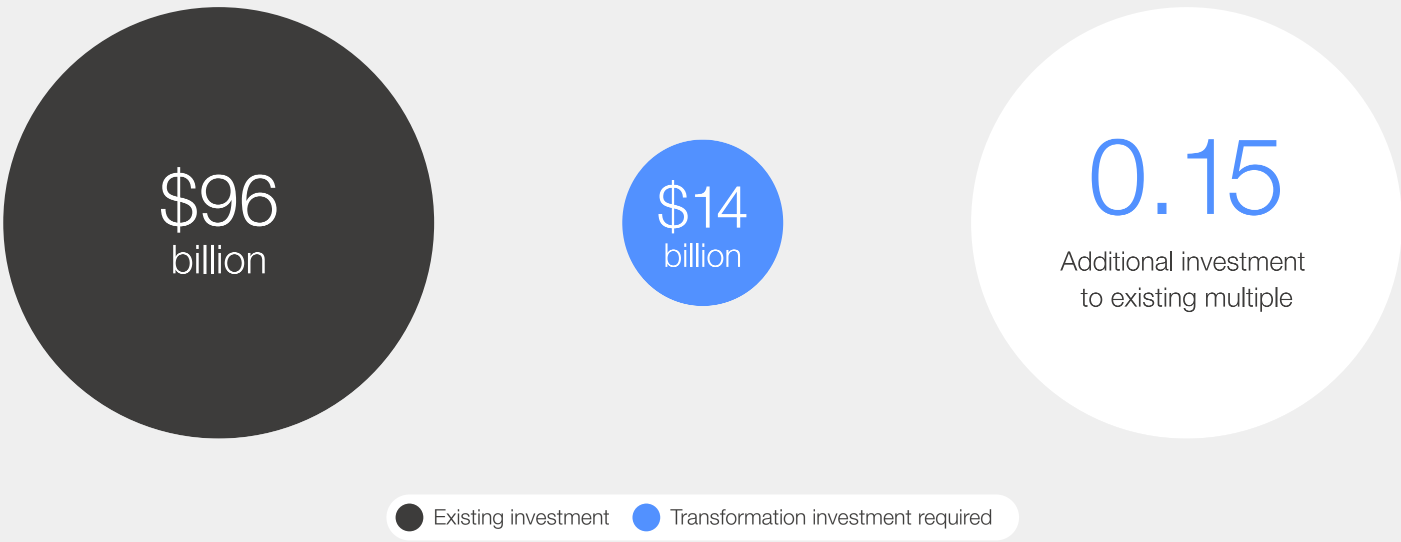
Enabler	Policy type	Policy instruments	Key examples	Impact
Technology	Incentive-based	Direct R&D funds/grants	– EU Clean Steel Partnership (CSP)[243] – Japan Green Innovation Fund	CSP: Allocated budget of $1.7 billion to achieve TRL 8 levels for identified technology pathways by 2030. Japan: $1.5 billion allocated to fund innovative steelmaking technologies.[244]
	Market-based	Carbon price	– EU-ETS[245] – California ETS[246] – South Korea ETS[247] – China ETS[248] (announced)	Incentivizes steel producers to reduce emissions but impact is limited by free emission allowances and lower carbon prices.
		Border adjustment tariff	– EU CBAM (pending implementation)[249]	Emission-intensive steel exporters to the EU face increased costs of compliance. Currently 30% of steel consumed is imported from non-EU countries. Needs to be complemented by transparent and fair carbon accounting standards.
Infrastructure	Incentive-based	Direct funding support	– IRA tax-credits to clean power[250]	Projected to accelerate clean power generation capacity in US, with clean power forming 80% of the power mix by 2030.[251] Supports faster transition of 70% of US steel production to clean power.
Demand	Incentive-based	GPP	– Federal buy clean initiative in US[252] – Key steel producers as IDDI members – US, India, Japan[253]	Creates a viable market for near-zero-emission steel through green public procurement commitments – 25% of steel demand already comes from public procurement.[254]
	Mandate-based	Product standards	– GSA low embodied-carbon steel standards in US[255]	Specific targets on embodied carbon in steel products provides clear guidelines to green public procurement.
Capital	Incentive-based	Direct funding	– EU public funding to steel plants to decarbonize[256]	More than $2 billion in public funding to install hydrogen-based DRI steel plants in Europe.
		Tax credits and subsidies	– IRA tax-credits to clean power, green hydrogen and CCUS	Potential to reduce cost of near-zero-emission steel by up to 35%.[257] With limited funding available in developing economies, international funding collaboration mechanisms can be an option to raise the required capital.

STEEL
1 Capital

In the steel industry, transforming existing assets with near-zero technologies could require cumulative investments of $372 billion by 2050.[258] Such a requirement implies annual investments of $14 billion, in addition to the regular annual CapEx of $96 billion – an additional 15% investment.[259]

Current industry profit margins of 13%[260] and WACC of 10%[261] suggest that the industry is not positioned to absorb these additional costs and generate sufficient returns to fund investment through own generated cash flows.

