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Government of Odisha

Sustainable green metals: A catalyst for decarbonisation in the face of climate change

NGMC 2024
National Green Metal Conference
An initiative of SPCB & BPNSI

National Green Metal Conference 2024

6 February - 7 February 2024 at Hotel Swosti Premium, Bhubaneswar

Knowledge Partner

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MESSAGE

I extend a warm welcome to the insightful discourse encapsulated in the knowledge paper, "Sustainable Green Metals: A Catalyst for Decarbonization in the Face of Climate Change." In my capacity as the Chief Patron of the National Green Metal Conference, it is an honor and responsibility to share perspectives on our collective journey towards sustainable practices in the metal industry.

Odisha's pivotal role is accentuated as the first state in the country to formulate a comprehensive State Climate Change Action Plan (SAPCC) encompassing 11 identified sectors. This plan, a collaborative effort by an inter-departmental team, reflects our commitment to addressing climate change challenges comprehensively. Notably, Odisha stands as the only state to prepare the second iteration of SAPCC (2018-23), highlighting our dedication to evolving strategies and staying at the forefront of climate action.

In alignment with our commitment, the ongoing research project, "Strengthening of the State Climate Change Cell under NMSKCC/ NMSHE," is a testament to our endeavors to enhance the scientific basis for evidence-based policymaking. This project aims at providing scientific support, raising stakeholder awareness, ensuring interdepartmental coordination, and consulting with national and international entities for the smooth implementation of SAPCC.

As we delve into the specifics of the mining sector, a critical aspect of our state's sustainable development, our key priorities unfold. Odisha is blessed with rich natural resources like iron ore, chromite, bauxite, coal, and other major minerals. Odisha is a hub for mineral-based industries, contributing more than 40.0% of India's mineral production by value during Apr-Feb 2023. The state holds over almost 99% share of chromite reserve, 45% share in iron ore reserve, and more than 60% of India's bauxite reserves, making it ideal for steel, stainless steel, and aluminum production. Odisha also ranks first in the country in terms of both production capacity and actual output of aluminum. With a large

coastline, access to best-in-class logistic infrastructure including roads, rail, and port, Odisha emerges as a crucial hub for trade and commerce.

We proactively work on preparing regional sustainable mining plans, aligning mining activities with ecological considerations. The establishment of a mechanism for green belt development and maintenance in mining clusters is underway, ensuring a harmonious coexistence of industry and nature. Our commitment extends further with the creation of an environmental restoration fund, supported by contributions from mining companies. This fund will fortify initiatives for environmental preservation and rehabilitation. Recognizing the importance of reclaiming and rehabilitating old, abandoned mines, we are formulating a comprehensive action plan to rejuvenate these areas.

In a visionary move, rest shelters with plantations are being constructed in mining areas to provide much-needed shelter during heatwave conditions. We prioritize the well-being of communities in mining clusters by actively working to supply drinking water in their vicinity. Additionally, we explore cleaner technologies and best practices in coal mining, aiming for a more sustainable and responsible industry.

A comprehensive study is underway to determine the potential of coal bed methane in the coal fields of Odisha, contributing to our understanding of cleaner energy options. Moreover, a methodology is being developed to measure, monitor, and verify the amount of carbon sequestered by plantation programs in the mining sector, ensuring accountability and transparency in our environmental efforts.

In conclusion, Odisha, as a testament to collaborative governance, is not just a state but a beacon for building a sustainable legacy. Let us continue this journey together, forging a path towards a resilient and eco-friendly future that transcends individual efforts for the collective good.

Warm regards,

[Pradeep Jena]

नागेन्द्र नाथ सिन्हा, भा.प्र.से.
सचिव
Nagendra Nath Sinha, IAS
Secretary

सत्यमेव जयते

भारत सरकार
इस्पात मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF STEEL

1st February, 2024

MESSAGE

It gives me immense satisfaction to learn of this significant event which is centered around the crucial theme of "Balancing the Metal Eco Systems: Towards Green Sustainability." It brings me great pleasure to witness the convergence of industry experts, policymakers, and stakeholders, all dedicated to shaping the future of the steel and overall metal sector.

I believe that this report will emerge as a valuable reference for policymakers, industry captains, and all interested parties committed to realizing India's goal of reaching net zero. By furnishing an in-depth comprehension of the present landscapes and the myriad initiatives undertaken by major steel entities in India and globally, this report aims to shed light on various facets of sustainable metal production.

India's steel industry stands as a beacon of industrial prowess, proudly securing its position as the world's second-largest producer and consumer of steel. In the fiscal year 2022-23, our nation achieved an impressive production of 127.20 million tons (MT) of crude steel, boasting an installed capacity of 161.3 MT. This sector contributes over 2% to India's GDP and provides employment to nearly 2.5 million individuals, underscoring its significance in our economic landscape. Our growth trajectory is equally remarkable, with per capita steel consumption experiencing a substantial 12.3% increase, reaching 86.7 kg in 2022-23 compared to the previous year. Aligned with the National Steel Policy (NSP) 2017, we aspire to achieve a projected installed capacity of 300 MT by 2030 and a visionary 500 MT by 2047, marking a significant leap in both capacity and production.

Our vision incorporates seamless technological integration and infrastructure planning. The integration of BISAG-N's capabilities into the PM GatiShakti National Master Plan is pivotal, offering valuable insights for strategic planning of efficient essential logistics across the nation. In this area, newer logistics mode such as slurry pipelines need to be encouraged. We also need to go a long way in utilizing leaner grade iron ores and domestic non or near coking coal through slew of technologies besides going for circularity as a defining yardstick for improving sustainability and boosting self-reliance.

Quality assurance and recycling initiatives are central to our commitment to delivering high-quality steel while embracing sustainable practices. Stringent measures, including the notification of 145 Indian Standards for steel and steel products and the Steel Scrap Recycling Policy of 2019, reinforce our dedication to quality and eco-friendly manufacturing.

In the pursuit of Green Steel, we are leveraging existing technologies such as improving energy efficiency, utilizing alternate green power sources, and increasing the use of scrap. Initiatives for cheaper availability of RE would be greatly appreciated by the industry. Simultaneously we are exploring interventions like green

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hydrogen and CCUS to effectively reduce carbon emissions in steel manufacturing. Our industry stands at the forefront of adopting modernization and expansion projects, embracing Best Available Technologies (BAT) globally.

Decarbonization initiatives are taking significant strides, with the establishment of 13 Task Forces in 2023 engaging industry, academia, think tanks, and various ministries. These task forces are focused on recommending strategies for the decarbonization of the steel sector. Discussions on financial incentives, including concessional finance and long-term loans, are underway, reaffirming the government's commitment to sustainable practices. Working with SMEs would be an area of emphasis.

We also need to boost our research and development efforts. Our academic institutions, research laboratories, think thanks and industry players must combine their efforts towards working on solutions that ensure energy transition and sustainability.

I am confident that this document, coupled with the broader event, will act as a forum for heightened awareness and deeper understanding of eco-friendly steel manufacturing. It is my belief that this collective effort will contribute to the reduction of the carbon footprint within the Indian Steel Industry, thereby shaping a future that harmonizes growth with environmental responsibility. State of the Eastern regions and especially Odisha will have to play a leading role in the journey.

NNS

(Nagendra Nath Sinha)

Message from Odisha State Pollution Control Board

In the pursuit of environmental stewardship, I extend my warmest greetings to all stakeholders engaged in the crucial discourse presented within the knowledge paper, "Sustainable Green Metals: A Catalyst for Decarbonization in the Face of Climate Change."

As Member Secretary of the Odisha State Pollution Control Board, it is both an honour and a responsibility to share reflections on the transformative potential inherent in our collective efforts towards sustainability in the metal industry.

The narrative woven within these pages resonates deeply with the environmental challenges we face and the imperative for sustainable solutions. The metal industry, a cornerstone of economic development, holds the dual responsibility of propelling growth while mitigating its environmental impact. This document serves as a timely reminder of the symbiotic relationship between industrial progress and environmental preservation.

