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Decarbonising Indian steel industry: Recent trends

Contents

Acknowledgment[1]

This report is a small cog in the wheel of energy transition. However, it provides a sense-check of the early trends in India with respect to the efforts being made to decarbonise this hard-to-abate sector. This report has been developed with support from the members of Alloy Steel Producers Associations of India (ASPA) and Sponge Iron Manufacturing Association of India (SIMA). We thank the leadership of ASPA and SIMA for extending their support. India is the second largest producer of steel in the world with only China ahead. In FY23, India's steel sector saw a growth of 6%, which was highest across the major steel-producing countries. Steel sector is one of the major drivers for the Indian economy, contributing 2% to the country's GDP and providing employment to 2.5 million people in the steel and related sectors. Today, India has operating capacity of 161 million tons. India is also the largest producer of sponge iron across the world. India's per capita steel consumption increased from 57.8 kg in 2013-14 to 81 kg in FY23 and is planning to achieve 160 kg by 2030-31 and 220 kg by 2047. As per Ministry of Steel, India has set a target of 300 million tons crude steel capacity by FY31 and 500 million tons by FY2047.

The Government of India committed to achieve Net Zero by 2070 at the 26th session of the Conference of the Parties (COP26) to the United Nations Framework Convention on Climate Change (UNFCCC) held in Glasgow, United Kingdom. Aligning with India's commitment, the Ministry of Steel has also committed to decarbonise the steel sector and various focus areas have been identified in this regard. The Ministry has set a target to reduce carbon emission from steel section by 20% by 2030, 50% in the medium term by 2047 and Net Zero in the long term by 2070. The major focus will be on promotion of energy and resource efficiency and greater use of renewable energy in the short term. For the medium term (2030-47), green hydrogen based steel making and carbon capture, utilisation and storage are the focus areas. For the long term (2047-70), disruptive alternative technological innovations can help achieve the transition to net-zero.

This report has been developed to showcase the status of the iron and steel sector in India with respect to decarbonisation and various steps taken by multiple companies to reduce carbon emission and achieve their respective net zero target. The report also highlights the various commitments made by major steel-producing countries along with key emerging technologies and their significance in making low emission or green steel in India.

Multiple stakeholders from across the steel value chain were interviewed during the preparation of this report. We would like to thank experts from the steel sector who provided their valuable suggestions and priority for the sector. We also acknowledge the support provided by TAFCON in organising the event and thereby providing a platform for interaction with industry participants.

Through this report, we would like to bring attention of Steel producers and various policy makers to understand the early challenges being faced by the Indian steel sector so that action can be taken to achieve the target of net zero carbon emission by 2070 or before.

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[1] Sources for the data mentioned in acknowledgment have been provided in the subsequent sections. Kindly refer to the main report for detail analysis and sources.

01

Introduction

Steel, the alloy of iron and carbon, is a cornerstone of modern industrial societies, used extensively in construction, manufacturing, and infrastructure. The global steel industry is not only a significant economic driver but also one of the largest industrial sources of CO^2 emissions. This duality underscores the urgent need for strategies to reduce the carbon footprint of steel production. With an increasing share of global steel expected to come from rapidly developing nations like India, the challenge of decarbonisation becomes both more urgent and complex. This section of the report seeks to highlight the importance of steel in the global economy, understand its environmental impact, and explore the specific context of the Indian steel industry.

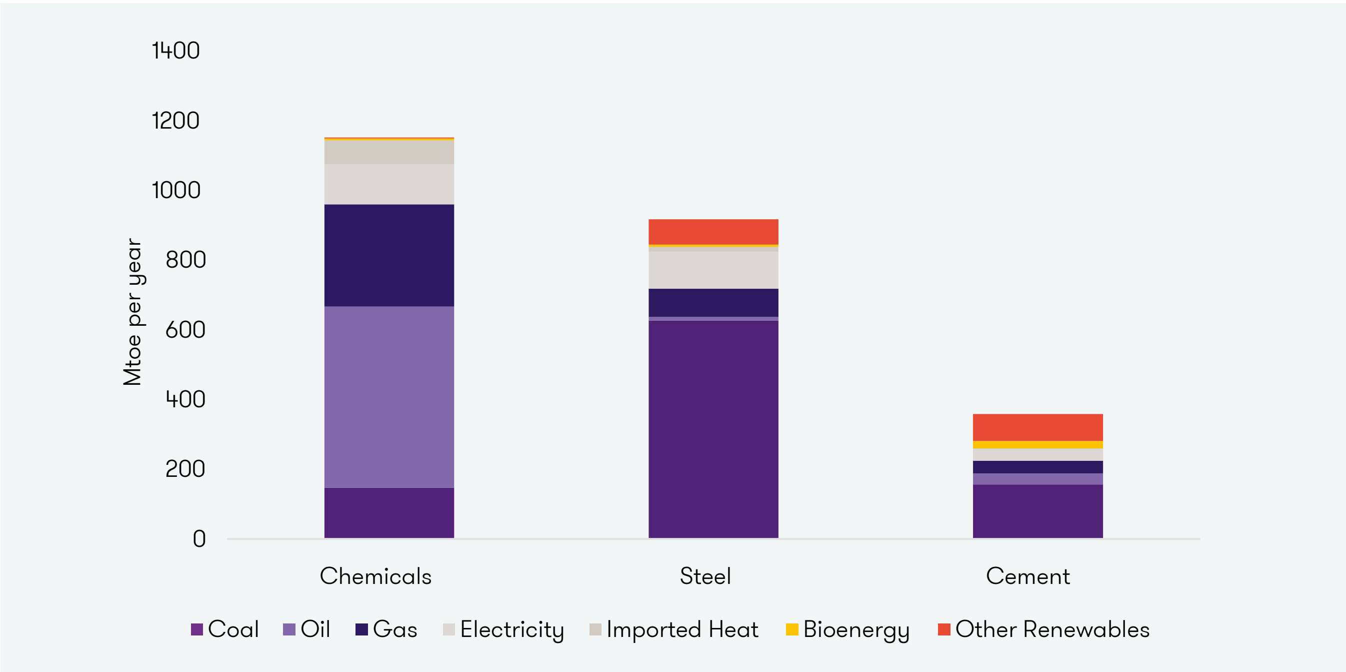
The importance of steel in the global economy

Steel is the third most produced man-made material on earth, offering strength, recyclability, and durability. Directly employing around six million people, the global steel sector generates approximately USD 2.5 trillion in revenue, signalling its immense economic significance [2].

Steel's demand is projected to rise, especially in emerging economies experiencing population growth and increasing economic welfare. Additionally, steel is crucial for the clean energy transition, forming an essential component of wind turbines, power plants, and electrical transmission infrastructure.

Global demand for steel is projected to increase by more than a third through 2050 [3]. After the pandemic slump, the steel sector is returning to a robust growth trajectory in baseline projections. The steel sector is currently the largest industrial consumer of coal, which provides around 75% of its energy demand [4]. Without targeted measures to reduce demand for steel where possible, and an overhaul of the current production fleet, CO^2 emissions are projected to continue rising.

Energy demand of heavy industry sectors by fuel, 2019[5]



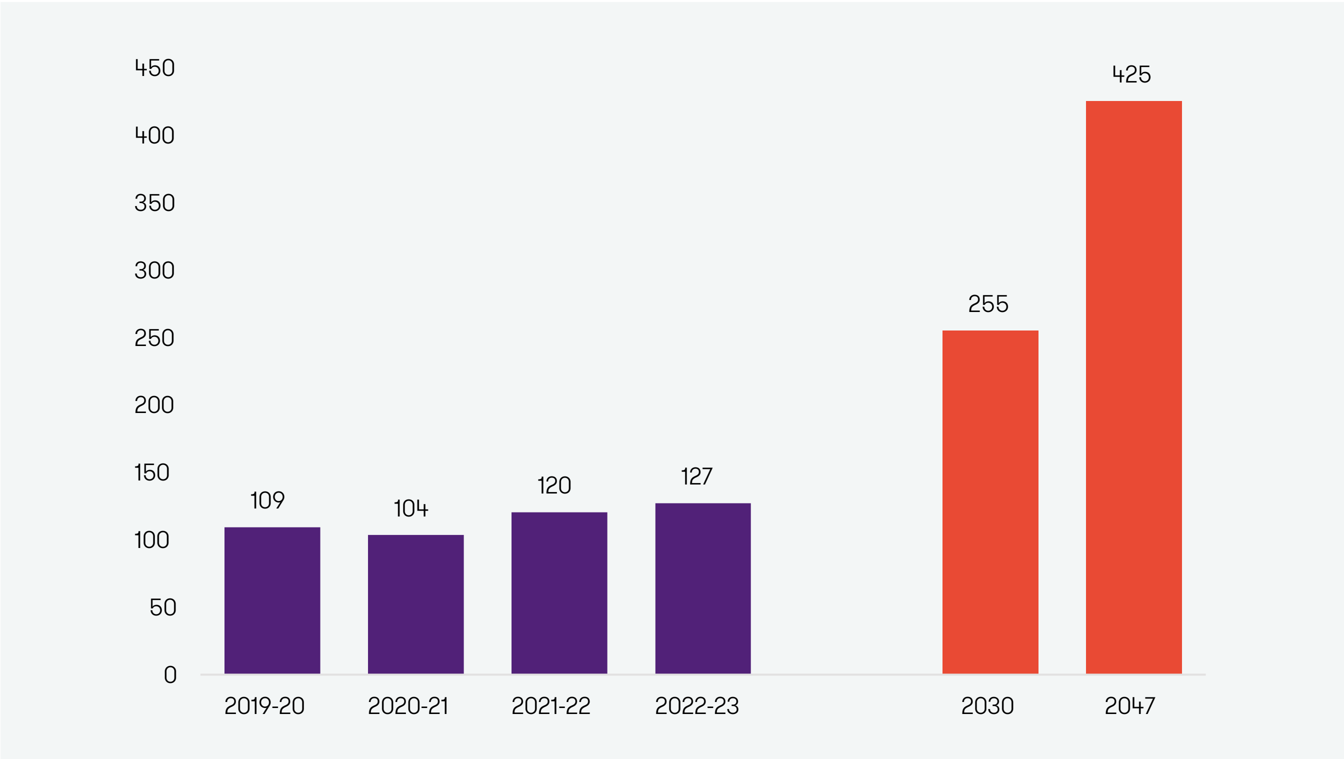
[2] World Steel Association
[3] Iron and Steel Technology Roadmap. IEA, 2020
[4] Iron and Steel Technology Roadmap. IEA, 2020
[5] Iron and Steel Technology Roadmap. IEA, 2020

Indian steel industry: Overview

India's steel industry has been an integral part of its economic fabric contributing approximately 2% to the national GDP[6]. From FY2020 to FY2023, crude steel production grew at a CAGR of 5.7%, reaching 127 million tonnes [7], despite a setback in FY2021 due to the pandemic. As per World Steel Association, India is currently the second largest producer and consumer of steel [8]. The industry's growth is propelled by increasing demands from urban infrastructure, government housing projects, and automotive sector. The steel sector is indispensable to India's growth aspiration.

