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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 CO_2 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.

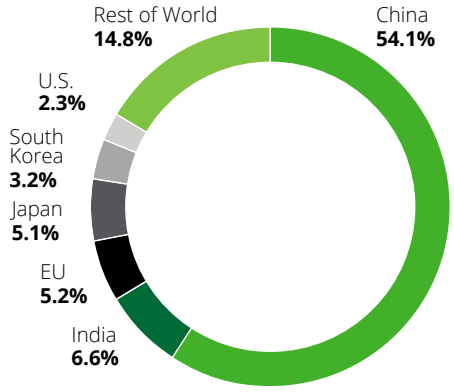


Figure 1: Estimated steelmaking CO_2 emissions per region[1] (2019)

In terms of the starting points for decarbonization, there are significant differences regionally within the steel sector in terms of the CO_2 intensity of steel production (tons of CO_2 per ton of steel), which reflects the mix of different steelmaking technologies being employed. 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.

Emission Sources

From a value chain perspective (Figure 2), the sector's highest source of CO_2 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 today[2].

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.

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

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.

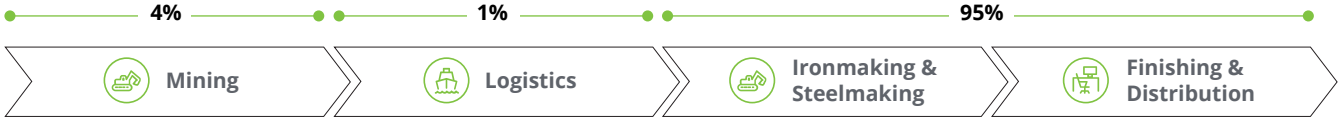


Figure 2: Proportion of emissions per stage of the steelmaking value chain

[1] Global Efficiency Intelligence, Steel Climate Impact - An international benchmarking of Energy and CO_2 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

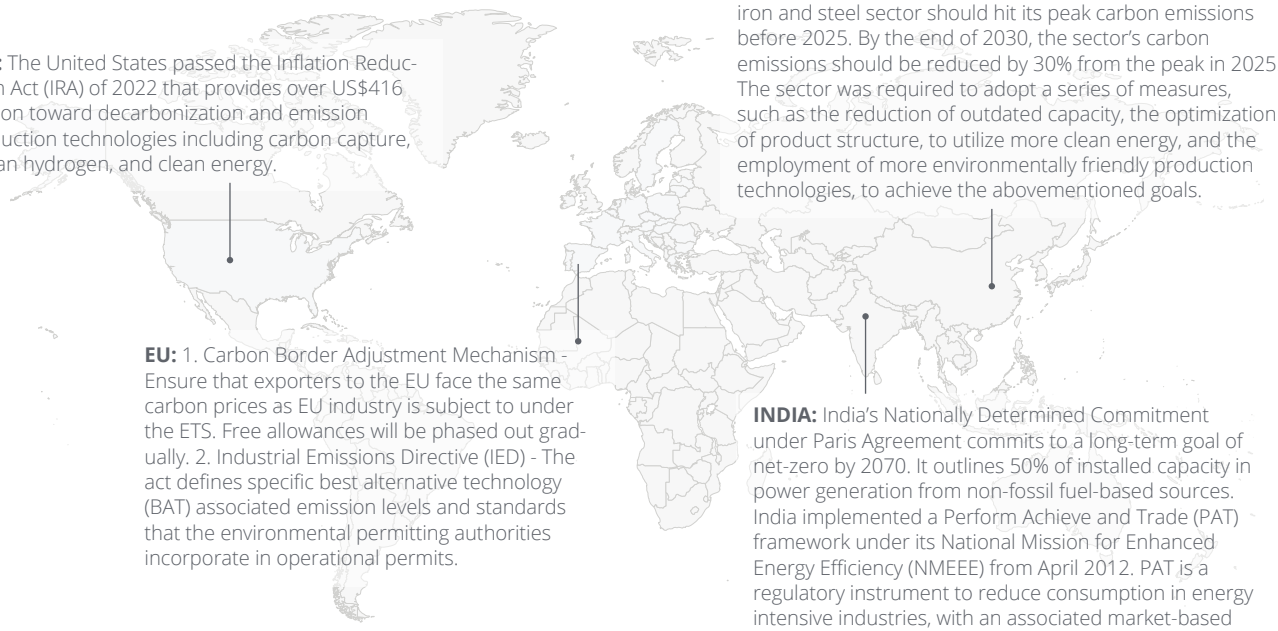
The steel industry is already facing a wide range of regional environmental policies and economic instruments that are helping to drive the green steel transition (Figure 3). In addition to stricter regulations, there is a clear trend toward greater transparency and reporting.

Customers and markets are creating demand for green steel

A number of leading steel producers have already started to deliver reduced CO_2 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.



*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/PressReleaseIframePage.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

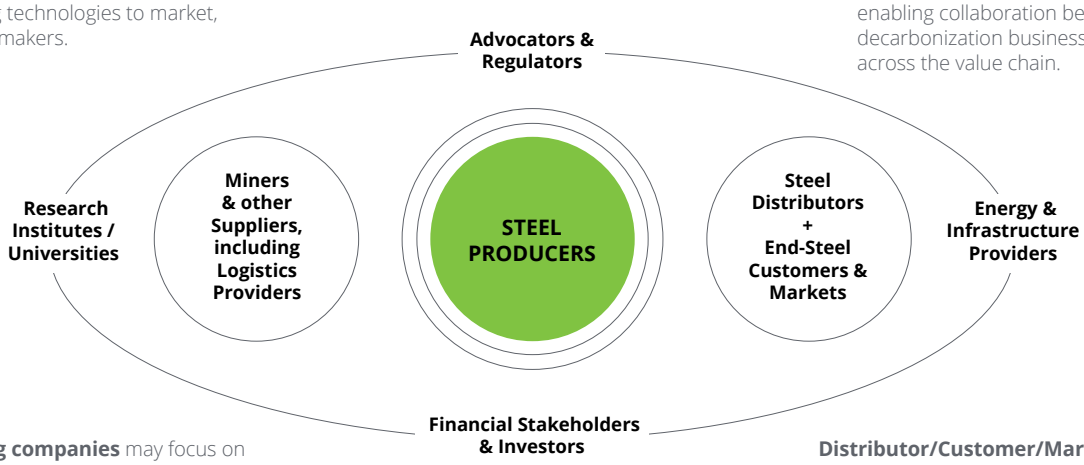
Based on an expected growing demand for green steel in key steel end-customer segments such as automotive, steel producers that are able to make early investments in decarbonization to produce green steel should see opportunities to build an early, leadership position in their core market segments and 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.

Research Institutes and Universities will continue to play a key role in bringing new steelmaking technologies to market, supporting steelmakers.

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

Energy and Infrastructure providers will seek to play a key role in enabling collaboration between steel decarbonization business partners across the value chain.



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

Investors and governments may play a key role in helping steel companies find the funds required for the large capital investments required.

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

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

Authors

Dr. Andrew Zoryk
Director
azoryk@deloitte.de

Ian Sanders
Partner | Mining & Metals leader
iasanders@deloitte.com.au

Deloitte.