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Steel

Pathways to decarbonization

Envisaging a net-zero green steel value chain

The steel sector produces 7% of industrial emissions globally

Direct CO₂ emissions generated by the approximate 1.9 billion tonnes of global steel sector production in 2020, amounted to 2.6 billion tonnes, representing about 7% of total worldwide industrial emissions, with China being responsible for more than 50% of total emissions (Figure 1) reflecting, in part, China's large share of overall steel production.

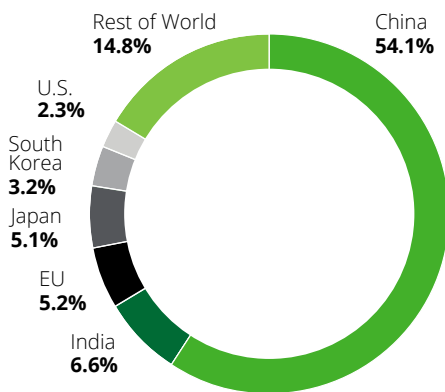


Figure 1: Estimated steelmaking CO₂ emissions per region¹ (2019)

In terms of the starting points for decarbonization, there are significant differences regionally within the steel sector in terms of the CO₂ intensity of steel production (tons of CO₂ per ton of steel), which reflects the mix of different steelmaking technologies being employed. The United States (US) currently has the lowest CO₂ intensity, due to it having the highest share of scrap-based Electric Arc Furnace (EAF) technologies.

In contrast, India and China have the highest CO₂ 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 CO₂ intensity for BF-based steelmaking, through implementing advanced BF technologies, which has successfully reduced emissions by around 50% over the past 50 years.

Emission Sources

From a value chain perspective (Figure 2), the sector's highest source of CO₂ emissions stem from the use of fossil fuels (coal) in coke production and the blast furnace, used to melt iron ore, combined with a BOF (basic oxygen furnace), converting the iron into raw steel (Table 1). On average, approximately 70% of steel is produced globally this way today².

STEELMAKING ROUTE	CO ₂ EMISSIONS (T CO ₂ /T STEEL)
BF-BOF	2.2
Scrap-based EAF	0.3
Natural Gas DRI	1.4

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

Abatement strategies

To achieve net-zero, there are a number of technologies at differing stages of commercial readiness being evaluated by steel producers (Table 2). Ironmaking using hydrogen-based direct reduced iron production is seen as one of the primary approaches to help companies achieve their goals.

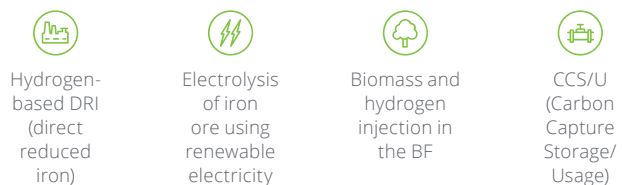


Table 2: Examples of (new) decarbonization technologies being evaluated by steelmakers

These technologies are in addition to the opportunity to lower emissions through the increased usage of recycled scrap steel, melted via the EAF steelmaking process.

In addition, companies are also evaluating the different country/region specific cost dynamics associated with renewable energy and green hydrogen, which may impact the distribution of key parts of steel value chains in the future.

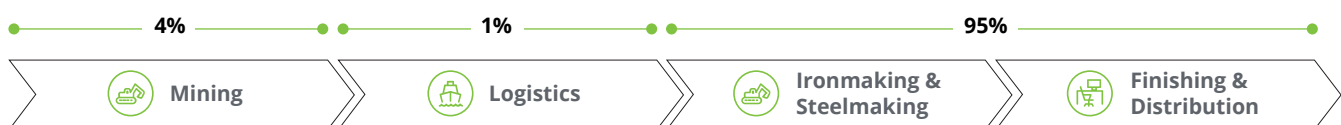


Figure 2: Proportion of emissions per stage of the steelmaking value chain

¹ Global Efficiency Intelligence, Steel Climate Impact - An international benchmarking of Energy and CO₂ intensities, 2022 and Deloitte analysis.

² European Commission, Technologies to decarbonise the EU Steel industry, 2022.

Implementing a net-zero value chain

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

Companies in the steel sector have widely committed to the Paris Agreement goal to limit global warming to 1.5 degrees Celsius, with clear commitments to achieve significant reductions already by around 2030. These reduction commitments typically range from between 30% to 40% of emissions, when 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).

Whilst to achieve these targets, steel producers can make incremental reductions in emission levels through improvements to existing production technologies (such as installing top pressure recovery turbines on a blast furnace) and process improvements (such as enhanced digital predictive process control and monitoring), it may be necessary for most companies to change currently established methods used for primary steel production.

A pathway to net-zero: current challenges

Having established ambitious emission targets, some steel producers have already started making the transition, with a wide variety of different investments in technologies. However, there are still a large number who still find themselves at the beginning of their transformation journey. Whilst basic necessary conditions for transformation have been set and technology options have been identified, the industry faces a number of key implementation issues.



Technology maturity and skills

- Young age of existing steelmaking assets
- 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

- Demand for green steel from region/industry is variable
- Significantly higher "green premium" price of low-carbon steel will be a challenge to get accepted
- The (continued) speed of industrialization of China, plus 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 may provide a level 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 frameworks vary regionally

Regulations across different regions are creating a framework for steel producers to act

The steel industry is already facing 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.

Customers and markets are creating demand for green steel

A number of leading steel producers have already started to deliver reduced CO₂ footprint steels to the market under a variety of branded names. Such steels are typically focused towards the automotive sector—representing the second largest steel consuming segment after construction, at roughly

16% of global steel demand—where there is already a clear appetite from the original equipment manufacturers (OEMs) for such products.

