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Steel

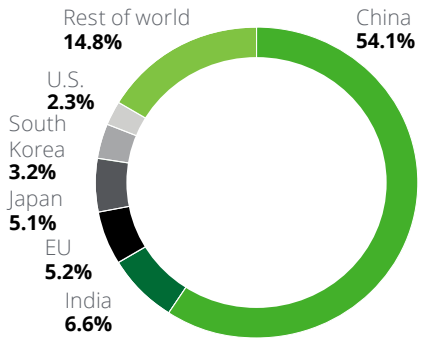
Pathways to decarbonization

Sector landscape

The steel sector produces 7% of global industrial emissions

In 2020, the global steel sector was directly responsible for 7% of total worldwide industrial CO_2 emissions—or approximately 2.6 billion tonnes. China was responsible for 50% of total emissions (Figure 1) reflecting, in part, China's large share of overall steel production.

Figure 1:
Estimated steelmaking CO_2 emissions per region (2019)[1]



Source: Global Efficiency Intelligence and Deloitte analysis

Emission sources

From a value chain perspective (Figure 2), the sector's highest source of emissions stem from the use of fossil fuels for different steelmaking production routes—such as coke production (using coke ovens), iron ore melting (using blast furnaces), and iron-to-raw-steel conversion (using basic oxygen furnaces) (Table 1).

Table 1
Typical direct and indirect emissions generated from different steelmaking production routes

Steelmaking route	CO_2 emissions (TCO_2/T steel)
Blast furnace – Basic oxygen furnace (BF-BOF)	2.2
Scrap-based electric arc furnace (EAF)	0.3
Natural gas direct reduced iron (DRI)	1.4

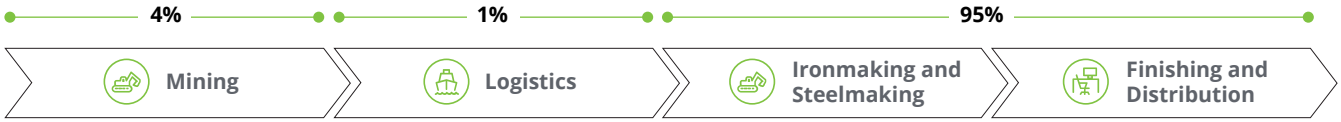
While approximately 70% of global steel is produced globally this way,[2] companies in the steel sector are widely committed to limiting global warming to 1.5 degrees Celsius, as per the Paris Climate Accord. As a result, many have clear commitments to reduce CO_2 emissions between 30% to 40% by 2030 (as compared to previously measured 2015-2018 emission levels). Furthermore, the same companies are committing to a net-zero target date of 2050 (or earlier in some cases).

Moving the entire industry towards decarbonization will be a challenge—as companies are at varying levels of maturity, and many haven't yet started their transformative journeys. Additionally, decarbonization pathways will vary dramatically from region to region as there are significant differences in how steelmaking technologies are deployed across the world and, as a result, varying CO_2 intensity of steel production (tons of CO_2 per ton of steel). The United States (US) currently has the lowest CO_2 intensity, due to it having the highest share of scrap-based Electric Arc Furnace (EAF) technologies.

In contrast, India and China have the highest CO_2 intensities, due to a predominance of coal as fuel and Blast Furnace (BF) ironmaking. Despite having a relatively high share of BF-based ironmaking of around 60%, the European Union (EU) has achieved the lowest average CO_2 intensity for BF-based steelmaking, through implementing advanced BF technologies, which has successfully reduced emissions by around 50% over the past 50 years.

That said, the good news is, in most cases, the basic necessary conditions for transformation are already set—and most companies have viable technology options. In this article, we'll explore how emerging technologies, shifting regulations, and customer demand for green steel are shaping the sector—as well as identify potential implementation strategies.

Figure 2:
Proportion of emissions per stage of the steelmaking value chain



Implementing a net-zero value chain

The industry's objective: a net-zero value chain by 2050

Achieving these targets will be anything but easy. In many cases, steel producers will have to make incremental reductions in emission levels through improvements to existing production technologies (such as installing top pressure recovery turbines on a blast furnace) and processes (such as enhanced digital predictive process control and monitoring). Some companies may also have to overhaul their existing methods of primary steel production.