As per Ministry of Steel, India has set a target to achieve 300 million tons crude steel capacity by FY2031 and 500 million tons by FY2047. Considering 85% capacity utilisation, steel production is poised to grow to 255 million tons and 425 million tons in FY2031 and FY2047, respectively [9].

India's crude steel production[10]

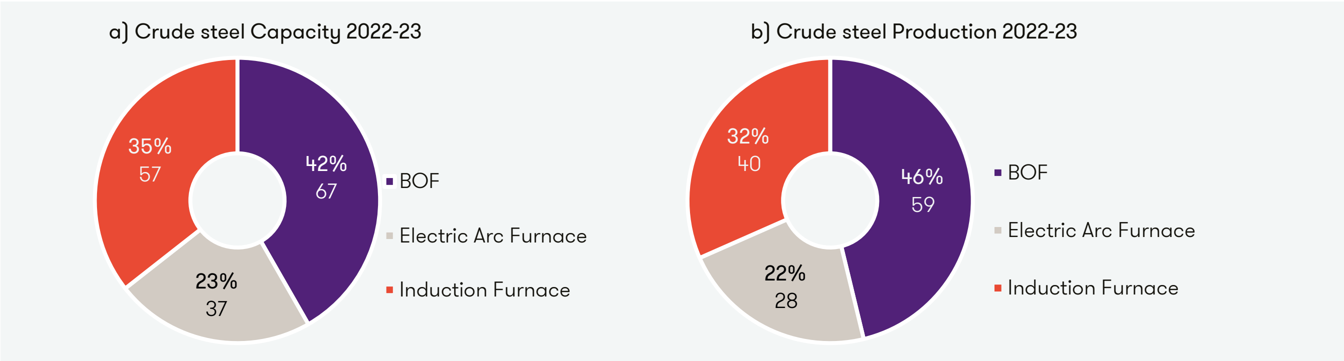


[6] Will Hall, Sachin Kumar, Sneha Kashyap, Shruti Dayal. 2022. Achieving Green Steel: Roadmap to a net zero steel sector in India. New Delhi: The Energy and Resources Institute (TERI)
[7] JPC Annual Statistics 2022-23
[8] 2023 World Steel in figures; World Steel Association
[9] JPC Annual Statistics, 2022-23; National Steel Policy, 2047; "Making India Atmanirbhar in Steel – Role of Secondary Steel Sector", PIB dated 27 Mar 2022 with assumption of 85% capacity utilisation of steel plants.
[10] JPC Annual Statistics, 2022-23; National Steel Policy, 2047; "Making India Atmanirbhar in Steel – Role of Secondary Steel Sector", PIB dated 27 Mar 2022 with assumption of 85% capacity utilisation of steel plants.

Indian steel sector has high share of electric furnace (including EAF and IF). In FY23, India's total steel capacity stood at 161 million tons out of which share of BOF was 42% while the rest 58% was of electric furnace (EAF ~ 23%, IF ~ 36%)[11].

However, capacity utilisation of electric plants is lower than BOF plants, which has led to increase in the share of BOF in overall production to 46%[12].

Route wise capacity & production of crude steel in 2022-23



India's use of sponge iron in EAF is high in comparison to other countries and use of coal based DRI process is unique to Indian steel sector. This is mainly due to availability of relatively cheap domestic coal and non-availability of coking coal in sufficient quantity. Also, non-availability of natural gas at an economic price, has not encouraged gas based DRI. DRI is being used extensively in EAF and IF route along with steel scrap.

However, use of DRI in induction-furnace based plants lead to production of lower quality steel as removal of residual phosphorus is not possible unlike in case of EAF and BOF. This is also one of the reasons that despite many induction furnaces in the country, majority of new steel capacities are based on BF-BOF route as focus on quality goes up.

[11] JPC Annual Statistics, 2022-23
[12] JPC Annual Statistics, 2022-23

02

Climate change and global responses

The steel industry, integral to the modern economy, faces profound challenges in the context of global climate change. Indian steel plants use coking coal for reduction whereas they use thermal coal / steam coal for captive power generation. Recognising the industry's substantial and hard-to-abate carbon footprint, this section emphasises pivotal international agreements and commitments, notably those established in the Conference of the Parties (COP) summits from COP21 through COP26. Understanding these agreements is critical for the steel industry to align its carbon minimisation strategies with global climate objectives.

The Intergovernmental Panel on Climate Change (IPCC) asserts that human activities are unequivocally driving climate change, primarily through CO^2 emissions from fossil fuel usage. This has led to significant global warming, with severe consequences including extreme weather events, sea-level rise, and biodiversity loss. The international community has responded through collaborative efforts under the United Nations Framework Convention on Climate Change (UNFCCC), aiming to mitigate these impacts by reducing greenhouse gas (GHG) emissions globally.

COP is the principal governing entity of UNFCCC, consisting of delegates from every country that has signed on (or become 'Parties') to the UNFCCC. Its role involves evaluating the outcomes of the actions undertaken by the Parties to curtail climate change, ensuring they align with the overarching objectives of the UNFCCC. Decarbonising the steel sector is crucial for meeting global climate targets. This ambition is prominently reflected in the resolutions from COP21 through COP26. These conferences have cumulatively applied pressure on industries, including steel, to commit to a low-carbon future.

COP21

The 2015 COP21 summit in Paris marked a significant turn in the global approach to climate issues. The conference culminated in the Paris Agreement, wherein participants agreed to endeavour to confine global warming to a maximum of 1.5°C - 2°C above pre-industrial averages (UNFCCC, 2015). A key element of this agreement is the Nationally Determined Contributions (NDCs), through which nations declare their own customised plans and objectives for reducing emissions. This strategy encourages worldwide cooperative efforts, tailored to each country's unique situation. For major industries such as steel, the message is unequivocal: achieving notable cuts in carbon emissions is imperative to meet both national and international climate pledges [13].

COP22 to COP25

In the conferences succeeding COP21, the focus was on propelling the objectives set forth in Paris. During COP22 in Marrakech in 2016, the conversation centred around the vital role of financial backing for climate initiatives, especially for underdeveloped countries, while laying the groundwork for the rulebook of the Paris Agreement (UNFCCC, 2016). The following conference, COP23, in Bonn in 2017, under Fiji's leadership, highlighted the necessity for building climate resilience and the immediate need for assistance for nations most susceptible to climate-related disasters (UNFCCC, 2017).

COP24 in Katowice in 2018 was a pivotal event with the introduction of the Katowice Rulebook, offering a detailed guide for the execution of the Paris Agreement, which included aspects of transparency, adaptation, emission curtailments, and financial contributions (UNFCCC, 2018). Subsequently, COP25 in Madrid in 2019 underscored the urgency for heightened ambition within NDCs and launched critical discussions regarding carbon trading systems, an essential consideration for various sectors, steel included, in their efforts to balance out emissions (UNFCCC, 2019).

[13] Britannica, The Editors of Encyclopaedia. "Paris Agreement", 17 Oct. 2023

COP26 [14]

The COP26 conference, which took place in Glasgow in 2021, was of paramount importance, calling for the realisation of the targets established in Paris. Notable developments comprised enhanced reduction commitments from various nations, declarations to eliminate coal usage, and augmented financial aid for climate change adaptation and countermeasures in developing nations. Of particular importance to the steel industry was the accelerated shift towards adopting environmentally friendly technologies and the prioritisation of partnerships between governmental bodies and commercial sectors to pioneer and apply solutions for diminishing carbon output. Post COP21, signatory nations have greater clarity over their bureaucratic expectations and financial obligation. COP26 made nations agree to the contentious Article VI, known as 'Loss and Damages'. It is also the first COP to mention specific types of power generation. Along with China, India pushed for 'phase-down' of coal-fired power generation. Amongst the several important deliberations, following were most prominent:

1. **The Glasgow Agenda:** It is the commitment by 40+ governments to promote clean energy and reduce emissions in most polluting industries – steel, hydrogen, energy, and transport.
2. **Global Coal to Clean Energy Transition:** It is a global pact supported by 40+ countries to eliminate use of coal in the main economies by 2030 and developing countries by 2040.
3. **The Global Methane Pledge:** It is a pledge to reduce their methane emissions by 30% by 2030 agreed by 100 countries. This is in line with latest IPCC report that 30-40% of increase in temperatures is due to greenhouse gases.
4. The UK, UAE, India, Germany, and Canada and have committed to support new markets for low carbon steel, cement, and concrete. They have pledged to achieve net zero in major public construction steel and concrete by 2050.

COP27 [15]

COP27, hosted in Sharm El Sheikh in 2022, marked a pivotal shift in the global climate change dialogue. Led by Egyptian Minister of Foreign Affairs, Sameh Shoukry, this summit saw over ninety-two heads of state and 35,000 delegates collaborating on tangible climate action. Unlike previous conferences which focused on formulating plans, COP27 emphasised 'every corner of human activity' aligning with the 1.5°C target, as highlighted by the UN Climate Change Executive Secretary, Simon Stiell.

One of the most significant accomplishments of COP27 was the agreement on funding for countries severely impacted by climate disasters. This decision recognised the necessity of financial support to address climate-related losses and damages. Moreover, the conference saw countries reaffirm their dedication to limiting the global temperature rise to 1.5°C above pre-industrial levels and underlined the importance of renewable energy sources in the fight against climate change.

Furthermore, finance emerged as a crucial topic, with the Sharm el-Sheikh Implementation Plan outlining the need for an annual mobilisation of USD 4-6 trillion for a successful transition to a low-carbon economy.