Climate change, a global concern of paramount importance, is intricately linked to the activities of major industries, particularly steel and aluminium. As we explore the implications of climate change both globally and within the Indian context, we must recognise the integral role that industries play in shaping our response to this existential threat. India's Nationally Determined Contributions (NDCs) underscores our nation's commitment to addressing climate change on the global stage.

The focus on decarbonisation within the industry sector, with a spotlight on steel and aluminium production, aligns seamlessly with our vision for a cleaner, greener future. The exploration of circular economy principles and innovative technologies, including digital advancements and alternative energy sources, signals a paradigm shift towards sustainability. These are not just concepts; they represent actionable strategies for reducing our carbon footprint and promoting responsible resource use.

The mining sector, often the starting point of the metal supply chain, assumes a pivotal role in upstream mitigation efforts. Responsible mining practices, align with our ongoing initiatives to strike a balance between resource extraction and environmental preservation.

This transformative journey towards a green and sustainable metal industry is not one that can be undertaken in isolation. This paper underscores the roles of various stakeholders, emphasising collaboration as the cornerstone of successful sustain ability initiatives. It is heartening to witness the acknowledgment of the workforce as architects of this change, necessitating their skill development to meet the challenges of a rapidly evolving industry.

As we navigate the financial requirements for a sustainable transition, the exploration of a green metal market in India is a forward-looking consideration. This aligns with our collective commitment to ensuring that economic growth is not at odds with environmental responsibility.

In conclusion, this knowledge paper stands not only as a compendium of insights but as a rallying call for collective action. It echoes the sentiments of the Odisha State Pollution Control Board in advocating for a balance between industrial growth and environmental well-being. May the discourse presented within these pages guide us in charting a course towards a green, sustainable, and resilient future for the metal industry in India.

Warm regards,

Dr. K. Murugesan, IFS
Member Secretary, Odisha State Pollution Control Board

Message from Biju Patnaik National Steel Institute

I am pleased to extend my warm greetings to all on behalf of Biju Patnaik National Steel Institute (BPNSI). It fills me with immense pride to share our commitment to advancing and sustaining the metal industry, a sector integral to India's economic growth.

Established in 2001 under the Ministry of Steel, Government of India, BPNSI has been at the forefront of reskilling and upgrading the skill sets of diploma/engineering students and the existing workforce in the steel sector. Our vision is to create a sustainable ecosystem for a skilled workforce, aligning with the challenges of a VUCA (Volatility, Uncertainty, Complexity, and Ambiguity) world and the rapid integration of disruptive technologies.

In line with our commitment to addressing the challenges of unsustainable development and climate change, BPNSI is proud to host the National Green Metal Conference'24 in collaboration with the State Pollution Control Board, Odisha. The conference's theme, "Balancing the Metal Eco Systems: Towards Green Sustainability," reflects our dedication to steering the metal industry towards a path of greater sustainability. The conference features an exhibition highlighting current technology trends in Environmental Pollution Control and Monitoring, as well as Circular Economy practices. The main focus areas for this event include technology advancement, alternative energy, sustainable mining, circular economy, green financing, and capacity augmentation through skilling, among others.

As we stand at the crossroads of industrial progress and environmental stewardship, this knowledge paper, "Sustainable Green Metals: A Catalyst for Decarbonization in the Face of Climate Change," is not merely an academic endeavor but a call to action, urging all stakeholders – industries, policymakers, researchers, and society at large – to collaborate in reshaping the narrative of the metal industry. It serves as a guide and an inspiration for a future that is not only economically vibrant but also environmentally resilient.

The emissions from major industries, particularly steel and aluminum, are dissected within these pages. With a focus on India, we delve into the country's commitment to global climate goals, as evidenced through its Nationally Determined Contributions (NDCs). The report also explores the key targets taken by other major countries to reduce GHG emissions and achieve net-zero targets. The paper also highlights major initiatives taken by top metals and mining companies across the world and in India to reduce their overall emission intensity. It requires orchestrated efforts from various stakeholders—industry leaders, policymakers, communities, and the workforce. Their roles are articulated within these pages, emphasizing the symbiotic relationships necessary for true sustainability. Skill development emerges as a crucial linchpin, ensuring that the industry is equipped with the expertise to navigate the complexities of a rapidly evolving green landscape. This foresight positions the workforce as the architects of a greener future.

I express my heartfelt gratitude to Grant Thornton Bharat LLP for playing a crucial role as the Knowledge Partner for this event and their involvement in the creation of the knowledge paper. Their expertise, dedication to sustainability, and collaborative approach have greatly enhanced the quality and influence of this document. Their extensive efforts in developing this knowledge paper, including conducting surveys to assess the current status of decarbonization initiatives in the Odisha Steel Sector, has been invaluable.

In conclusion, as we embark on this collective journey, let us seize the opportunities presented, think in terms of solutions, and work towards a greener and more sustainable future. I extend my gratitude to all contributors, partners, and supporters who have played a role in this endeavor.

Warm regards,

Pritam S. Purkayastha
Director, Biju Patnaik National Steel Institute

01

Introduction

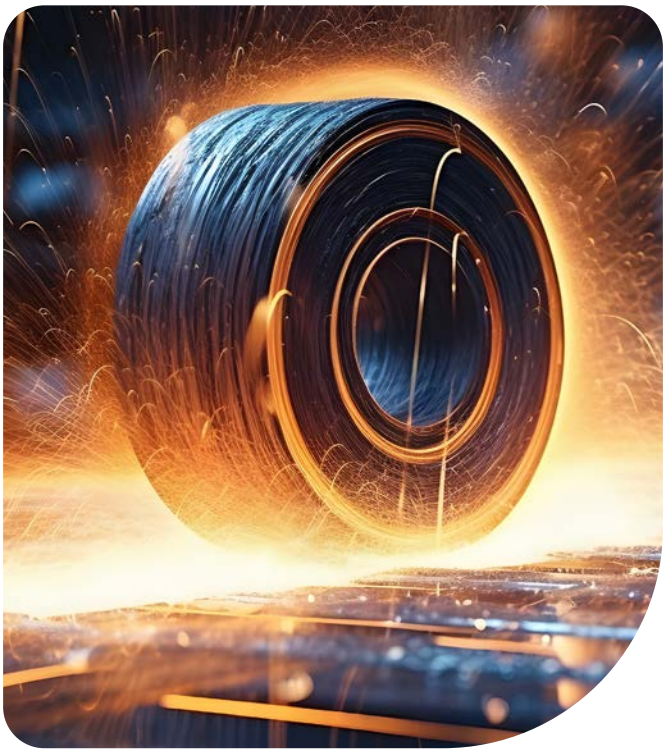
Introduction

Metals are essential to modern living, supporting infrastructure growth, everyday conveniences, and technological advancement. Metals include iron and steel, tools and cutlery, articles made of iron, steel, aluminium, copper, nickel, ceramite, zinc and lead, among other things. These are crucial to advancing society in various fields, including technology, infrastructure, healthcare, and transportation. The metals and mining sector is the backbone of India's industrial and infrastructure growth. From steel in the automotive industry to the copper used in the construction of Ram Lala Mandir in Ayodhya, the industry supplies vital raw materials to many other industries. Therefore, the expansion of the metals sector is essential to any country's total industrial development.

Metals also play an important role in driving current trends, especially in the shift towards electric vehicles (EVs) and other emerging technologies. Essential metals such as lithium, cobalt and nickel are crucial for producing high-performance EV batteries, while copper and aluminium play key roles in EV components. In renewable energy (RE) technologies, copper is widely used for its conductivity, and rare earth elements contribute to the efficiency of wind turbines and EV motors. Metals such as gold, silver and rare earth elements are used in the production of smartphones and electronics. Steel and aluminium are also crucial for infrastructure development and titanium in aerospace and medical devices.

However, most heavy metals cause environmental and atmospheric pollution, and are lethal to humans.
The production of metals, especially through traditional methods such as smelting, is energy-intensive and releases significant amounts of carbon dioxide (CO2) into the atmosphere. By adopting cleaner and more sustainable practices, such as using renewable energy sources and implementing advanced technologies, the industry can contribute to global efforts in achieving carbon neutrality.