Emerging technologies and abatement strategies

To achieve net-zero, steel producers are evaluating a number of technologies, many of which are at differing stages of commercial readiness (Table 2). Ironmaking using hydrogen-based direct-reduced iron production is seen as one of the primary approaches to help companies achieve their goals. Additionally, many companies are exploring opportunities to lower emissions through the increased usage of recycled scrap steel, melted via the EAF steelmaking process.

Given differing regional cost dynamics associated with renewable energy and green hydrogen, many companies are also evaluating how these variations may impact key parts of steel value chain—both today and in the future.

Table 2:
Examples of (new) decarbonization technologies being evaluated by steelmakers

Hydrogen-based DRI (direct reduced iron)	Electrolysis of iron ore using renewable electricity	Biomass and hydrogen injection in the blast furnace (BF)	CCS/U (Carbon Capture Storage/ Usage)

Current challenges

Having established ambitious emission targets, some steel producers have already started making the transition. However, the steel industry continues to face several key implementation issues. These include:

Technology maturity and skills

- Young age of existing steelmaking assets that will be replaced
- Varying maturity of proven enabling decarbonization technologies
- Shortage of skills in engineering, metallurgy, and IT/ software

Shortage and cost of green hydrogen and renewable electricity

- Lack of green infrastructure for renewable electricity and hydrogen production
- High cost of green hydrogen may make green steel uncompetitive

End-consumer markets

- Variable demand for green steel from different regions and industries
- Low appetite to pay significantly higher "green premium" price for low-carbon steel
- Continued reliance on higher-carbon steel due to China's (continued) speed of industrialization and the recent global economic downturn

Regulations and policies

- Phasing in/out of Carbon Border Adjustment Mechanism (CBAM) and EU Emissions Trading System (ETS) could negatively impact steel producers (in EU)
- Lack of a low-carbon steel taxonomy and clear certification standards
- Regulatory framework could level the playing field between different regions and countries

Financing and capital expenditures

- High-asset investments needed (e.g., in EU estimated at around US$70-100 billion)
- Steelmakers have low profit margins and may not be able to absorb investment costs

Raw material availability

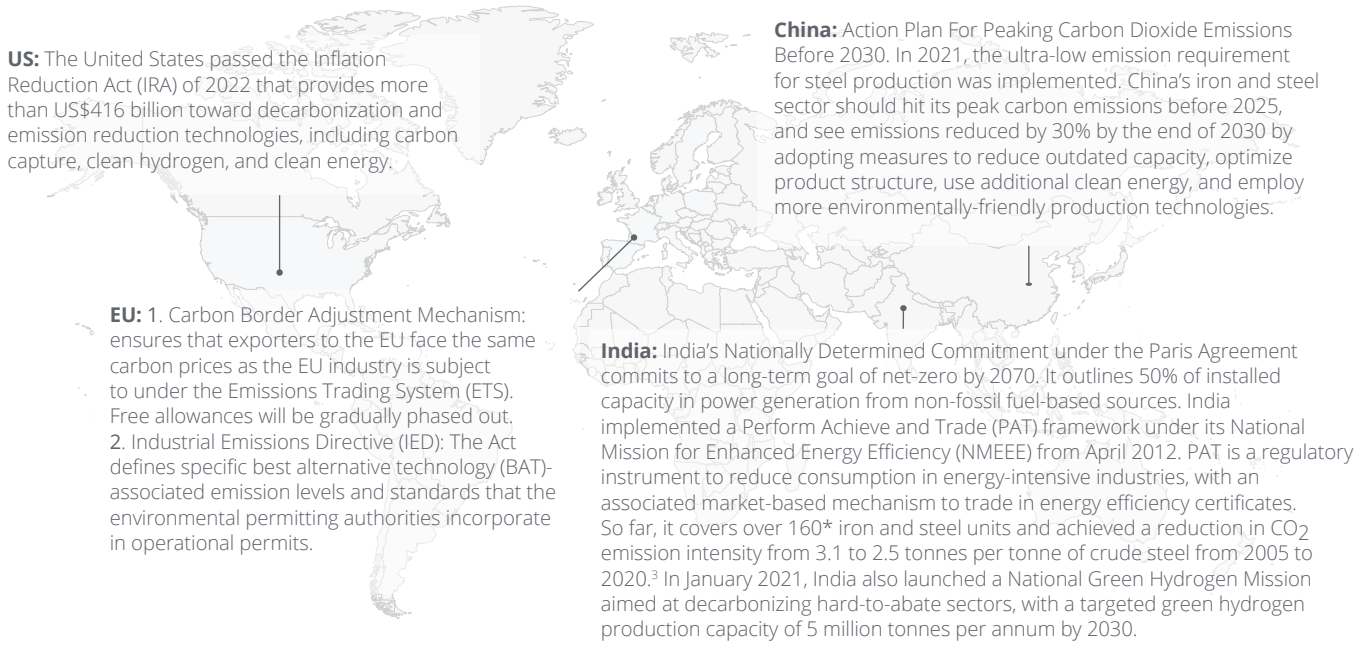
- Scarcity of high Fe-content iron ore needed for DRI and pressure on supply sources
- Limited availability of high-quality, prime scrap for EAF production