[14] Conclusions from COP26: The challenge of doing away with coal. Sustainability for all.
[15] Five key takeaways from COP 27, UNFCCC; last accessed on 01-Nov-2023

Country-specific declarations [16]

This section delves into the commitments made by the top five steel-producing countries – China, India, Japan, the United States, and Russia – in the COP21 through COP26 conferences and analyses their implications on the iron and steel sector in three primary dimensions: financial, sustainability, and health and safety

China

As the world's largest steel producer, China's climate pledges significantly influence the steel industry. At COP21, China committed to peaking CO^2 emissions by 2030, with efforts to peak earlier, and to reduce CO^2 emissions per unit of GDP by 60-65% from 2005 levels (UNFCCC, NDCs, 2015). In COP26, China reiterated its pledge to reach carbon neutrality by 2060, significantly impacting its iron and steel sector (COP26, 2022). During this period, Chinese induction furnace industry has seen strict closures due to environmental reasons.

India

India, the second-largest steel producer, declared its intention to reduce the emissions intensity of its GDP by 33-35% by 2030 from 2005 levels at COP21 (UNFCCC, NDCs, 2015). At COP26, India made a commitment to achieve net-zero emissions by 2070, an ambitious goal for its rapidly expanding steel industry (COP26, 2022). At the event, the Government of India presented five nectar elements *(Panchamrit)* of India's climate action plan:

a. Reach 500GW non-fossil energy capacity by 2030.

b. 50% of its energy requirements from renewable energy by 2030.

c. Reduction of total projected carbon emissions by one billion tonnes from now to 2030.

d. Reduction of the carbon intensity of the economy by 45% by 2030, over 2005 levels.

e. Achieving the target of net zero emissions by 2070.

Japan

Japan committed to an emissions reduction of 26% by 2030 based on 2013 levels at COP21 (UNFCCC, NDCs, 2015). In COP26, Japan pledged a 46% reduction by 2030 from 2013 levels and net-zero emissions by 2050. This has profound implications for its technologically advanced steel sector, pushing for rapid decarbonisation (COP26, 2022).

United States

The U.S., under different administrations, has had varying climate commitments. Initially, it aimed for a 26-28% reduction in emissions by 2025 from 2005 levels at COP21 (UNFCCC, NDCs, 2015). Re-joining the Paris Agreement in 2021, the U.S. pledged to reduce emissions by 50-52% by 2030 from 2005 levels at COP26, necessitating substantial transitions in its steel industry (COP26, 2022).

Russia

Russia pledged a 25-30% reduction of emissions by 2030 from 1990 levels, declared during COP21 (UNFCCC, NDCs, 2015). Russia did not significantly update its pledge in subsequent conferences, including COP26, leaving its heavily carbon-dependent steel industry with fewer immediate regulatory pressures for decarbonisation (COP26, 2022).

[16] COP21, Paris Agreement under the United Nations Framework on Climate Change, Paris Climate Agreement by The Editors of Encyclopaedia Britannica last updated on 31-Oct-23

03

Emission from steel industry

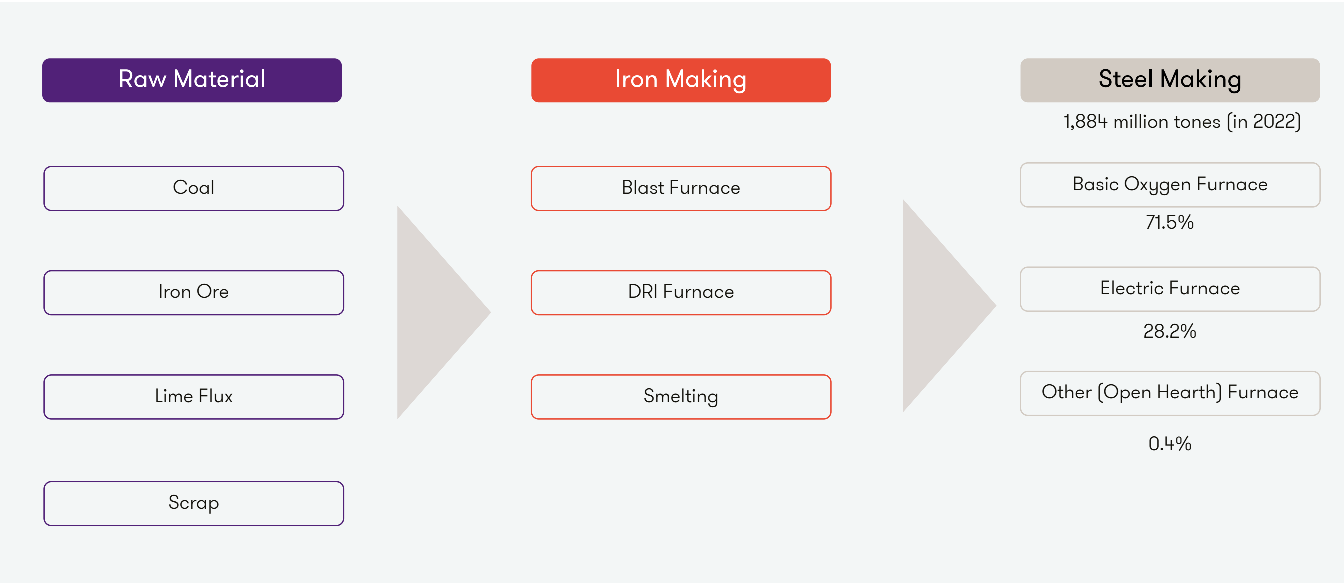
Steel production technology and its environmental impact

To understand the emission from the steel sector, one needs to understand the various technology pathways through which steel is being produced. Conversion of iron ore to iron and subsequently into steel is often referred to as primary steel production, whereas use of scrap or mixture of iron and scrap is referred as secondary steel production. However, in current times, this distinction between primary and secondary has become less clear, as scrap is being increasingly used to improve metallic output. The main two routes for steel production in India are:

Route 1: Integrated steel making which is based on blast furnace (BF) and basic oxygen furnace (BOF) and utilises Iron ore as primary raw material along with Coal as reducing agent, limestone, and recycled steel. As per WSA, globally average of 1.37 ton of iron ore, 0.78 ton of metallurgical coal, 270 kg of limestone and 125 kg of recycled steel is required to produce one ton of crude steel [17] . The specific consumption of Iron ore as raw material in India in primary route is much higher due to lower use of scrap. In India, average of 1.5 – 1.7-ton iron ore is required to produce one ton of crude steel.

Route 2: The secondary steel producers use electric arc furnace (EAF) route that utilises recycled steel and direct reduced iron (DRI) or hot metal, and electricity for production of crude steel. As per WSA, the recycled steel-EAF route typically uses 0.71 ton of recycled steel, 0.59 ton of iron ore, 150 kg of coal and 88 kg of limestone and 2.3 GJ of electricity, to produce one ton of crude steel [18]. However, scrap availability is a perennial issue in India.

Global Steel production pathway [19]



Note: Electric furnace includes both EAFs and induction furnaces; blast furnace input into EAFs are less common. Crude steel production quantity and route wise percentage based on World Steel Association

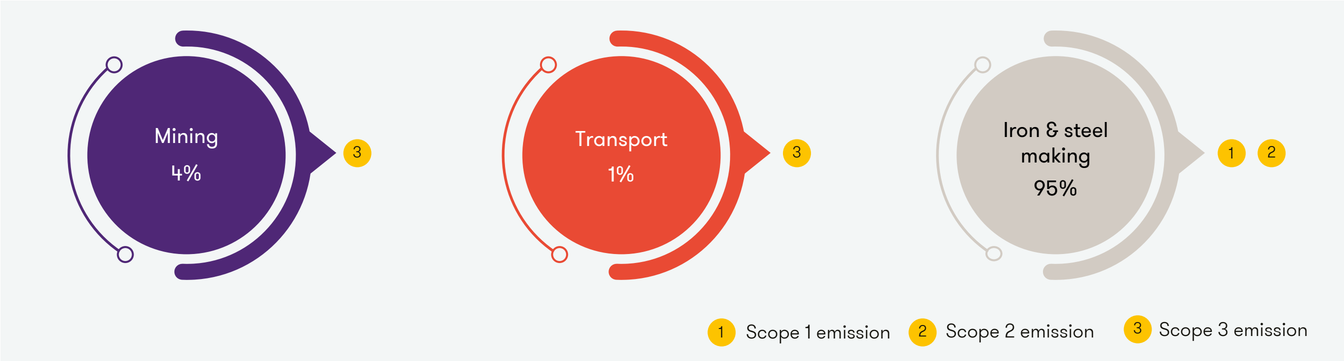
As per world steel estimates, global steel industry used 2.3 billion tonnes of iron ore, 1.1 billion tonnes of metallurgical coal and 680 million tonnes (Mt) of recycled steel to produce 1.95 billion tonnes of steel in 2021 [20].

The iron and steel sector are highly energy consuming and high emissions industry. It accounts for 8% of global energy use and 7% of direct CO_2 emissions and 3% indirect CO_2 emission[21,22] (IEA, 2020). In India, total CO_2 emissions from this sector is 250 MtCO_2 which is around 10% of total emission and this will further increase to 800 MtCO_2 by 2050, if no concerted action to decarbonise is taken [23].

Iron and steel production alone is responsible for around 95% of overall emissions in the Iron and Steel value chain, from mining to steel making [24].

[17] World steel calculation, 2018; Steel and raw materials fact sheet, world steel association
[18] World steel calculation, 2018; Steel and raw materials fact sheet, world steel association
[19] Reproduced from Iron and Steel Technology roadmap, IEA 2020
[20] Steel and raw materials fact sheet, world steel association
[21] Will Hall, Sachin Kumar, Sneha Kashyap, Shruti Dayal. 2022. Achieving Green Steel: Roadmap to a net zero steel sector in India. New Delhi: The Energy and Resources Institute (TERI)
[22] Decarbonising Steel: forging new paths together
[23] Will Hall, Thomas Spencer, Sachin Kumar. 2020. Towards a Low Carbon Steel Sector: Overview of the Changing Market, Technology and Policy Context for Indian Steel. New Delhi: The Energy and Resources Institute (TERI)
[24] Decarbonising Steel: forging new paths together

Iron and steel value chain



Total Scope 1 & 2 emission from Iron and steel industry are mainly due to high dependency of BF-BOF process on coking coal, for iron making. Around 90% of total emission is from BF-BOF process while remaining 10% are from scrap-EAF and NG DRI-EAF [25]. The emission from EAF process is lower than BF-BOF due to removal of Iron making step from Iron ore but there is shortage of scrap availability across world.