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.

Despite there currently being no clearly agreed standard for how to define what green steel is, progress is being made. The ResponsibleSteel™ organization 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.

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

EU: 1. Carbon Border Adjustment Mechanism - Ensure that exporters to the EU face the same carbon prices as EU industry is subject to under the ETS. Free allowances will be phased out gradually. 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.

CHINA: Action Plan For Peaking Carbon Dioxide Emissions Before 2030. In 2021, the ultra-low emission requirement for steel production was implemented within the sector. China's iron and steel sector should hit its peak carbon emissions before 2025. By the end of 2030, the sector's carbon emissions should be reduced by 30% from the peak in 2025. The sector was required to adopt a series of measures, such as the reduction of outdated capacity, the optimization of product structure, to utilize more clean energy, and the employment of more environmentally friendly production technologies, to achieve the abovementioned goals.

INDIA: India's Nationally Determined Commitment under 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. It so far covers over 160* iron and steel units and achieved a reduction in CO₂ emission intensity from 3.1 to 2.5 tons/tons of crude steel from 2005 to 2020**. 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 tons per annum by 2030.

*More plants keep getting added each year as units cross threshold limit of energy consumption. 163 was at end of 2021.

**<https://pib.gov.in/PressReleaseframePage.aspx?PRID=1794782>

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

³ Government of India, Energy and Environment management in the iron and steel sector, accessed December 2022

Many different stakeholders in the steel value chain will play key roles

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

Many different players in the steel value chain ecosystem—beyond steel producers and the end steel consuming markets—will play a valuable role in enabling decarbonization (Figure 4). A successful green steel transition will require a variety of coalitions to be formed, that may help address key decarbonization requirements, such as access to adequate supplies of green hydrogen and high-quality iron ore, among others.

Early focus on a decarbonization transition offers opportunities

Based on an expected growing demand for green steel in key steel end-customer segments such as automotive, steel producers that are able to make early investments in decarbonization to produce green steel should see opportunities to build an early, leadership position in their core market segments and potentially grow market share. Such a transition should also help producers support long-term market competitiveness and business viability, as well as establish stronger brand value.

Furthermore, early moves by steel companies will enable them to take advantage of potential funding opportunities (both governmental and those established through partnerships and joint ventures), which will help to address the challenge of finding the large investments needed for a complete industry transformation.

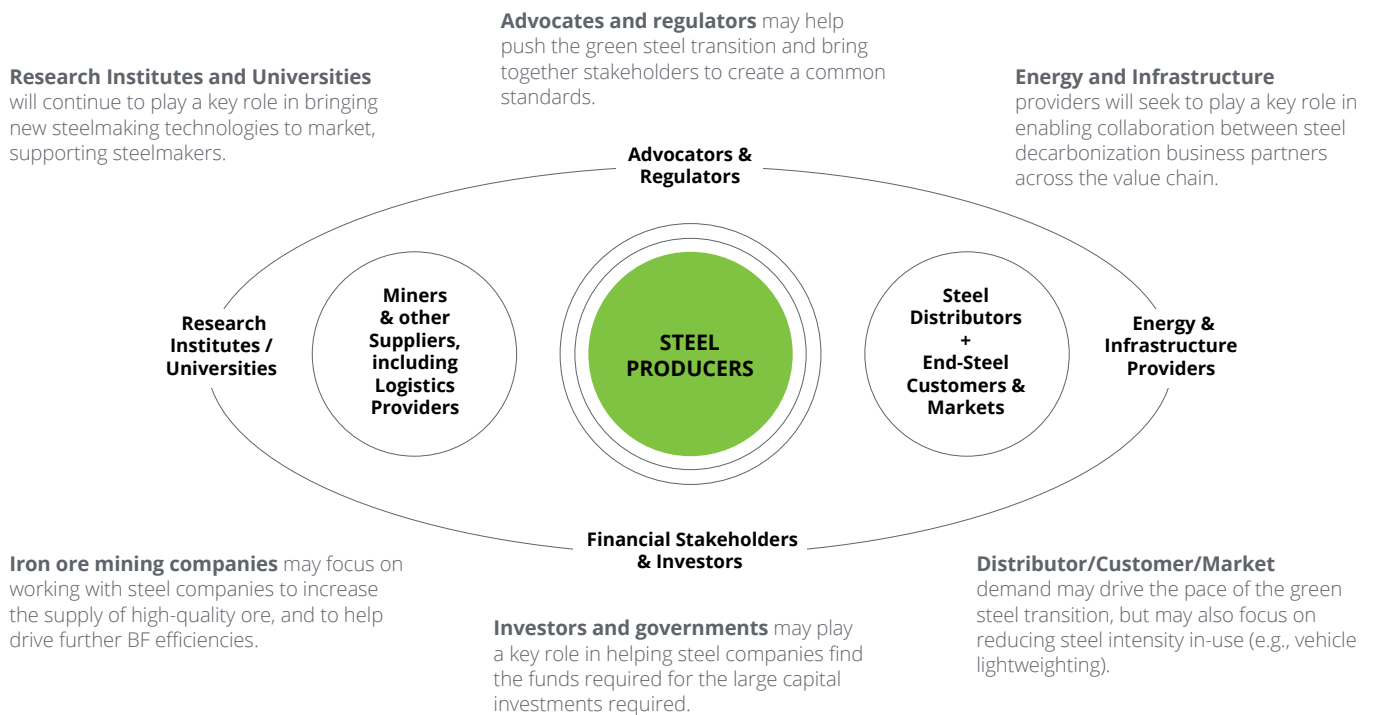


Figure 4: A variety of value chain stakeholders will play key roles in steel decarbonization

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