Regulatory landscape

Shifting regulations across regions are creating a framework for steel producers to act

There are already a wide range of regional environmental policies and economic instruments that are helping to drive the green steel transition (Figure 3). In addition to stricter regulations, there is a clear trend toward greater transparency and reporting.

Figure 3:
Selection of regional regulations influencing the decarbonization of the steel industry



US: The United States passed the Inflation Reduction Act (IRA) of 2022 that provides more than US$416 billion toward decarbonization and emission reduction technologies, including carbon capture, clean hydrogen, and clean energy.

China: Action Plan For Peaking Carbon Dioxide Emissions Before 2030. In 2021, the ultra-low emission requirement for steel production was implemented. China's iron and steel sector should hit its peak carbon emissions before 2025, and see emissions reduced by 30% by the end of 2030 by adopting measures to reduce outdated capacity, optimize product structure, use additional clean energy, and employ more environmentally-friendly production technologies.

EU: 1. Carbon Border Adjustment Mechanism: ensures that exporters to the EU face the same carbon prices as the EU industry is subject to under the Emissions Trading System (ETS). Free allowances will be gradually phased out.
2. Industrial Emissions Directive (IED): The Act defines specific best alternative technology (BAT)-associated emission levels and standards that the environmental permitting authorities incorporate in operational permits.

India: India's Nationally Determined Commitment under the Paris Agreement commits to a long-term goal of net-zero by 2070. It outlines 50% of installed capacity in power generation from non-fossil fuel-based sources. India implemented a Perform Achieve and Trade (PAT) framework under its National Mission for Enhanced Energy Efficiency (NMEEE) from April 2012. PAT is a regulatory instrument to reduce consumption in energy-intensive industries, with an associated market-based mechanism to trade in energy efficiency certificates. So far, it covers over 160* iron and steel units and achieved a reduction in CO_2 emission intensity from 3.1 to 2.5 tonnes per tonne of crude steel from 2005 to 2020.[3] In January 2021, India also launched a National Green Hydrogen Mission aimed at decarbonizing hard-to-abate sectors, with a targeted green hydrogen production capacity of 5 million tonnes per annum by 2030.
*More plants are added each year as units cross threshold limit of energy consumption. 163 was at the end of 2021.

Customer and market demand

Several leading steel producers have already started to deliver "greener" steels—or steel products with a reduced CO_2 footprint—under a variety of branded names. Such steels are typically focused towards the automotive sector, where there is already a clear appetite from the original equipment manufacturers (OEMs) for such products. The automotive sector represents 16% of global demand for green steel—second only to the construction sector.

Such steels are already being sold at a premium price, indicating a clear opportunity for steel producers to move towards value-based selling of green steels in the future. That said, as of yet there is no clear standard for defining green steel—although progress is being made on this front. The ResponsibleSteel™ organization, for instance, is leading work to create a unified, global, and cross-industry standard and certification program. Such an initiative may help create additional momentum and incentives for steelmakers to bring green steel products to the market.