As per world steel association, every tonne of steel produced globally led to the average emission of 1.91 tonnes of CO^2 into the atmosphere [26]. This emission varies between 0.67 to 2.32 ton CO^2 per ton of crude steel cast depending upon the route used for steel production. Detail route wise emission are given in the table:

Route wise global CO^2 emissions and share in overall crude production (in 2021) [27]

Route used	CO^2 emission intensity (Tonnes CO^2 per ton of crude steel cast)	Share in overall crude steel production
BF-BOF	2.32	71%
Scrap-EAF	0.67	22%
DRI-EAF	1.65	7%
Global average	1.91	100%

[25] Decarbonising Steel: forging new paths together
[26] (2022) Sustainability performance of the steel industry 2003-2021, World Steel Association
[27] Sustainability performance of the steel industry 2003-2021, December 2022; world steel association

If we compare the Indian Steel companies' emission vs global average emission for BF-BOF, it lies in fourth quartile of global CO2 emission curve. The average emission for top 5 Indian steel manufacturers varies from 2.5 to 2.8 tCO2/MT of crude steel against global average of 2.32 tCO2/MT of crude stee [28].

In 2022, 1.87 billion tonnes of crude steel were produced. The blast furnace-basic oxygen furnace (BF-BOF) route, which accounts for 71% of production, is particularly emissions-intensive. Transitioning to sustainable steel production necessitates a reduction of these emissions, aligning with global climate goals requiring a minimum 50% reduction in emissions from the steel industry by 2050 [29].

Nonetheless, the environmental impact of this expansion cannot be overlooked. The steel industry in India accounts for roughly 12% of its total CO^2 emissions, registering an average emission intensity of 2.6 tonne of CO^2 per tonne of crude steel in comparison to 1.91 tCO^2/TCS globally [30]. The infrastructure proposals from India's 2023 Union Budget, which aim to double steel production, may exacerbate these emissions. Without transitioning to eco-friendly production techniques, emissions from this sector could potentially double, risking India's commitments made during COP26. Green steel mission envisages reduction of CO^2 emission intensity by 20%, 50% and 100% by 2030, 2047 and 2070, respectively. It is envisaged to reduce the CO^2 emission intensity from 2.6 tCO^2/TCS to 1.3 tCO^2/TCS by 2047 [31].

However, initiatives such as Carbon Border Adjustment Mechanism (CBAM) will influence steel exports to the European Union. As per ICRA, CBAM is projected to influence 15% to 40% of India's yearly steel exports to Europe. CBAM may substantially reduce the profit margins of Indian steel exports to the European Union (EU) by an estimated $60-165 per tonne from 2026 to 2034 [32]. This, along with other global measures like the US Inflation Reduction Act (IRA) 2022, highlights the pressing need to revisit India's carbon emission policies.

The Indian production fleet is young and energy-intensive, with growth outpacing domestic scrap availability. Fortunately, India's rich renewable resources and expertise in Direct Reduced Iron (DRI) production present diverse technological opportunities for decarbonisation.

As the industry forges ahead, it must concurrently champion sustainable practices, balancing economic objectives with ecological obligations.

> Climate change and the need for Decarbonization is undeniable. Globally, individuals, societies, companies and governments are undertaking an unprecedented energy transition in response to this need of Decarbonization. Steel sector, contributing ~9% to global emission, will have a definite role in this transition. Energy transition in Steel Sector is a complex problem and will have multiple facets including adoption of carbon free electricity, Green hydrogen (and other green chemicals), energy efficiency and potentially, adoption of new technologies. We, at Greenko, have been investing in technologies and assets which allows us to enable this energy transition competitively and sustainably, evident from our partnership with Arcelor Mittal and with other metal major.

Gautam Reddy
COO and Head, New Energy Business, Greenko Group

[28] steel industry trends & outlook, ICRA dated October 10, 2023
[29] Public Policy paper on Climate change and the production of iron and steel, 2021, WSA
[30] Ministry of Steel
[31] Indian govt stresses on decarbonization in Vision 2047, SteelMint dated 04-Oct-22

04

Financial, sustainability, and health impacts of global agreements

The agreements from COP21 to COP26, coupled with the steel production giants' national strategies, have materially impacted the global steel landscape. While these accords drive financial flows towards sustainable practices, prompt innovation, and emphasise health and safety, the transformation also presents substantial challenges. Meeting these dynamic facets will require continued global collaboration, policy harmonisation, and industrial participation.

Financial impact

The industry has faced substantial financial pressure stemming from the need to innovate and implement innovative technologies for emissions reduction. Capital has been directed towards energy efficiency improvements, waste gas recovery, and transition to low-carbon technologies such as hydrogen-based steelmaking. While these investments are sizeable, they are essential for future-proofing operations and ensuring compliance with emerging regulatory requirements.

Financial risk profiles of companies within this sector have evolved, with increased scrutiny from investors and financiers who are now more sensitive to the environmental, social, and governance (ESG) criteria. Companies proactive in their environmental strategies are more likely to secure investment and funding at preferential rates, while those viewed as laggards face higher financing costs and divestment.

Sustainability impact

There has been a concerted drive to lower carbon intensity in production processes. Initiatives include optimising the use of scrap in electric arc furnaces, enhancing the energy efficiency of blast furnaces, and exploring breakthrough technologies like carbon capture, utilisation, and storage (CCUS) and direct reduced iron (DRI) with green hydrogen.

By maximising the use of scrap steel and developing new materials with lower carbon footprints, the industry is gradually decoupling production growth from resource use and emissions. Recycling steel, a focus in India's Steel Scrap Recycling Policy (2019), reduces raw material consumption, energy use, and GHG emissions, promoting sustainability. (Steel Scrap Recycling Policy, 2019)

Beyond direct operations, steel companies are increasingly responsible for emissions across their value chains. This accountability has necessitated a more meticulous selection of raw material sources, co-product applications, and downstream user industries, fostering a more holistic approach to sustainability.

Health and safety impact

Decarbonisation efforts positively influence occupational and community health and safety. Reduced air pollution lowers respiratory and cardiovascular diseases. Moreover, transitioning to cleaner energy sources minimises workplace hazards, such as those associated with coking operations.

The industry's efforts to reduce emissions and environmental footprints are consequential for the health of communities surrounding operations or along supply chains. A decrease in pollutants like particulate matter and effluents directly contributes to local environmental quality, with pronounced public health benefits.

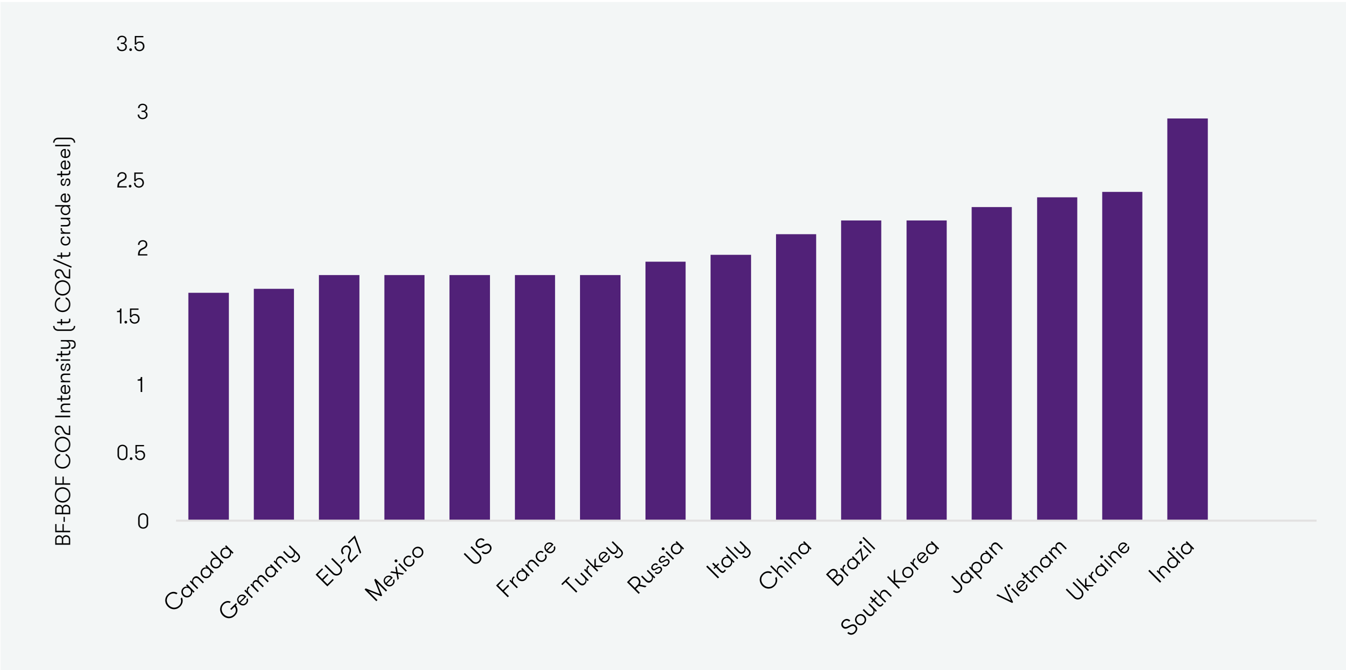
05

Global view of major steel producers

Noteworthy disparities exist in energy consumption across major steel-producing nations. The U.S. is distinguished by relatively lower energy intensity. This can be principally attributed to its substantial reliance on electric arc furnace (EAF) methodologies, which generally involve lower emissions. Conversely, India, and China are characterised by heightened energy use and CO^2 emissions. Though electric furnace has a high contribution (54%) in India's steel production, India's steel sector is notably energy-intensive, primarily due to its unique reliance on direct reduced iron (DRI) for EAF production. About half of the EAF's input comes from DRI, derived from iron ore through an energy and carbon-intensive method, differing from the usual scrap recycling process. Furthermore, India's use of coal-based DRI technology, instead of the global standard of natural gas, results in increased energy consumption and higher emissions in its DRI-EAF steel production.

Canada and India stand at opposite ends of the spectrum with respect to the CO^2 emissions intensity specific to blast furnace-basic oxygen furnace (BF-BOF) operations. The former benefits from one of the least CO^2-intensive fuel profiles in the industry, while the latter grapples with one of the most carbon-intensive[33].

CO^2 intensity of BF-BOF steel production, 2019



Sweden's experiment for the future – case study for the world [34]

Sweden is the pioneer in 'green steel' production without using coal. As a trial run, it has also delivered it to a truck manufacturer before full commercial production.