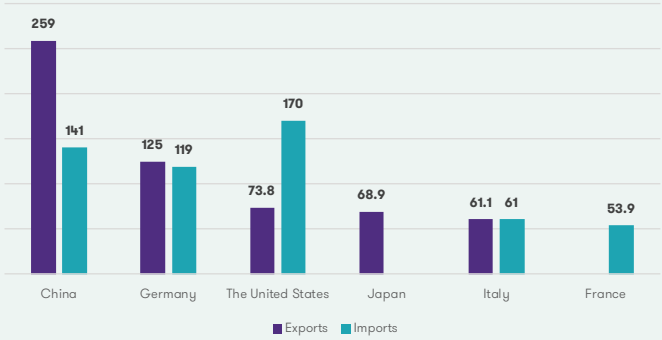
Metal sector is also a significant source of employment for developing countries. Globally, the steel and aluminium sector provides employment to around 7.6 million people.[1 2] The demand for metals is expected to increase in emerging economies where economic welfare is rising along with population expansion. The Government of India has launched a focus program for critical minerals exploration and auction. Needless to say, this extremely important segment of the metals industry is also on the cusp of a major expansion. Processing and extraction of metals from these minerals will require sensitive handling of environmental conditions.



The importance of metals in global trade

With a total trade value of USD 1.63 trillion in 2021[3], metals rank as the fifth-most traded product globally. Trade in metals represent 7.75% of total world trade.[4] In 2021, China (USD 259 billion), Germany (USD 125 billion), the US (USD 73.8 billion), Japan (USD 68.9 billion), and Italy (USD 61.1 billion) were the largest metal exporters. The US (USD 170 billion), China (USD 141 billion), Germany (USD 119 billion), Italy (USD 61 billion), and France (USD 53.9 billion) were the largest metal importers.[5]

Trade in Metals (in billion USD)



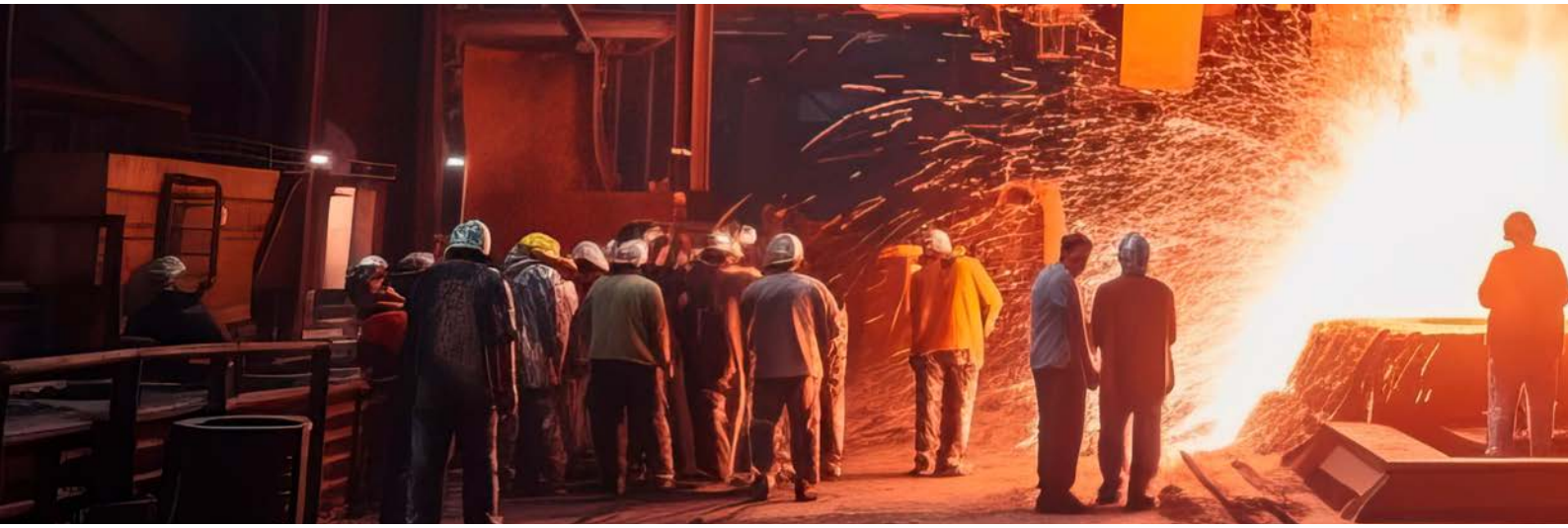
Indian metals industry: Overview

The metal industry's rapid expansion is a major factor in the development of new jobs, technology, and general economic prosperity. Furthermore, the metals industry acts as a booster for the growth of ancillary services and downstream businesses, multiplying its impact on associated sectors. India has extensive plans for urbanisation, industrialisation, and infrastructure development, which puts increased pressure on the metal industry to meet the growing demand for metal goods.

To support the expansion of the metals and mining industry, the government has developed several beneficial policies, including the National Mineral Policy, 2019 and the Mines and Minerals Development & Regulation Act (MMDR) 2021. There are 608 metallic mineral mines in India as of 2020-21.[6]

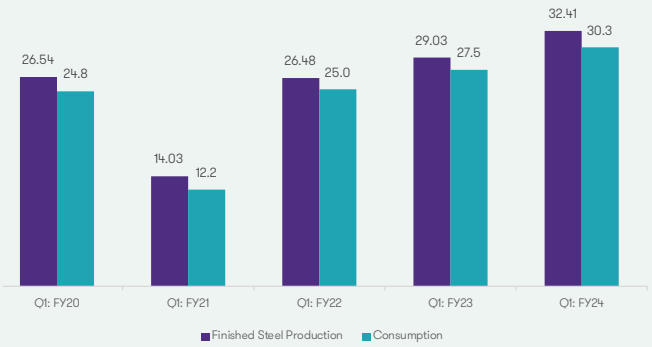
The goal of the Mines and Minerals (Development and Regulation) Amendment Act, 2023, which amends the Mines and Minerals (Development and Regulation) Act, 1957 is strengthening the exploration and extraction of vital minerals necessary for India's economic development and national security. Major amendments of this bill are:

1. Six minerals (lithium, beryllium, niobium, titanium, tantalum, and zirconium) are being removed from the list of 12 atomic minerals that state agencies are only allowed to explore.[7] This allows the private sector to get involved in mining and exploration.
2. Central Government is being provided the authority to sell mineral concessions at auction only in order to get vital minerals such rare earth elements, phosphate, graphite, cobalt, lithium, nickel, phosphate, potash, and tin. The concerned state governments will get the proceeds from these auctions, which will quicken the pace of auctions and production for crucial sectors, including electronics, space, and the transition to energy.
3. Exploration licenses (EL) have been introduced to draw in foreign direct investment (FDI) and encourage junior mining companies to investigate essential and deep-seated minerals such as rare earth elements, gold and platinum. The goal of the amendment is to improve the legal climate to attract foreign direct investment and junior mining firms.



Steel: Steel contributes around 2% to India's GDP.[8] During FY2023, 123.20 MT of total finished steel were produced, an increase of 8.5%.[9] The production of pig iron decreased by 6.4% to 5.86 MT.[10] Production of sponge iron was 43.62 MT, an increase of 11.3%.[11] Domestic crude steel capacity increased from 137.97 MT in 2017–18 to 154.06 MT in 2021–22, at a compound annual growth rate (CAGR) of 3.7%.[12] Total crude steel capacity of 300 MT has been projected for FY2031 against the demand projections of 255 MT.[13] The Ministry of Steel is providing financial assistance for R&D in technological aspects of the iron and steel sector.[14]

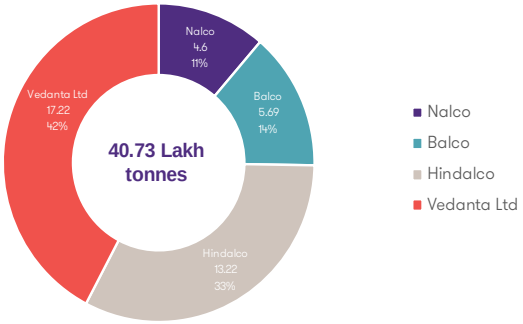
Fininshed Steel Production and Consumption



Aluminium: Aluminium contributes approximately 2% to India's overall manufacturing GDP.[15] After iron and steel industries, the aluminium industry is the second-most significant sector.[16] In 2023–24 (April–June), the global production of primary aluminium metal was approximately 17.35 million tonnes, whereas the global consumption was 17.72 million tonnes resulting in a 0.37 million tonnes market deficit.[17] Aluminium production in India reached 4 million tonnes in 2022, making it the world's second-largest producer.[18] Production by some of the major aluminium producers in India during FY2022-23 is as follows.[19]

The alumina extraction plant for aluminium factories, which uses bauxite ore, needs to be located close to cheap energy sources, i.e., electricity and hybrid power supplies. In the past sixty years, it has increased by almost 20 times, making it the fastest-growing metal (other metals have grown by 6–7 times).[20] Other than the aluminium smelter, Upstream and downstream are the two main segments that make up the aluminium business.