Key drivers for transformation

A successful green steel transition will require the involvement of multiple stakeholders

To overcome these challenges, players across the steel value chain ecosystem—including those beyond steel producers and the end steel consuming markets—must take steps to support decarbonization (Figure 4). In many cases, this will involve forming a variety of coalitions to help address key decarbonization requirements, such as increasing access to adequate supplies of green hydrogen and high-quality iron ore, to successfully facilitate a green transition.

Those that seize the moment will likely benefit from a growth in market share, long-term market competitiveness and business viability, as well as stronger brand value.

Seizing the opportunities

In the face of growing demand for green steel, particularly in key end-customer segments such as automotive, those steel producers able to make early investments in decarbonization have the potential to become leaders in their respective core market segments.

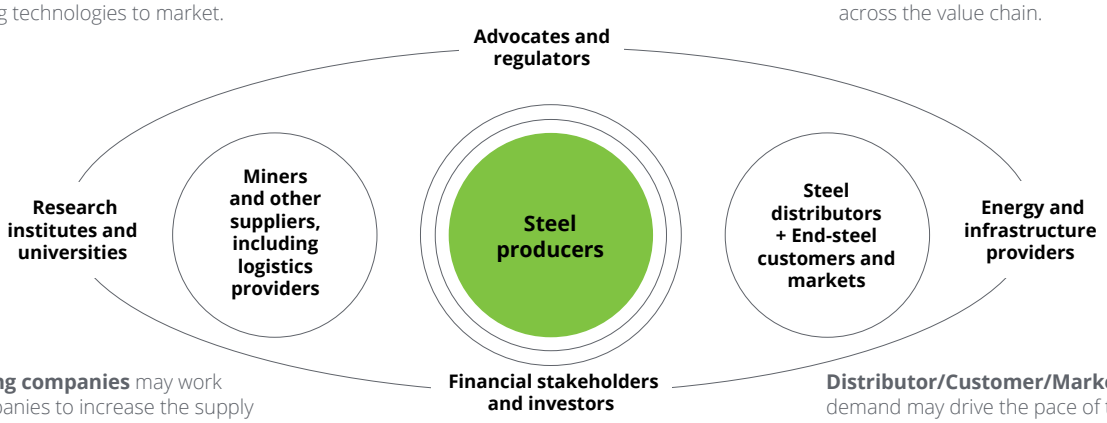
Forward-thinking companies should be able to take advantage of the potential regional funding opportunities available today (both governmental and those established through partnerships and joint ventures), to find the large investments needed to support their transformations. Those that seize the moment will likely benefit from a growth in market share, long-term market competitiveness and business viability, as well as stronger brand value.

Figure 4:
A variety of value chain stakeholders will play key roles in steel decarbonization

Research institutes and universities will continue to play a key role in supporting steelmakers by bringing new steelmaking technologies to market.

Advocates and regulators may help push the green steel transition and bring together stakeholders to create common standards.

Energy and Infrastructure providers will seek to enable collaboration between steel decarbonization business partners across the value chain.



Iron ore mining companies may work with steel companies to increase the supply of high-quality ore and help drive further BF efficiencies.

Investors and governments may help fund steel companies to meet the large capital investments required.

Distributor/Customer/Market demand may drive the pace of the green steel transition, while also focusing on reducing steel intensity in-use (e.g., vehicle lightweighting).

Authors and contacts

This paper is part of a collection of insights on possible pathways to decarbonization for high-impact sectors. Each sector perspective offers a foundational starting point for leaders who would like to better understand the landscape across these critical sectors. For additional sector papers and links to in-depth reports, please visit Pathways to decarbonization on Deloitte.com.

To learn more about how Deloitte can help your business seize this moment—and adopt a proactive approach to decarbonization that offers substantial business benefits and helps shape tomorrow's low-carbon future—contact us.

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Endnotes

1 Ali Hasanbeigi, *Steel Climate Impact - An international benchmarking of Energy and CO_2 intensities*, Global Efficiency Intelligence, 2022 and Deloitte analysis.
2 Julian Somers, *Technologies to decarbonise the EU Steel industry*, Publications Office of the European Union, 2022.
3 PIB Delhi, Indian Steel Industry Reduces its Energy Consumption and Carbon Emissions Substantially with Adoption of Best Available Technologies in Modernisation & Expansions Projects, February 2, 2022.

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