Sweden's 'Hydrogen Breakthrough Ironmaking Technology' – HYBRIT project – is a consortium comprising of the miner LKAB, steelmaker SSAB and state-owned utility Vattenfall. As per SSAB's President and CEO, Martin Lindqvist, the world's first fossil-free steel is evidence of the possibility to transition and reduce global carbon footprint of the steel Industry. It is a breakthrough for the world and not just for SSAB. The HYBRIT project is driven by Sweden's 2045 Net Zero target. The pilot plant began in 2018 with a goal to have demonstration by 2035. LKAB has committed $47 Billion for operations.

When zero-carbon H2 is supplied – combined with an electric arc furnace supplied with zero-carbon electricity – it has the potential to reduce emissions by over 94% compared with conventional technologies.

India can benefit from Sweden's developing capabilities in 'green steel'. The India-Sweden Green Transition Partnership (ISGTP) – to promote exchange of carbon-neutral business practices, solutions and share knowledge related to green transition – is set to benefit India in three areas of cement, steel and automotive sectors in its first phase [35]. ISGTP can prove to be a big driver for India's commitment towards achieving its net zero target by 2070.

[33] Hasanbeigi, A. (2022). Steel Climate Impact: An International Benchmarking of Energy and CO2 Intensities. Global Efficiency IntelligenceHarnessing green hydrogen - NITI AAYOG.
[34] Harnessing green hydrogen - NITI AAYOG.
[35] Sweden's largest electrolyser project inaugurated to produce hydrogen for green steelmaking. Hydrogen news and intelligence | Hydrogen Insight

06

CO^2 mitigation solutions: Overview

The steel industry, being a significant contributor to global CO^2 emissions, is increasingly under scrutiny to decarbonise and adopt more sustainable practices. As steel production methods have traditionally been carbon-intensive, there is a pressing need to identify and implement innovative solutions that can significantly reduce emissions while maintaining production efficiency. The following table provides an in-depth overview of various CO^2 mitigation solutions, examining their technological details, potential for CO^2 reduction, cost implications, challenges in implementation, projected timeframes for tangible results, and companies leading the charge in these areas. These solutions range from transitioning to less carbon-intensive fuel alternatives, enhancing production efficiency, to adopting advanced carbon management techniques. By understanding the nuances of each solution, stakeholders can make informed decisions on the most viable strategies for decarbonising the steel industry.

CO^2 mitigation solutions [36]

	Technology	Details	Potential CO^2 Reduction	Cost Implications	Implementation Challenges	Timeframe for Results	Companies Involved
Fuel switching to less Carbon-intensive alternatives	Electrification using commercial technologies	Increasing the use of electricity in place of fossil fuels for various processes in steel production including the use of electric arc furnaces, especially in secondary steelmaking, and potentially in other heat-intensive processes.	Medium: Direct emission reductions are significant with renewable electricity, but the overall impact is moderate due to the current limits on technology and application.	High: Substantial costs associated with retrofitting existing facilities to accommodate electrification, in addition to the cost of electricity.	High: Technical challenges in direct electrification of certain processes; reliant on the availability of low-carbon electricity and the development of innovative technologies for maximum impact.	Medium to Long: While some electrification can be implemented quickly, maximal benefits require technological advancement and grid decarbonisation.	SSAB, LKAB, Vattenfall (Sweden)
	Biomass and Hydrogen Injection	Introducing biomass and hydrogen into blast furnaces or using biomass in DRI furnaces. This approach aims to reduce the reliance on fossil fuels.	Medium: Biomass and hydrogen can significantly reduce emissions, but the overall potential is limited by the sustainable availability of biomass and the carbon intensity of hydrogen production.	Medium to High: Costs are associated with the production of low-carbon hydrogen and the sourcing of sustainable biomass, as well as necessary modifications to existing infrastructure.	High: Limited by sustainable biomass availability, the need for low-carbon hydrogen solutions, and technical modifications for injection processes.	Medium: Benefits are tied to the pace at which suitable production and injection technologies can be developed and implemented.	ArcelorMittal (Belgium) Salzgitter AG (Germany) Nippon Steel (Japan)

[36] Iron and Steel Technology Roadmap. IEA, 2020

CO² Mitigation Solutions

	Technology	Details	Potential CO² Reduction	Cost Implications	Implementation Challenges	Timeframe for Results	Companies Involved
Fuel Switching to Less Carbon-Intensive Alternatives	Charcoal Blast Furnaces	Using biomass, primarily charcoal, as a primary energy source in blast furnaces. This method is limited in application due to constraints on sustainable biomass supply and technical challenges.	Low to Medium: While charcoal use can significantly reduce direct emissions, its impact is constrained by sustainable supply limits and its restricted application in the industry.	Medium to High: Costs are linked to the sustainable sourcing of biomass, the production of charcoal, and the potential need for furnace modifications.	High: Limited by the availability of sustainable biomass, technical constraints on furnace size and operation, and competition for biomass within the energy system.	Medium: Some immediate benefits post-implementation, but scale and sustainability issues limit long-term potential.	Nippon Steel (Japan)
	Natural Gas-Based DRI Technologies	Utilising natural gas in direct reduction processes to produce iron. While effective in reducing emissions compared to coal, it does not achieve near-zero emissions without CCS.	High: Significant CO² reductions compared to coal-based methods but requires CCS for near-zero emissions.	Medium to High: While natural gas may be cheaper than coal in some regions, the costs associated with technology transition and CCS implementation are significant.	Medium: Practical mainly in regions with abundant low-cost natural gas. Requires new infrastructure and CCS for maximum impact.	Short to Medium: Benefits seen soon after implementation but transitioning to CCS or hydrogen will take longer.	Midrex Technologies, Inc. (USA)
Efficiency Enhancement	Process Optimisation and Integration	Enhanced use of energy flows, advanced process controls, and artificial intelligence for predictive maintenance and operational efficiency.	Medium: Optimised energy usage leads to moderate CO² reduction.	Low to Medium: Mainly involves optimising existing processes, though advanced systems may incur additional costs.	Medium: Integration of advanced control systems can be complex, requiring skilled personnel.	Short to Medium: Some results may be immediate, while others develop over time.	POSCO (South Korea) Tata Steel (India)
	Specific Technology Modifications	Examples include Waste Heat Recovery Systems, Coke Dry Quenching (CDQ), and Top-Pressure Recovery Turbines (TRTs).	Medium to High: These technologies have a substantial impact on energy savings, leading to decreased CO² emissions.	High: Significant initial investment for installation and maintenance.	Medium: Retrofitting existing plants can be technically challenging and disruptive.	Medium to Long: Depends on the scale of implementation and technology maturation.	Thyssenkrupp (Germany)

CO^2 Mitigation Solutions

	Technology	Details	Potential CO^2 Reduction	Cost Implications	Implementation Challenges	Timeframe for Results	Companies Involved
Efficiency Enhancement	Quality of Raw Materials	Using high-quality coke and iron ores, or introducing scrap in primary steelmaking, improves efficiency and reduces energy needs.	Low to Medium: Efficiency gains provide moderate CO^2 reductions.	Low to High: Higher costs for quality materials, offset by savings from reduced energy needs.	Low to Medium: Availability of high-quality raw materials and competition for scrap.	Short to Medium: Benefits seen as soon as higher-quality materials are utilised.	Tata Steel (India)
Carbon Management	CO^2 Management Technologies	Capturing CO^2 emissions at the source during iron and steel production, and either storing it underground (Carbon Capture and Storage, CCS) or utilising it for other purposes (Carbon Capture and Utilisation, CCU), such as enhanced oil recovery (EOR) or production of chemicals and fuels.	High: Manages CO^2 emissions by capturing and either storing or utilising them. Specific reduction depends on the scale of implementation and the specific technology used.	High: CCUS can be expensive due to the need for new infrastructure and the costs of capture and storage processes. Revenue from EOR can offset some costs.	High: Infrastructure needs; limited suitable sites for storage; regulatory hurdles; technology integration with existing plants; public acceptance.	Medium to Long-term: Technological developments and installations will take time.	ArcelorMittal (France) ROGESA (Germany) Baowu Steel Group (China)
	CCU Concepts (transitional role)	Focus on converting captured CO^2 into products, such as fuels, plastics, or chemicals.	Medium: CO^2 is utilised but generally released later during product use or at end-of-life. The long-term impact depends on the development of non-emitting CCU options.	Varies: Costs can be offset by the production of valuable fuels and chemicals, but overall profitability depends on market conditions for these products.	Medium: depends upon market for end products; technological development for efficient conversion; integration with existing production processes; regulatory frameworks.	Medium-term: Some concepts are well-developed, while others are still under development. Expected to evolve by 2030.	LanzaTech, Shougang Group and TangMing (China)

Environmental and sustainability certifications in steel industry

The contemporary steel industry is marked not only by its advancements in technology but also by its evolving commitment to sustainability and environmental consciousness. As the world grapples with pressing environmental concerns, various certification bodies have established benchmarks to guide industries towards sustainable practices. These certifications not only validate a company's environmental efforts but also build trust with stakeholders, ensuring that companies stay abreast of global sustainability standards. This section elucidates key certifications that the steel industry can acquire, underscoring their criteria, significance, and verification processes. Through these certifications, companies demonstrate their dedication to environmental stewardship, paving the way for a greener and more sustainable future.

Environment and sustainability certifications [37]

Certification Name	Issuing Body	Criteria/Requirements	Some Certified Companies	Significance	Verification Process
ISO 14001	International Organisation for Standardisation	Environmental management system standards; Continuous improvement in environmental performance	ArcelorMittal, Tata Steel, POSCO	Demonstrates commitment to environmental management; Meets regulatory requirements; Improves stakeholder relationships	Audit by a third-party certification body
ResponsibleSteel™	ResponsibleSteel	Commitment to principles and criteria: greenhouse gas emissions, water stewardship, biodiversity	BlueScope Steel, SSAB, POSCO, U.S. Steel, Tata Steel	Enhances sustainability in the steel sector; Builds confidence among stakeholders; Recognises environmental stewardship	Independent third-party audit and certification process
Science Based Targets initiative (SBTi)	SBTi (CDP, UN Global Compact, WRI, WWF joint collaboration)	Setting science-based emission reduction targets; Alignment with 1.5°C Paris Agreement pathway	Thyssenkrupp AG, Nucor Corporation, Mahindra Sanyo Special Steel	Drives competitive advantage in transition to low-carbon economy; Boosts investor confidence; Reduces regulatory uncertainty	Targets validated by the SBTi team
LEED Certification	U.S. Green Building Council	Use of sustainable building materials, including green steel; Promotion of resource efficiency in buildings	Gerdau, Steel Dynamics	Recognises sustainability in construction; Promotes environmental responsibility; Attracts eco-conscious clients	Review and approval by Green Business Certification Inc.