Major Aluminium producers in India (FY23)



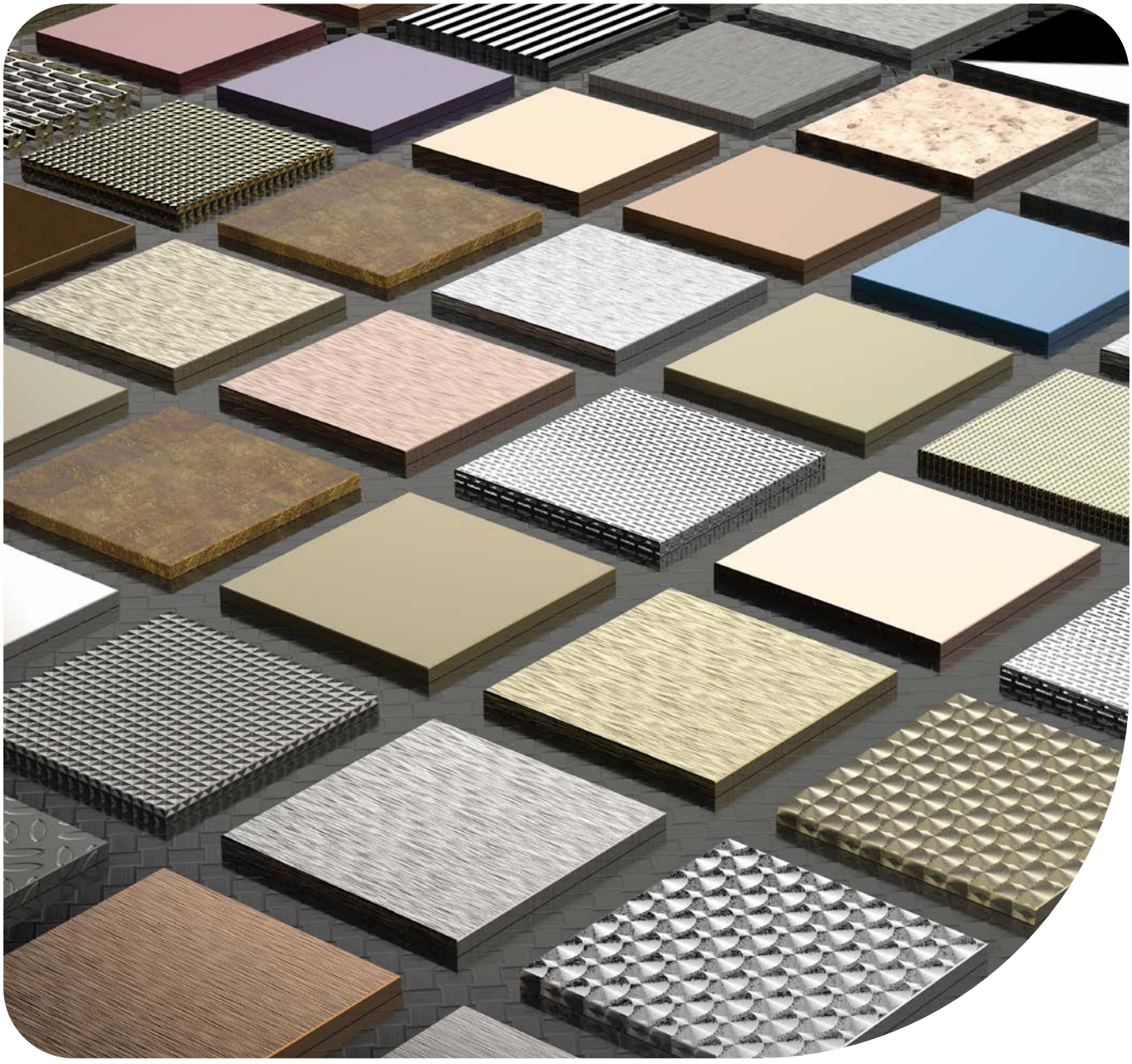
- The upstream industry mines bauxite to provide raw materials for the production of primary aluminium.
- The downstream industry involves turning aluminium into semi-finished products such as forging, castings, rods, and bars, among other things.

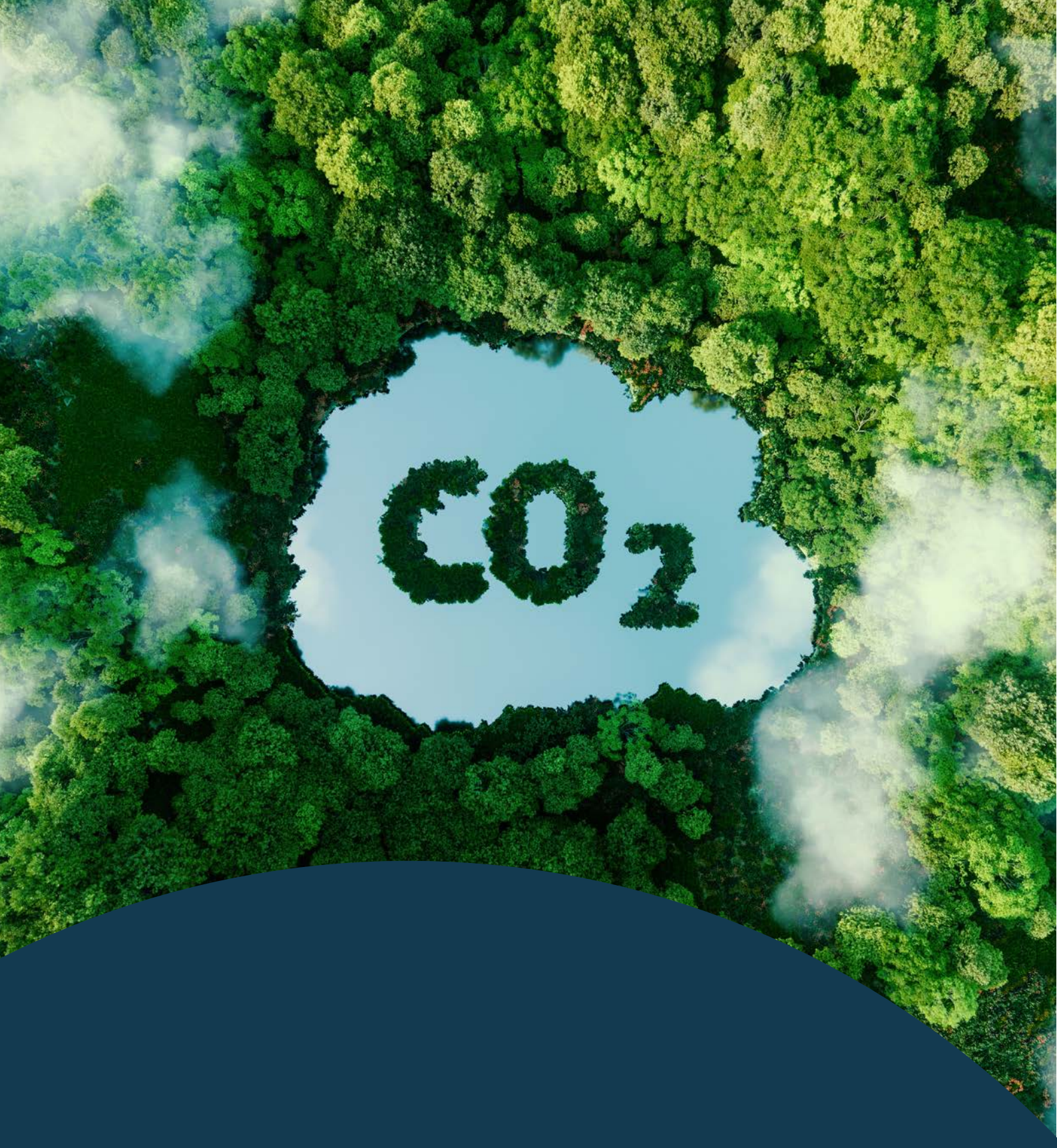
Zinc[21]**:** In April-May 2023, the global production of zinc metal was approximately 2,342,000 metric tonnes, whereas the global consumption was 2,252,000 metric tonnes. In April 2023, India's proportion of global zinc metal production was 6%. Hindustan Zinc Limited, Glencore Plc, Boliden and Nexa Resources are some of the largest zinc producers in the world.