FIGURE 41 **Additional investment required to existing investment ratio**

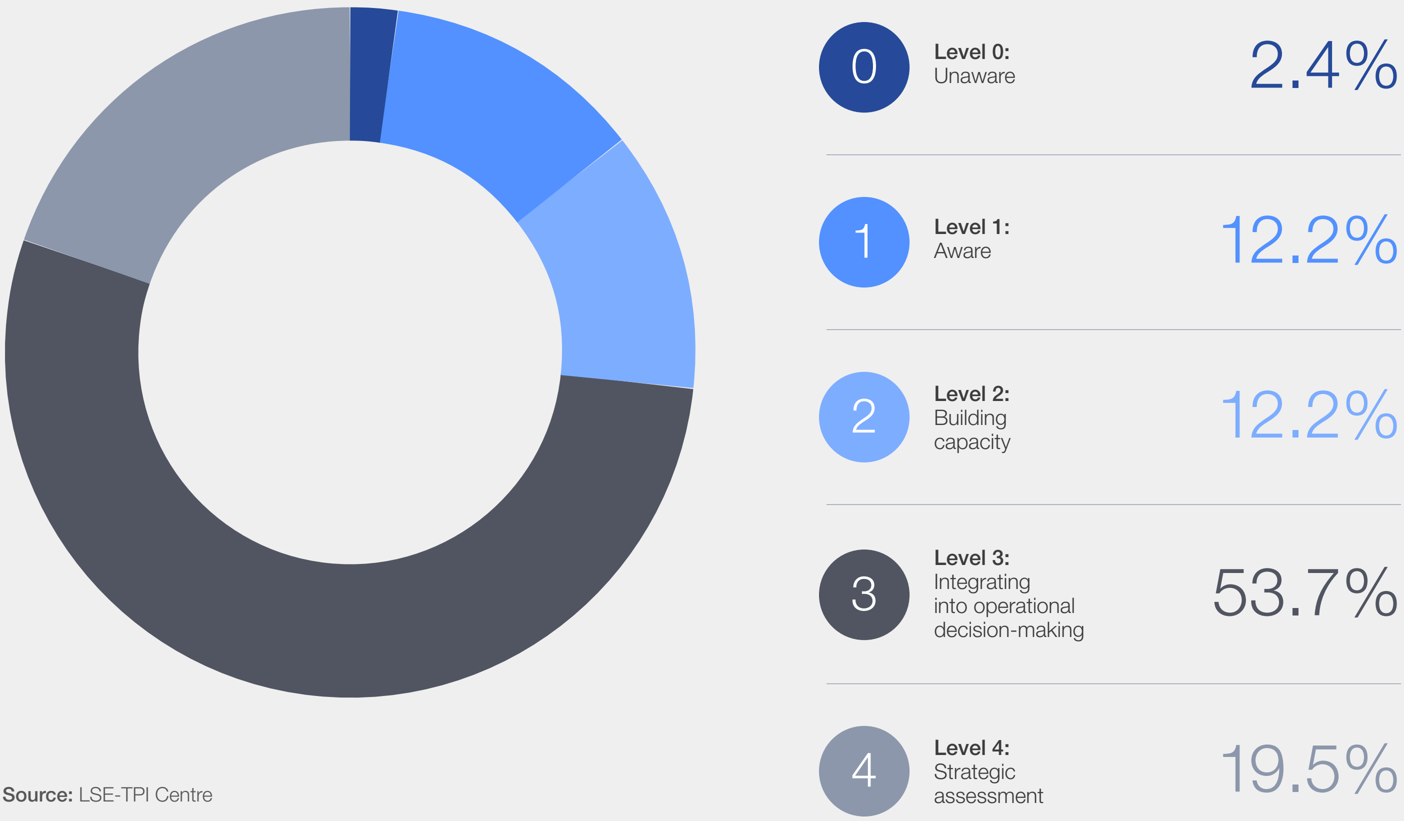


Source: Accenture analysis based on Green Steel and ETC data

To direct the capital towards transforming the industry, policy interventions like carbon pricing, subsidies/incentives for technology development and public procurement commitments will need to be adopted to improve returns. Large institutional investors and multilateral banks (World Bank, Asian Development Bank etc.) can play a crucial role by providing access to low-cost capital linked to stringent emission reduction targets. Additionally, capital flows within this industry are tied to region-specific technology pathways. For the EU and China, the capital should mainly be directed towards expanding their EAF asset base as secondary steelmaking assumes a major role. In India and the US, capital flows will need to address the maintenance of existing EAF asset base as capacity expansion will be limited by scrap availability.

Approximately 70% of large publicly-traded steel companies consider climate change as a key consideration for their strategic assessment and integrate it into their operational decision-making.[262] Meanwhile, 12% of companies are building basic emissions management systems and process capabilities. Finally, 12% of companies acknowledge climate change as a business issue.

FIGURE 42 **Distribution of companies in the steel sector according to the management of their GHG emissions and of risks and opportunities related to the low-carbon transition**



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