[37] Decarbonising Steel: forging new paths together

07

Key Indian steel producer decarbonisation actions

The Indian steel industry is proactively embracing sustainability, with major players setting ambitious decarbonisation targets. In line with this, the Ministry of Steel has committed to decarbonise the steel sector significantly in India and adopted multiple initiatives. In the short term by FY 2030, carbon emissions reduction will be major focus with help of promotion of energy and resource efficiency and higher uses of renewable energy. However, in the medium term by 2047, Green Hydrogen and Carbon Capture, Utilisation and Storage will be key focus areas to reduce the carbon emission in steel production. In the long run from 2047-2070, help of disruptive alternative technological innovations will be required to achieve the net-zero target.

In this regard, Ministry of Steel has taken multiple initiatives [38]:

1. 13 Task Forces have been constituted with the engagement of industry, academia, think tanks, S&T bodies, different Ministries, and other stakeholders to discuss, and provide recommendations for **decarbonisation of steel sector.**

2. Steel Scrap Recycling Policy, 2019 to increase the availability of scrap in the country so that consumption of coal can be reduced. It is targeted to achieve 60% steel production through scrap by 2047.

3. National Green Hydrogen Mission for **green hydrogen production and usage** was launched by Ministry of New and Renewable Energy (MNRE) where **steel sector** has also been involved.

4. Motor Vehicles (Registration and Functions of Vehicles Scrapping Facility) Rules September 2021, to **increase availability of scrap** for the steel sector.

5. Perform, Achieve and Trade (PAT) scheme, under National Mission for Enhanced Energy Efficiency, **incentivises steel industry** to **reduce energy consumption.**

6. Adoption of the **Best Available Technologies** (BAT) globally, in the modernisation & expansions projects.

Apart from this, Indian Steel industry has also started taking various initiatives. JSPL aims to keep carbon emissions remain below 2.0 t/TCS by 2030 and become net carbon zero by 2035 [39]. Jindal Stainless pledges net zero emissions by 2050, driven by renewable energy transitions and hydrogen plants [40]. Tata Steel targets CO^2 reduction to 1.8 tons per ton of steel by 2030, leveraging new technologies like carbon capture [41]. JSW Steel commits to a 42% CO^2 emission intensity reduction by 2030, investing heavily in green energy [42]. Vedanta seeks net zero by 2050, exploring hydrogen-based green steel tech in collaboration with IIT Bombay, while SAIL focuses on cutting emissions to under two tonnes of CO^2 per ton of steel by 2030. Collectively, these initiatives underscore the Indian steel sector's commitment to global sustainability goals.

Key initiative taken by Indian Steel producers:

Tata Steel [43]

Tata Steel has been showcasing its commitment to a more sustainable future. Some of the significant strides taken by the company:

Partnership with LeadIT

In July 2023, Tata Steel announced its collaboration with the Leadership Group for Industry Transition (LeadIT) - an initiative backed by the governments of Sweden and India, and the World Economic Forum. Tata Steel's association with LeadIT marks it as the first Indian steel company to join the group, elevating its position as a global pioneer advocating net-zero industry transformation. Through this collaboration, Tata Steel plans to leverage the LeadIT platform to communicate the intricacies of the Indian steel market, focusing on its anticipated growth in the coming decades.

[38] Government of India committed towards decarbonising the Indian steel sector, PIB dated 31-Jul-2023
[39] ESG: Jindal Steel & Power becoming net carbon zero by 2035 by IndiaCSR dated 15 September 2022
[40] Jindal Stainless' ambitious ESG efforts, plans to commit to Net Zero by 2050 dated 28-Nov-22; JSL website last accessed on 01-Nov-23
[41] Tata Steel says it won't reach emissions goal by 2030 with current tech by Financial Express dated 23-Jun-23
[42] JSW Steel's Seshagiri Rao on going green, carbon financing & hydrogen fuel cells by The Economic Times dated 17-Dec-21
[43] Tata Steel Joins UN initiative 'LeadIT' to Drive Net-Zero Emissions in Heavy Industry dated 12-Jul-23; Tata Steel Website Press release; last accessed on 01-Nov-23

Tata Steel's Net-Neutral Goal

The company has set an ambitious target to achieve net-neutral carbon emissions by 2045. This goal underlines Tata Steel's dedication to the global decarbonisation agenda

Innovative Carbon Negative Technologies – Trial Injection of Hydrogen Gas [44]

Tata Steel has actively been integrating cutting-edge carbon-negative technologies into its operations. In its pursuit of decarbonisation, Tata Steel has adopted a two-pronged approach:

- Carbon Direct Avoidance (CDA), and
- CO^2 Capture and Use

The trial injection of hydrogen gas is part of the CDA approach, focussing on the blast furnace, one of the heaviest known industrial contributors to CO^2 emissions worldwide. This is crucial for its journey towards Net Zero Emissions by 2045. Tata Steel has started the trial injection of H2 gas using 40% of injections in 'E' Blast Furnace at its Jamshedpur Works. Globally, it is the first time that such a large quantity of H2 gas is injected in a blast furnace. The benefits of this trial are –

- It can reduce the coke rate by 10%, which can translate into around 7-10% reduction in CO^2 emissions per ton of crude steel produced in the furnace.
- It will establish Tata Steel's capability to develop and establish necessary general and process safety protocols and provide process control insight for pure hydrogen injection into the blast furnace.

The company achieved a landmark by successfully trailing the injection of hydrogen gas at unprecedented levels in its Blast Furnace located in Jamshedpur. Other noteworthy implementations include the Coal Bed Methane (CBM) injection, and the commissioning of a carbon capture plant.

Acknowledgments and Recognitions

Tata Steel's sustainability initiatives have garnered global recognition. The company has been awarded the World Economic Forum's Global Lighthouse recognition for several of its plants and has been consistently ranked among the top steel companies in the DJSI Corporate.

Sustainability Assessment

The company's Jamshedpur Plant became India's first site to receive the ResponsibleSteelTM Certification, further solidifying its position as a sustainability leader.

JSW Steel [45]

JSW Steel has recognised the pressing need to address climate change. As a testament to this commitment, the company has integrated sustainability into its fundamental operations and decision-making processes.

Carbon Reduction Commitment:

JSW Steel has set an ambitious objective of curbing specific carbon dioxide emissions to approximately 1.95 tCO^2/tcs, by 2030. To fulfil this, the company has pledged to Address root causes of climate change, diminish and adapt to the repercussions of climate change and fortify resilience against climate change impacts. Responsible for 23% of India's steel production, JSW Steel and its subsidiaries carry a significant mantle in the industry. Acknowledging the challenges posed by climate change, the company has seamlessly incorporated climate change scenarios into its risk management mechanisms and devised strategies to counteract climate-related hazards and natural disasters.

Initiatives by JSW Steel

Climate Action Group (CAG)

JSW Steel instituted the CAG, a multi-disciplinary team, to devise and execute climate change mitigation strategies, ensuring the company's alignment with global best practices.

Scenario Analysis for Climate Change Risk

The company is assessing long-term climate risks and opportunities through detailed scenario analyses. These analyses focus on both physical and transitional risks, with a keen interest in examining potential climate-induced impacts like temperature shifts, rainfall variability, water stress, and sea-level changes.

Internal Carbon Pricing

JSW Steel has implemented an internal carbon price of USD 20/tonne as a measure to internally account for carbon emissions.

Stakeholder Engagement and Advocacy

JSW Steel actively collaborates with stakeholders at multiple levels. Their lobbying efforts, overseen by the Board and the Sustainability Committee, advocate for robust climate-related regulations and policies aligned with the Paris Agreement.

Recognition by World Steel Association

The company's commitment to climate action has been acknowledged by the World Steel Association. It has consistently participated in the Climate Action Programme for CO^2 emissions data collection.

CDP Disclosure

JSW Steel has been consistently transparent in its climate actions, with a notable 'A' rating from CDP, signalling its commitment to best practices in climate change mitigation.

CII Working Group

The company leads the CII Working Group focused on GHG data collection for pivotal sectors like Iron & Steel and Cement.

[44] Services, H. D. Tata Steel initiates trial for record-high hydrogen gas injection in blast furnace at its Jamshedpur Works
[45] Sustainability framework measuring success-Climate Change; JSW website last accessed on 01-Nov-23

Jindal Steel and Power [46]

Jindal Steel & Power Limited (JSPL) is carving out a path toward greener steel production. JSPL's commitment to producing green steel is evident in its strategic initiatives:

Transitioning from coal to hydrogen in Direct Reduced Iron (DRI) processes

JSPL is exploring the use of hydrogen as an alternative to coal in Direct Reduced Iron (DRI) processes, which can significantly cut down carbon emissions. To further curb GHG emissions, JSPL is delving into CCUS technologies.

Odisha Plant and Green Hydrogen Ambitions

In its quest to lead in green steel production, JSPL aspires to transform its Odisha facility into the world's most extensive and environmentally friendly steel production plant. This vision is complemented by plans to establish a 500MW green hydrogen plant to serve steel production processes.

Green Energy Collaboration

Emphasising its commitment to clean energy, JSPL has partnered with Greenko to secure 1,000MW of green power for its steel production activities in Angul, Odisha. This collaboration promises a substantial reduction in CO^2 emissions, estimated at seven million tonnes annually.

Commitment to ESG and Carbon Neutrality

Jindal Steel & Power's commitment to Environmental, Social, and Governance (ESG) principles is paramount. The company's aspirations include Establishing the world's largest single-location steel-making complex in Angul, Odisha by 2030 and achieving net carbon zero by 2035.

ArcelorMittal Nippon Steel India [48]

ArcelorMittal Nippon Steel India (AMNS) India stands as a testament to the global steel industry's potential to pivot towards a sustainable future. As one of the industry's frontrunners in the decarbonisation drive, AMNS India has embarked on several significant initiatives that underline its commitment to a greener future.

Renewable Energy Collaboration with Greenko Group

AMNS India has made a strategic partnership with the Greenko Group, a notable player in the renewable energy sector. With a significant investment of $600 million, the collaboration aims to set up green energy generation facilities in Andhra Pradesh. This move not only strengthens AMNS's position in the green energy landscape but also underscores its determination to reduce its carbon footprint.