Lead[22]**:** In April–May 2023, the global lead metal output was approximately 2,104,000 metric tonnes, whereas the global lead metal consumption was 2,078,000 metric tonnes. In April 2023, India produced 8% of global lead metal production. Leading lead producers are Glencore Plc, Vedanta Resources Ltd, South32 Ltd, Teck Resources Ltd, Industrias Penoles SAB de CV and Boliden AB.

Copper[23]**:** Between June 2022 and May 2023, the global production of copper mines was around 22,088 thousand metric tonnes (TMT). India's contribution to global output from May 2022 to April 2023 was 25.03 TMT, i.e., 0.11%. Some of the world's leading copper producers are Codelco, BHP Group, Glencore, Freeport-McMoRan and Southern Copper. The three largest manufacturers of refined copper in India are Sterlite Industries, Hindalco Industries, and Hindustan Copper Ltd.

The annual consumption of refined copper in the Indian copper sector is approximately 6.6 lakh tonnes, representing 3% of the global copper market.[24]





02

Climate change and its impact

Climate change and its impact

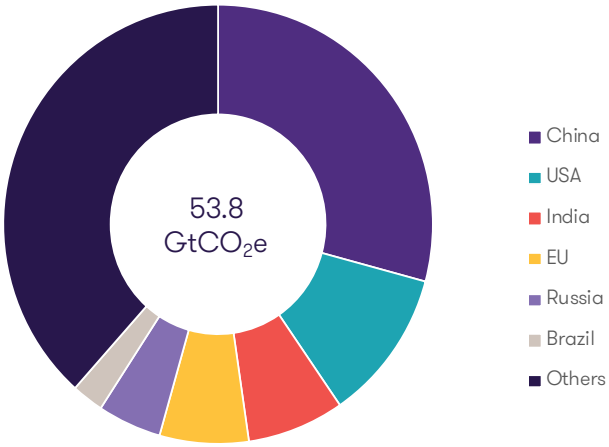
Changes in earth's climate brought about by increased human emissions of heat-trapping greenhouse gases (GHG) are already having a significant effect on the environment — glaciers and ice sheets are retreating, lake and river ice is melting earlier, animal and plant ranges are shifting, and trees and plants are blooming earlier. The repercussions of global climate change will include sea ice loss, rapid sea level rise, and longer, more extreme heat waves. At least 10,967 species on the IUCN Red List of Threatened Species TM are currently impacted by climate change, which raises the possibility that they may go extinct.[25]

The current production of 2 billion tonnes of metals and alloys per year is responsible for around 40% of all industrial GHG emissions, using 10% of the world's energy resources and 3.2 billion tonnes of minerals for primary synthesis.[26] Metals must, therefore, become more sustainable. Furthermore, massive volumes of tailings, removed overburden, and residual and waste products are produced during mining, production, and processing. These materials, including mineral gangue, dusts, and processing wastes, have a combined volume roughly 15-20 times greater than the entire amount of metal produced.[27] The steel and aluminium industries alone are responsible for roughly 8% and 2% of direct global carbon dioxide emissions in 2022.[28] [29]

The most significant impact of climate change is that if global temperatures rise by 3.2°C by 2050, it may wipe out up to 18% of GDP from the global economy.[30]

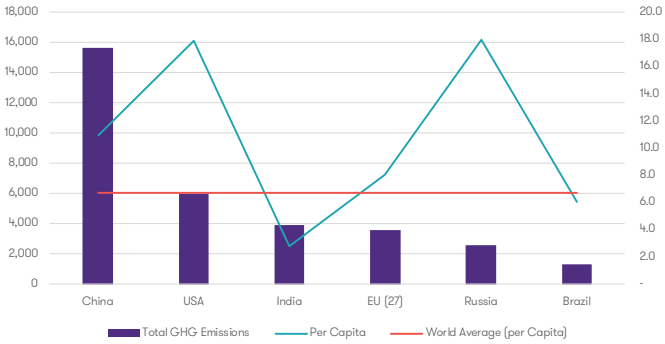
Five countries that are responsible for more than 50% of GHG emissions are China (12,705.1 MtCO2e), the US (6001.2 MtCO2e), India (3394.9 MtCO2e), the EU (3383.4 MtCO2e) and Russia (2476.8 MtCO2e).[31]

% of GHG Emissions- 2022



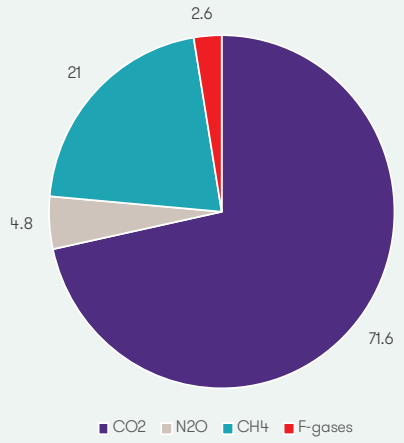
However, the per capita GHG emissions show an entirely different picture. Per capita GHG emissions for the above five countries are as below[32]

GHG emissions: Country wise



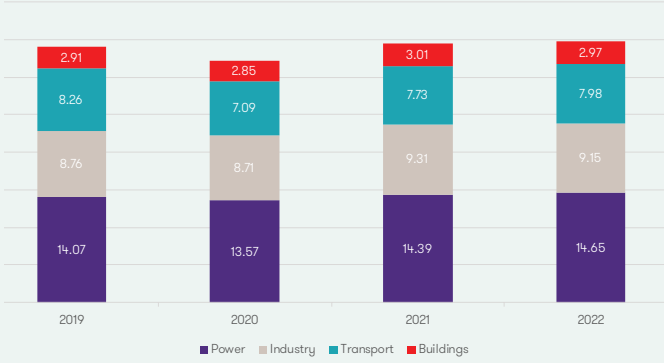
Carbon dioxide (CO2) is the most common and persistent GHG causing climate change, and hence CO2 emissions are important when considering total GHG emissions. Its lengthy atmospheric lifetime, which increases its impact on global warming and makes it a primary target in attempts to slow down climate change, accounts for its relevance. Following is the share of CO2 emissions in overall GHG emissions[33]

Share of different gases in GHG emission (2022)



CO2 emissions from four of the main sectors, i.e., Power, Industry, Transport and Buildings as in 2022 is as follows[34]