Dedicated Investments in Decarbonisation Projects:

Under the broader umbrella of its parent company, ArcelorMittal, AMNS India is not a mere participant but an active contributor to the global effort in decarbonising the steel industry. The company's endeavours are backed by substantial financial commitments: A whopping investment of over $122 million is directed towards various decarbonisation projects.

The focus is not just limited to internal projects. AMNS India, leveraging ArcelorMittal's global network, has forged partnerships with pioneering firms such as Heliogen, From Energy, LanzaTech, H2Pro, and NerraPower.

These collaborations spotlight AMNS India's diversified approach in addressing decarbonisation, encompassing renewable energy harnessing, carbon recycling technologies, and innovative steel production methodologies

Other Players [47]

During interaction with other players, we understand that at least 50% of the respondent has started monitoring the Scope 1 & Scope 2 emission while others are planning to start the monitoring process. Even some have also started tracking Scope 3 emission in their value chain holistically. It was also highlighted that Customers and Regulators are two major factors to start the decarbonisation journey. When asked about their decarbonisation strategy for next three years, there was mixed response between 1) Invest extensively to make low emission steel & seek certification and 2) Undertake studies to assess cost-benefit trade-offs. This shows that Indian steel manufacturers are actively looking for decarbonisation strategy, but cost factors are the major constrains.

Majority of the players with whom interactions have been organised have also started various decarbonisation projects e.g., Reduction in use of Coal, Waste heat recovery, energy efficient pumps and motors and move to renewable source of energy through installation of Solar power plant under 100 MW capacity. Only one of them have started using Biomass while another is looking into this opportunity. Apart from these initiatives, another major initiative taken by steel players is to increase Steel Scrap in the steel making process.

As per the Steel players, Energy efficiency (e.g., use of WHR, use of LED etc.) and Migration of energy source to renewables by investing in solar are the two most promising abatement methods. Use of more scrap and biomass for power generation and as reductant are other two methods under exploration in the short term.

[46] ESG: Jindal Steel & Power becoming net carbon zero by 2035 by IndiaCSR dated 15 September 2022
[47] Press release on ArcelorMittal establishes strategic renewable energy partnership with Greenko Group in India by ArcelorMittal dated 22 Mar 22 on its website
[48] Steel companies including DRI players across state of Maharashtra, Odisha, Chhattisgarh, and Haryana were interviewed. Majority of the companies have captive power plant, and their annual turnover is below 10,000 crore ; survey conducted by Grant Thornton

08

Major challenges of Indian steel sector

The First Movers Coalition (FMC) is a coalition of companies using their purchasing power to create early markets for innovative clean technologies across eight hard to abate sectors including Steel, Aluminium and Cement industry including others. FMC has set target for its members to commit to a at least 10% (by volume) of all steel purchased per year will be near-zero emissions by 2030. Apart from this, FMC has also set a stringent threshold for near-zero emission steel having less than 0.4 tCO^2 per ton of crude steel for (0% scrap inputs) and less than 0.1tCO^2 per ton of crude steel producer with 100% scrap inputs [49].

Few Indian companies who are members of FMC and have committed to the FMC's steel target includes Mahindra & Mahindra, ReNew Power, and Bharat Forge [50]. By signing offtake agreements to purchase near-zero emission steel at a premium upon delivery in 2030, these companies are providing advance contract to Indian producers so that they can raise the required capital for decarbonising steel production. Currently there are no projects in India which can produce low carbon / green steel with the FMC required criteria.

Apart from this, European Union has also implemented the Carbon Border Adjustment Mechanism (CBAM) from Oct-2023 which will be in transition till Jan-2026 (effective date of implementation). This will impact the steel exports to the European nations from India. As per ICRA [51], CBAM is projected to influence 15% to 40% of India's yearly steel exports to Europe. CBAM may substantially reduce the profit margins of Indian steel exports to the European Union (EU) by an estimated $60-165 per tonne from 2026 to 2034. This, along with other global measures like the US Inflation Reduction Act (IRA) 2022, highlights the pressing need to revisit India's carbon emission policies.

Along with the requirement of reductio in emission, there are other challenges which is being faced by Indian Steel industry.

Requirement of rapid growth

- India's economy is one of the fastest growing economies in the world, and steel demand is a major driver for such growth. With the anticipated growth rate for Indian economy, India's per capita consumption of steel will increase from existing 81 kg in 2022 [52] to ~160 kg by 2030 [53] and ~220 kg by 2047 [54]. In line with the National Steel Policy, 2017, major steel players in India have already started major expansion of steel plants. Approximately 120 million tons of capacity expansion [55] has already been planned at the start of 2021 by large-scale integrated steel producers, which will be completed by end of this decade and majority of these expansion are though the BF-BOF route. The BF-BOF route in its current form is an emission intensive technology; however, major steel players in India are planning for this route mainly due to economies of scale for the integrated players, non-availability of high-quality scrap for EAF and availability of domestic iron ore.
- Although the swift increase in steel demand is beneficial for India's progress, it also creates challenges in the short term for the steel industry. Consequently, there is a risk that newly added production capacity may become underutilised in the future, as the global steel industry shifts towards decarbonisation, and high-emission steel production becomes less viable.

Cost competitiveness

In recent years, there have been notable improvements in the efficiency of steel production in India. However, Indian steel producers still face a cost disadvantage of about 5-10% compared to the global average [56]. The key factors contributing to these higher costs are the expenses associated with finance, logistics and infrastructure. Indian steel producers incur relatively high expenses for transporting raw materials. These factors, among others, place India at a comparative disadvantage in certain advanced steel production areas, such as stainless steel and alloy steel, in comparison to major producers like China, Japan, and South Korea.

Apart from this, with the current dominance of the BF-BOF route in India, which is highly carbon intensive process, CCUS is critical for decarbonisation of Steel sector. However currently, CCUS is still at the pilot stage only. Currently there are no government incentives or policies to incentivise CCUS deployment in India. This will further increase the cost of production for major steel players and will reduce their margin and cost competitiveness.

[49] White paper on Surfacing Supply of Near-Zero Emission Fuels and Materials in India, World Economic Forum, July-2023
[50] List of Members of FMC on its website; last accessed on 31-Oct-23
[51] Steep rally in carbon prices and CBAM compliance requirements could pull down the profits of Indian steel exports to EU by US$60-165/MT1 between CY2026 and CY2034; press release dated 22-Jun-23 by ICRA
[52] 2023, World Steel in figures; World Steel Association
[53] National Steel Policy, 2017
[54] Union Minister of Steel and Union Minister of Mines inaugurate two-day Conference on "Indian Minerals & Metals Industry: Transition towards 2030 & Vision 2047; PIB dated 23-Aug-22
[55] Parth Kumar 2022, Decarbonising India: Iron and Steel Sector, Centre for Science and Environment, New Delhi
[56] Will Hall, Sachin Kumar, Sneha Kashyap, Shruti Dayal. 2022. Achieving Green Steel: Roadmap to a net zero steel sector in India. New Delhi: The Energy and Resources Institute (TERI)

Technology availability and capital requirement

From a technology point of view, India's steel sector is uniquely placed mainly due to unique characteristics of raw material availability. India is the largest coal-based sponge iron ore producer, which makes coal based DRI-EAF a unique steel making process. To achieve decarbonisation in the steel sector, key technological interventions are required which fall under the following categories:

1. Carbon capture and storage for existing for planned BF-BOF plants
2. Use of green energy in EAF/IF furnace
3. Replacement of solid fuels with gas for reduction which can be replaced with hydrogen at later stage.

To transition towards the net zero steel sector, huge capital expenditure will be required. As per estimates, building a new BF-BOF plant requires ~INR 5,000 – 6,000 crore for a one-million-ton steel plant; however, to convert this to produce near zero emission steel, the capex requirement will reach beyond INR 8,300 crore [57].

Report	Detail Scenario	Description	Investment INR ('00000 crores)
Evaluating Net-zero for the Indian Steel Industry, CEEW, 2023 [58]	Achieving net-zero emissions in the steel sector	Cumulative Capex for steelmaking pathway across all decarbonisation measures, including energy efficiency, RE power use, alternative fuels, and carbon management measures.	21.19
Iron and Steel Technology Roadmap, IEA 2019 [59]	STEP - Stated Policies Scenario constructed by projecting forward its current trajectory, shaped by existing and announced policies - 7% increase in e mission by 2050 against 2019	Cumulative capital investment in process equipment in the iron and steel sector between 2021 to 2050	16.72
	SDS - Sustainable Development Scenario constructed by stipulating a more sustainable end point and examining the pathway by which it might be realised. - 54% fall in emission between 2019 to 2050 SDS is more aligned with Paris agreement and assumes that energy system as a whole will reach to net zero by 2070 Direct emission intensity of crude steel production will fall by 60% between 2019 and 2050 and 90% by 2070		21.28

Apart from this, to reduce the emission through use of renewable energy to power the electric furnaces, India needs to double its target of 450GW of installed capacity by 2030. This requires significant investment and financing for additional 250GW of wind and solar development around USD 223 billion between 2022 and 2029.

Along with requirement of significant capex, India's borrowing cost of capital is also very high, which prevents investments that would be viable in other markets. Overall cost of debt was 7% higher than the U.S. in 2020. Also, OECD estimated that a 1% increase in the cost of debt can result in a 5% increase in the levelised cost of energy from offshore wind [60].

From the various estimates, it can be estimated that to achieve net zero emission steel in India, INR 16 to 22 lakh crore investment will be required. And these estimates are only for the steel sector, which only contributes to 10% of overall emission.

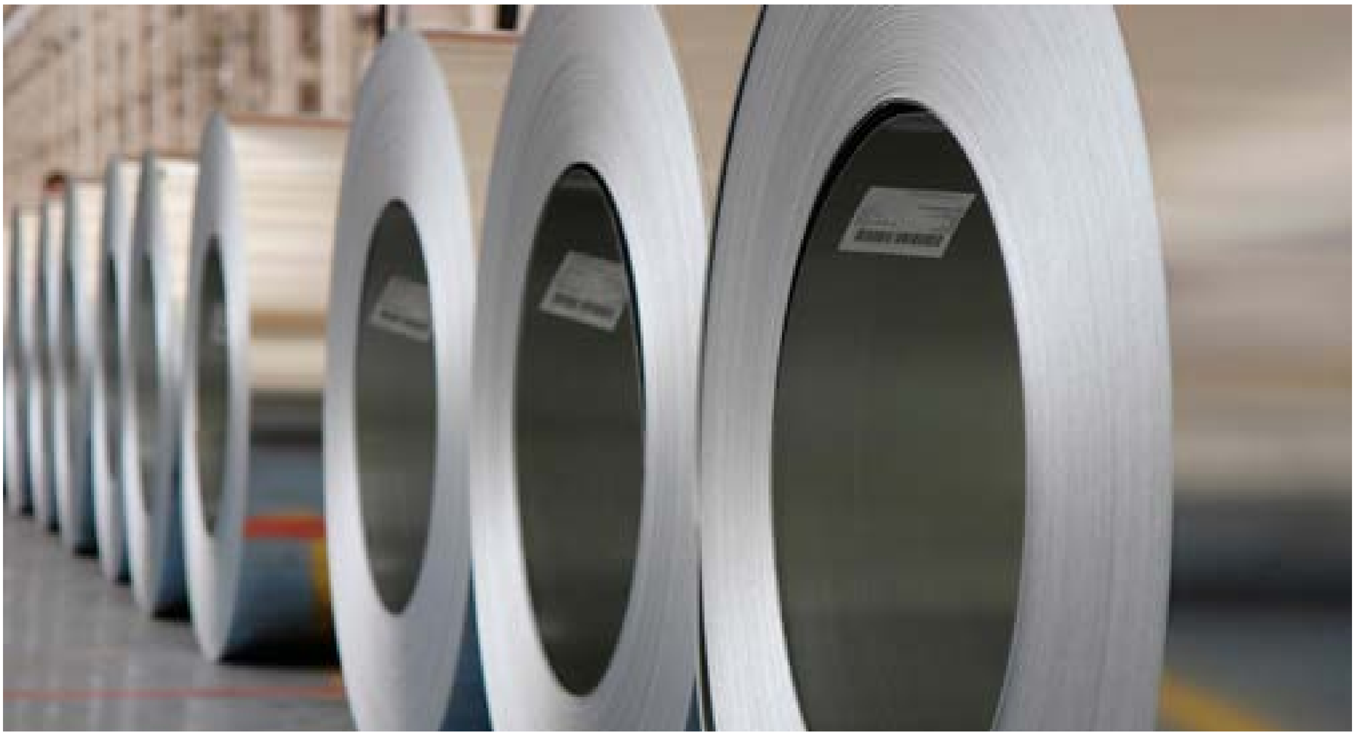
[57] White paper on Surfacing Supply of Near-Zero Emission Fuels and Materials in India, World Economic Forum, July-2023
[58] Elango, Sabarish, Kartheek Nitturu, Deepak Yadav, Pratheek Sripathy, Rishabh Patidar, and Hemant Mallya. 2023. Evaluating Net-zero for the Indian Steel Industry: Marginal Abatement Cost Curves of Carbon Mitigation Technologies. New Delhi: Council on Energy, Environment and Water.
[59] Iron and Steel Technology Roadmap. IEA, 2020
[60] White paper on Surfacing Supply of Near-Zero Emission Fuels and Materials in India, World Economic Forum, July-2023

Availability of scrap

Use of scrap can reduce the emission from the steel sector. Scrap provides an alternate pathway by replacing the high emission iron making through BF / DRI from iron ore. When scrap is used along with EAF, it reduces the carbon emission by 71% against the high emission BF-BOF route at the current stage. If it is combined with the green energy powered EAF, it will further reduce the carbon emission in steel making process. The use of scrap can reduce the dependency on high emission BF-BOF till the green hydrogen or CCUS technologies are ready for implementation. However, India's steel recycling is significantly lower than global average of 85% [61]. Despite a National Steel Scrap Recycling Policy published in 2019, significant investment will be required to develop the scrap supply chain. In FY22, around 20% of steel was produced by use of domestic and imported scrap

The Indian steel industry is aiming to increase usage of scrap in steel making from the current level of 3-4% to around 15-20% to reduce emission of greenhouse gases.
In this regard, digital platforms have a very important role to play in connecting the steel industry with the fragment and unorganised scrap processors and not only helping in transparent price discovery but also in building of reliable supply chains to ensure consistent & timely supply of good quality scrap to the steel industry.
I am happy to share that through our platform more than 500,000 MT of scrap from dismantled projects, RVSFs & other sources have been sourced by the steel industry, efficiently and transparently from steel processors located across India.

Vinaya Verma
MD & CEO, Mjunction



[61] White paper on Surfacing Supply of Near-Zero Emission Fuels and Materials in India, World Economic Forum, July-2023

09

Priorities for Indian steel sector and way forward

Priorities for the Indian steel sector to mitigate the risk associated with decarbonisation and achieve the set target for net zero emission as committed in COP26

India is uniquely placed among other countries either in terms of growth potential or investment potential. As Jeff Bezos has rightly said, "21st Century belongs to India." It was further stressed by Hon'ble Prime Minister of India in January 2023 that the 21st century needs to be century of India and the country must be ahead of developed nations. Many countries have taken a pledge to achieve net zero by 2070 or before. India has also committed to achieve net zero by 2070 at COP26, and Ministries have already started chalking out plan to achieve this in a phased manner.

The steel industry in India is on a growth trajectory in short as well as long term as per capita consumption of steel in India is far below the current global average steel consumption. Hence, significant investment is required in the steel sector to achieve the targeted per capita consumption of steel of 160 kg by 2030 and 220 kg by 2047. However, the steel sector needs to invest in decarbonisation, and entire ecosystem must work together to achieve the target of net zero. Some of the interventions which need to be taken by various steel players, buyers and policy makers are given in the table below:

Intervention	Description
Implement, monitor, manage, audit and report energy efficiency and carbon abatement initiatives	Use of Best Available Technology (BAT) for efficient energy consumption is particularly important for Indian steel sector in short term to reduce the carbon emission. There is potential to reduce 38% to 44% reduction in Specific energy consumption from current technologies being used at Indian BF-BOF plants and BAT [62]. Apart from this, Government shall initiate the policy for measuring of Carbon emission similar to energy monitoring under PAT scheme for Steel Sector.
Increase availability and utilisation of scrap	Improving the resource efficiency is another key factor in short term to reduce the emission. Every tonne of scrap being used for steel production reduces the emission of 1.5 tons of CO2, and the consumption of 1.4 tons of iron ore, 740 kg of coal and 120 kg of limestone. [63] Major steel producers must come forward for establishment of scrap across the country to increase the availability of scrap for steel sector.
Collaborate for R&D, Capital Investment for Conversion and Retrofitting, Establishment of indigenous standards and Certifications	Steel Sector need to collaborate along with their Buyers, Academia, Policy makers and OEMs to innovate the technology and secure the future demand of Green Steel. Similar to FMC, platform need to be created where buyers shall provide assurance for purchase of green steel with reduced carbon emission to provide the security for decarbonisation. Apart from this, Government also needs to play role in putting down the policies for procurement of green steel for public infrastructure development. Collaborative research with inclusion of Industry, academia and research organisation should be done to expedite the development of key decarbonisation technologies viably for Indian Steel sector. In this, major steel producer and OEMs will need to play a significant role for investment in R&D. Companies should also explore various technologies available for retrofitting in the existing plant to increase the energy and material efficiency in the short term start their decarbonisation journey. Government has already created 13 task force to identifying action points for each aspect of green steel production. Their major task is to identify the sustainable steel making practices and technologies for Indian Steel sector. There are many certifications for low carbon or green steel which suits the various countries, however due to unique position of Indian Steel sector, Government should devise indigenous standards for low carbon steel / green steel.
Financing and Incentivisation of the Transition	India's steel sector has large no of secondary steel players who contributes major portion of Steel production. Government and Financial institution must provide incentives in terms of low cost of finance and relaxation on taxation for companies taking steps for green steel. At current stage, operating cost of green steel is much higher than conventional steel which is also a deterrent for steel producers in the domestic market. Unless these cost disadvantages will be compensated with incentive policies, it will be difficult for Steel sector to adopt the technologies in short term.
Setting up of domestic carbon credit market	Carbon trading market is an important tool to accelerate adoption of new technologies. Similar to implementation of PAT scheme, where energy efficiency certificates are being traded between Designated Consumers (DCs), policies need to be changed to monitor and control carbon emission along with the energy consumption in the steel sector. This will be similar to the EU Emissions Trading Scheme (ETS). Apart from this, similar to EU's CBAM policy which is going to affect the high emission steel import to EU, it will be worth exploring the similar mechanism for Imports in India to provide the cost advantage to Indian Steel players. This will persuade Indian consumers in near future to work with steel producers.

[62] Will Hall, Sachin Kumar, Sneha Kashyap, Shruti Dayal. 2022. Achieving Green Steel: Roadmap to a net zero steel sector in India. New Delhi: The Energy and Resources Institute (TERI)
[63] Analysis using TATA steel sustainability report FY 21

Abbreviations

AMNS	ArcelorMittal and Nippon Steel
BAT	Best Available Technology
BF	Blast Furnace
BF-BOF	Blast furnace-basic oxygen furnace
BOF	Basic Oxygen Furnace
CAGR	Compound annual growth rate
CBAM	Carbon Border Adjustment Mechanism
CCEW	Council on Energy, Environment and Water
CCUS	Carbon Capture, Utilisation, and Storage
CDA	Carbon Direct Avoidance
CDP	Carbon Disclosure Project
CEO	Chief Executive Officer
CII	Confederation of Indian Industry
COP	Conference of the Parties
DRI	Direct Reduced Iron
EAF	Electric Arc Furnace
ESG	Environmental, Social, and Governance
ETS	Emissions Trading Scheme
EU	European Union
FMC	First Movers Coalition
FY	Financial Year
GDP	Growth Domestic Product
GHG	Greenhouse Gas
GHG	Green House Gas
GW	Gigawatt
ICRA	Investment Information and Credit Rating Agency
IEA	International Energy Agency
IF	Induction Furnace
IMF	International Monetary Fund
INR	Indian National Rupee
IPCC	Intergovernmental Panel on Climate Change
IRA	Inflation Reduction Act
ISGTP	The India-Sweden Green Transition Partnership
JSPL	Jindal Steel and Power
kg	Kilograms
LED	Light Emitting Diode
MD	Managing Director
MW	Megawatt
NDCs	Nationally Determined Contributions
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
PAT	Perform, Achieve and Trade
SDS	Sustainable Development Scenario, IEA
STEPS	Stated Policies Scenario, IEA
tCO_2/tcs	tons CO_2 emission per ton of Crude Steel
TERI	The Energy and
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WHR	Waste Heat Recovery
WSA	World Steel Association

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