Global CO2 emissions by sector



Emissions from Major Industries

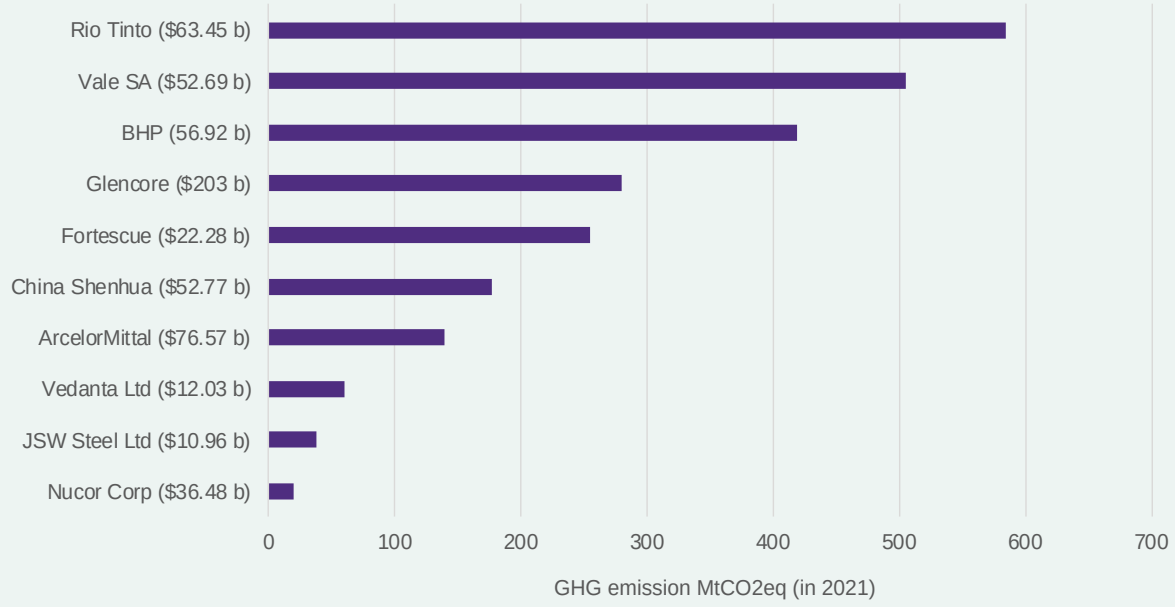
One of the primary reasons of the increasing global warming trend is GHG emissions. Methane, NOx, and CO2 are among the major GHGs released by burning fuel, using on-site power, and other sources.[35] The iron and steel sector contributed 6.1% to world GHG emissions in 2020.[36]

CO2 emissions intensity of crude steel cast is 1.91 tonnes CO2 per tonne of production in 2021 and 2022 globally and the energy intensity of the same was 20.99 GJ per tonne of crude steel cast.[37] Primary aluminium smelting emission intensity is 1.6 tonnes of CO2e per tonne and energy intensity of 14,103 Kilowatt hours (kWh) per tonne of production.[38]

Energy intensity is measured as the amount of energy used per unit of economic output (e.g., energy used per unit of GDP). Improvements in energy intensity indicate that less energy is being used to produce a given level of economic output, which is often seen as a positive development in terms of energy efficiency. The average annual growth rate in energy efficiency decreased to 0.6% in 2020 from 1.8% in the previous ten years[39] primarily because of the travel bans and lockdowns brought on by the Covid-19 epidemic, as well as important changes in the world economy that occurred at the same time as the first lockdowns. Due to rise in energy consumption, the growth in energy intensity decreased in 2021 as well.[40] With several energy efficiency policies announced globally, energy intensity is expected to decrease by 2.4% yearly from 2021-2030 on average.[41]

Introducing the corporate environmental footprint: The graph below shows the total greenhouse gas emissions of the top 10 revenue-generating organisations. This overview explains the crucial part these organisations play in relation to total emissions.[42]

Total GHG Emissions by Revenue (2021, MtCO2eq)



Indian Context

The "Assessment of Climate Change over the Indian Region," released in 2020 by the Ministry of Earth Sciences (MoES), provides a thorough analysis of the effects of climate change on the Indian subcontinent. The report highlights that-

- Average temperatures in India increased by about 0.7 degrees Celsius from 1901–2018.[43]
- There was a roughly 75% rise in the frequency of daily precipitation extremes from 1950 to 2015.[44]
- There was a considerable increase in both the frequency and geographic area of droughts in India during 1951–2015.[45]
- Over the past 25 years, the North Indian Ocean has seen an increase in sea level of 3.3 mm year (1993–2017).[46]
- Around the Arabian Sea, the frequency of severe cyclonic storms has increased in the post-monsoon seasons.

According to the Reserve Bank of India's most recent report, labour hours missed due to intense heat and humidity might put as much as 4.5% of India's GDP at risk by 2030. It is predicted that by 2030 eight crore jobs worldwide could be lost due to heat stress, of which roughly 3.4 crore would be lost in India.[47]

03

Global response to climate change

Global response to climate change

This section highlights important international agreements and promises, particularly those made in the Conference of the Parties (COP) summits from COP21 through COP28, in recognition of the industry's significant and difficult to reduce carbon impact. Understanding these international agreements is vital for the industry to synchronise its approaches to reduce carbon emissions with worldwide climate goals.

The Intergovernmental Panel on Climate Change (IPCC) categorically states that CO2 emissions from burning fossil fuels are the main cause of climate change caused by human activity. Significant global warming as a result has had dire repercussions, such as increased sea levels, extreme weather, and a decline in biodiversity. In response, the global community has worked together under the United Nations Framework Convention on Climate Change (UNFCCC) to reduce greenhouse gas (GHG) emissions worldwide in an effort to lessen these effects.

The primary governing body of the UNFCCC is the Conference of Parties (COP) made up of delegates from each nation that have ratified the UNFCCC. Its responsibility is to assess the results of the Parties' efforts to mitigate climate change and ensure they are consistent with the main goals of the UNFCCC. These conferences have put pressure on industries, including steel, to commit to a low-carbon future.

COP21

The 2015 COP21 summit held in Paris marked a pivotal shift in the global response to climate challenges. This gathering led to the formulation of the Paris Agreement wherein, participating nations committed to striving for a maximum global temperature increase of 1.5°C–2°C above pre-industrial levels (UNFCCC, 2015). A central aspect of this accord is the adoption of Nationally Determined Contributions (NDCs), where countries outline their tailored plans and objectives for emission reduction. This approach fosters collaborative efforts on a global scale, adapted to the unique circumstances of each nation. In sectors like steel production, the mandate is crystal clear: substantial cuts in carbon emissions are imperative to fulfill national and international climate commitments.[48]

COP22 to COP25

The focus of the conferences followed by COP21 was to take forward the goals announced in Paris. While establishing the framework for the Paris Agreement's rules, the 2016 COP22 in Marrakech focused on the critical role that financial support plays for climate efforts, particularly for developing nations (UNFCCC, 2016). Under Fiji's leadership, the COP23 summit in Bonn in 2017 brought attention to the need to develop climate resilience and the urgent need for aid for countries most vulnerable to climate-related disasters (UNFCCC, 2017).

With the release of the Katowice Rulebook, which provided a comprehensive manual for carrying out the Paris Agreement and included topics like transparency, adaptation, emission reductions, and financial contributions, COP24 in Katowice in 2018 was a significant occasion (UNFCCC, 2018). Afterwards, the 2019 COP25 in Madrid emphasised the need for increased ambition in NDCs and initiated important conversations about carbon trading schemes, which are crucial for many industries, including steel, to consider when trying to achieve carbon neutrality (UNFCCC, 2019).

COP26

The aims set in Paris were to be realised, and that was the primary objective of the COP26 meeting, which was held in Glasgow in 2021. Prominent developments included increased reduction pledges from many countries, proclamations to end coal use, and more funding for developing country adaptation and mitigation strategies to climate change. The steel industry placed special emphasis on the faster adoption of eco-friendly technologies and the promotion of collaborations between public and private sectors to develop and implement solutions for reducing carbon emissions. Following COP21, signatory countries are more aware of their financial and bureaucratic responsibilities. COP26 forced countries to ratify the controversial "Loss and Damages" Article VI. Moreover, it is the first COP to address certain forms of power generation specifically. India advocated for the "phase-down" of coal-fired power generation alongside China. Of the many significant discussions, the following stood out the most:

1. The Glasgow Agenda: Forty-plus[49] governments have pledged to support renewable energy and cut emissions in most polluting industries, including steel, hydrogen, electricity, and transportation.
2. The Global Coal to Clean Energy Transition is an international agreement backed by more than 40 nations that aims to phase out the use of coal in developed nations by 2030 and in poor nations by 2040.
3. The Global Methane Pledge: One hundred nations have committed to reducing their methane emissions by 30% by 2030. This is consistent with the most recent IPCC report, which states that greenhouse gases account for 30–40%[50] of temperature increases.
4. New markets for low-carbon steel, cement, and concrete are to be supported by the UK, UAE, India, Germany, and Canada. They have promised to reach net zero in concrete and steel used in major public building by 2050.

COP27

The 2022 Sharm El Sheikh hosted COP27, which signalled a turning point in the worldwide conversation on climate change. At this conference, which was chaired by Egypt's Minister of Foreign Affairs, Sameh Shoukry, 92 heads of state and 35,000 participants worked together to develop concrete climate action plans.[51] UN Climate Change Executive Secretary Simon Stiell underlined that COP27 focused on "every corner of human activity" coinciding with the 1.5°C objective, in contrast to past conferences that prioritised plan formulation.

A major achievement of COP27 was the agreement to provide cash to nations badly affected by climate disasters. This ruling acknowledged that funding was required to compensate for losses and damages brought on by climate change. In addition, countries reaffirmed at the conference their commitment to keeping the rise in global temperature to 1.5°C over pre-industrial levels, and they emphasised the role that renewable energy sources play in the battle against climate change.

Additionally, money came up as a key issue. According to the Sharm el-Sheikh Implementation Plan, USD 4-6 trillion[52] must be raised annually to transform the economy into a low-carbon one.

COP28

The world committed in 2015 at COP21 to keep global warming to 1.5°C over pre-industrial levels by 2050. Emissions must be cut in half by 2030[53] in order to stay on course. The UAE's COP28 offers a prime chance to rethink, reboot, and refocus the climate agenda.

Climate, nature and people:

Acknowledging the imminent threats posed by climate change to biodiversity and livelihoods, and recognising the interconnected impacts of nature loss, greenhouse gas emissions, and hindrance to sustainable development, there is a need to commit for addressing climate change, biodiversity loss, and land degradation holistically.

Objectives:

1. Enhancing synergies in national climate, biodiversity, and land restoration plans, emphasising coherence between Nationally Determined Contributions, National Adaptation Plans, and National Biodiversity Strategies and Action Plans.
2. Scaling finance and investments for climate and nature, ensuring inclusive and equitable access, with a focus on nature-based solutions and ecosystem-based approaches.
3. Ensuring the full representation and participation of indigenous peoples, local communities, women, girls, youth, and other vulnerable groups in implementing climate and biodiversity plans, respecting rights and traditional knowledge.
4. Promoting a whole-of-society approach in planning, involving indigenous peoples, local communities, civil society, the private sector, financial institutions, academic institutions, and subnational authorities.
5. Encouraging coherence and interoperability across data sources and reporting frameworks for climate change, biodiversity, and sustainable land management.

Declaration on Hydrogen:

There is a necessity for increased collaborative efforts on a global scale to tackle climate change, expedite the worldwide shift towards sustainable energy, and ensure international energy security. Simultaneously, these efforts should promote sustainable economic growth and advance environmentally friendly industrialisation.

Intentions:

1. To collaborate on mutual recognition of their respective certification schemes to facilitate the establishment of a global market for renewable and low-carbon hydrogen and its derivatives
2. To expedite the development of technical solutions for this recognition, with a focus on cooperation within the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) and the Hydrogen Technology Cooperation Programme (Hydrogen TCP)
3. To appoint government experts to IPHE and Hydrogen TCP to contribute to relevant solutions
4. To align with globally recognised standards such as the ISO methodology for assessing greenhouse gas emissions in hydrogen production and transport
5. To monitor progress on this cooperation annually

Cooling pledge:

In order to achieve the 1.5° C global temperature, there is a need for sustainable cooling as a climate mitigation, which serves as a dual-purpose strategy for climate mitigation and adaptation. This involves the reduction of GHG emissions, mitigating heat stress, promoting human well-being, minimising food loss, improving access to healthcare and medicines, and facilitating equitable energy transitions.

Pledge:

1. To integrate cooling measures into an existing strategy or action plan, or establish a Heat Action Plan by 2026, aimed at addressing and adapting to urban heat through implementing sustainable cooling solutions.
2. To substantially expand both the size and quality of green and blue spaces in urban settings for cooling purposes by 2030.
3. To actively engage in the public procurement of cooling technologies with low global warming potential and high efficiency, prioritising the lowest lifecycle cost for government buildings by 2030

Gender-responsive:

1. Reaffirm previous conference outcomes and international agreements on gender equality, sustainable development, and climate action.
2. Recognise and emphasise the crucial roles of women and girls in decision-making, governance, and finance for climate action, stressing the importance of their full participation and leadership.
3. Acknowledge the disproportionate impacts of climate change on women and girls, emphasising the need to address intersecting inequalities and promote secure land rights.
4. Commit to advancing a "Gender-Responsive Just" Transition by incorporating human rights, encouraging gender-responsive strategies, implementing budgeting and policy measures, and enhancing funding access for women and girls in climate-affected regions.
5. Support collaboration, sharing of best practices, and efforts across sectors to counteract negative consequences and ensure the benefits of transitioning to a Paris Agreement-aligned economy, including addressing unpaid care and domestic work and promoting gender equality in transparency reports.

Agriculture, Food and Climate:

There is significant potential in agriculture and food systems to promote strong and creative solutions to climate change and unlock universal prosperity.

Intentions:

1. Foster inclusive engagement in our national contexts to integrate agriculture and food systems into key strategies like National Adaptation Plans, Nationally Determined Contributions, and National Biodiversity Strategies before COP30.
2. Review and align policies to boost incomes, reduce greenhouse gas emissions, enhance resilience, and address food loss and waste, alongside ecosystem health and productivity in agriculture and food systems.
3. Increase access to finance from various sectors, including public, philanthropic, and private, using blended instruments and partnerships, to adapt and transform agriculture and food systems for climate resilience.
4. Promote science-based innovations, including indigenous knowledge, to enhance sustainable productivity, ecosystem resilience, and livelihoods in agriculture, benefiting rural communities and smallholders.
5. Strengthen the World Trade Organization-centered multilateral trading system, ensuring it is open, fair, transparent, and inclusive.

Renewables and energy efficiency:

The projections from the International Energy Agency and the International Renewable Energy Agency indicate that in order to keep global warming to 1.5°C, the world will need triple the amount of renewable energy capacity by 2030—that is, at least 11,000 GW—and double the average annual rate of improvement in energy efficiency worldwide from about 2% to over 4% until 2030.[54]

Declarations:

1. Work together to fortify resilient value chains and advance technology development, emphasising voluntary transfers under mutually agreed terms and conditions.
2. Increase financial backing for expanding renewable energy and energy efficiency programs in emerging markets and developing economies. This involves leveraging investment from diverse sources, including the private sector, multilateral development banks, and philanthropic entities.
3. Collaborate on creating accessible financing mechanisms to reduce the cost of capital in emerging markets and developing economies.
4. Strengthen technical support and capacity-building initiatives for renewables and energy efficiency in developing economies.
5. Expedite the development of cross-border grid interconnections to enhance the efficiency and effectiveness of energy distribution systems.

Climate Relief, Recovery and Peace:

1. Scale up financial resources for climate adaptation, emphasising the importance of public and grant-based funding, and mobilise diverse financing sources while ensuring environmental and social safeguards
2. Improve access to financial resources by enhancing predictability, flexibility, and simplifying procedures, including application, accreditation, procurement, and monitoring and evaluation
3. Strengthen the technical and institutional capacity of national governments and local actors to effectively absorb, account for, report on, allocate, and leverage climate finance
4. Prioritise local ownership, impact, and results, channeling finance at the local level and working collaboratively with affected communities, local governments, and non-government partners
5. Leverage private sector support and adopt tailored financial instruments to mobilise new sources of finance for national and local climate responses, while monitoring and reporting on commitment and disbursement.

Climate and Health:

To better prepare communities and the most vulnerable people for the effects of climate change, as well as to work towards ensuring better health outcomes, particularly through the transformation of health systems to be climate-resilient, low-carbon, sustainable, and equitable.

1. Advocate for increased investments in climate and health, urging contributions from various sources such as domestic budgets, multilateral development banks, climate funds, health financing institutions, philanthropies, bilateral agencies, and private sectors.
2. Encourage international finance providers, including development banks, to strengthen collaboration between climate and health portfolios, supporting country-led projects at the intersection of health and climate.
3. Share knowledge and best practices in financing and implementing climate-health interventions, emphasising identifying needs based on country priorities. Acknowledge ongoing efforts by COP28 presidency, the ATACH finance working group, and the joint Development Bank working group.
4. Enhance monitoring, transparency, and evaluation of climate finance, particularly in climate-health initiatives, to ensure efficiency, effectiveness, and positive health outcomes.
5. Integrate health considerations into relevant Paris Agreement and UNFCCC processes to minimise adverse impacts on public health. Mainstream climate considerations in global health work programs, including those led by the World Health Organization. Consider health in the design of nationally determined contributions, long-term low greenhouse gas emission development strategies, national adaptation plans, and adaptation communications.

Climate finance:

1. Green economy investment: Invest USD 5-7 trillion annually by 2030 for inclusive, low-carbon, and nature-positive growth. Utilise initiatives like the Paris Pact, Bridgetown Initiative, and G20 New Delhi Leaders' Declaration.[55]
2. Climate finance commitments: Deliver on the USD 100 billion annual mobilisation goal for meaningful mitigation and double adaptation finance.[56] Support Green Climate Fund, Adaptation Fund, and loss and damage response funding.
3. Fiscal resilience: Ensure climate-resilient debt structures, debt-for-climate swaps, and sustainability linked bonds. Rechannel additional IMF Special Drawing Rights and fully implement the Common Framework for Debt Treatments.
4. Concessional finance expansion: Explore innovative mechanisms like hybrid capital, policy-based guarantees, and philanthropy. Re-channel subsidies and employ emissions pricing for non-debt financing, especially in adaptation.
5. Inclusive transitions: Provide concessional resources for private finance, knowledge transfer, and technology adoption in developing countries. Base efforts on robust domestic climate policies, commitments, and adaptation strategies.
6. Country platforms: Establish country-owned investment platforms for energy, forests, biodiversity, water, and adaptation. Develop investment pipelines collaboratively with multilateral institutions and private sector finance.

High ambition multilevel partnerships:

Coalition for High Ambition Multilevel Partnerships (CHAMP) to strengthen collaboration with subnational governments in planning, financing, implementing, and monitoring climate strategies. This includes activities like Nationally Determined Contributions (NDCs), National Adaptation Plans (NAPs), National Biodiversity Strategies and Action Plans (NBSAPs), and Long Term Low-Emission Development Strategies (LT-LEDS).

1. Engage with sub-national governments to identify avenues for their contribution to national mitigation and adaptation efforts, involving them in the implementation and monitoring of national commitments
2. Work with sub-national governments to unlock and implement mitigation and adaptation opportunities at the local level, involving them in the design and enhancement of national commitments
3. Establish inclusive processes for subnational governments to contribute to enhancing NDCs before COP30 in 2025, integrating local baseline information, targets, and actions for emissions mitigation and adaptation
4. Include subnational government projects in climate-related investment priorities and support their access to resources from public and private financial institutions for implementation, including project preparation, pipeline development, and policy reform
5. Conduct regular and inclusive country-led reviews of CHAMP commitments' progress at national and subnational levels, aligning with existing processes like the Voluntary National Review of the 2030 Agenda for Sustainable Development
6. Participate in a global high-level political dialogue on multilevel climate action before COP29 and COP30, sharing experiences and lessons learned among endorsers of CHAMP and contributing to the Ministerial Meeting on Urbanisation and Climate Change

The 1.5 C climate benchmark status

The primary goal of the Paris Agreement is to maintain global temperature rise below 2 degrees Celsius above pre-industry levels in order to fortify the global response to the issue of climate change and further continue working at keeping the increase in temperature to 1.5 degrees Celsius[57] as according to researchers, going above 1.5 degrees increases the risk of warming-related catastrophes. According to a report released by the World Meteorological Organisation in May-2023, there is a strong probability that annual average near-surface temperature will rise above 1.5 degrees Celsius between 2023 to 2027 and there in 98% likelihood that, at least one of the year or the next 5 year as whole will be warmest on record.[58]

According to WMO predictions, the average global temperature is expected to fluctuate between 1.1 and 1.8 degrees Celsius[59] over pre-industrial levels for each of the ensuing four years. The IPCC states that to keep the planet's long-term average temperature below the 1.5-degree threshold, net zero emissions must be achieved by 2050.[60]

04

Nationally Determined Contributions (NDCs)

Nationally Determined Contributions (NDCs)

Nationally Determined Contributions (NDCs) are a key component of the Paris Agreement, which is an international treaty adopted in 2015 to address climate change. The NDCs represent the efforts and contributions that each country pledges to undertake in order to mitigate and adapt to climate change. Each country that is a party to the Paris Agreement is required to submit its own NDC, outlining its climate action plans and commitments. NDCs set by the top countries are as follows:

China

On June 30, 2015, China submitted its Intended NDC, outlining its commitments to climate change mitigation and adaptation beyond 2020. The NDC includes the following key objectives:

I. To reach the peak of its CO2 emissions by approximately 2030, with efforts to achieve this target sooner if feasible.
II. To reduce CO2 emissions per unit of GDP by 60–65% by 2030[61], relative to 2005 levels.
III. To increase the proportion of non-fossil fuels in its primary energy mix to around 20%[62] by 2030.
IV. To augment its forest stock volume by about 4.5 billion cubic meters[63] above 2005 levels by 2030.
V. Proactive approach to adapting to climate change, involving capacity-building, effective risk management in sectors like agriculture and forestry, and the enhancement of early warning and emergency response systems.

The US

I. To reduce net greenhouse gas emissions by 50-52%[64] below 2005 levels by 2030.
II. Deployment of zero-carbon solutions, anticipating benefits like job creation, improved health, and reduced local air pollution.
III. To stand with affected workers and communities, ensuring well-paid employment in the low-carbon economy and reaffirming a commitment to environmental justice.
IV. Sector-specific pathways for electricity, transportation, buildings, industry, and the land sector, including reaching 100% carbon pollution-free electricity by 2035[65] and reducing emissions across various modes of transportation.
V. To reduce emissions from forests, agriculture, and non-CO2 greenhouse gases, supporting climate-smart agricultural practices, reforestation, and measures to reduce short-lived climate pollutants.
VI. A whole-of-government approach is emphasised, promoting collaboration between federal, subnational governments, civil society, and the private sector to achieve these goals.

Russia

I. To reduce greenhouse gas emissions by 70%[66] below the 1990 level by 2030, considering the absorptive capacity of forests and ecosystems, and ensuring sustainable socio-economic development.
II. Forming a national climate change adaptation system, considering a differentiated approach based on natural-climatic, socio-economic, and technological specifics.
III. The adaptation system is based on principles such as a differentiated approach, staging and consistency of planning, and the integrity of planning, covering preventive and post-crisis adaptation measures.
IV. The National Action Plan for the first stage of adaptation includes the formation of methodological and statistical bases, priority measures for economic sectors, regions, and the preparation of a national action plan for the second stage of adaptation.

India's NDCs

I. The 2015 Nationally Determined Contribution comprised eight goals, three of which had quantifiable targets until 2030, which are:
II. Cumulative electric power installed capacity from non-fossil sources to reach 40%[67]
III. In comparison to 2005 levels, reduce the GDP's emissions intensity by 33 to 35%[68]
IV. By adding more forest and tree cover, create an extra 2.5–3 billion tons of CO2[69] equivalent of carbon sink.

At COP26[70], India set the crucial targets to-

I. Reach 500GW non-fossil energy capacity by 2030
II. Meet 50% of its energy requirements from renewable energy by 2030
III. Reduce total projected carbon emissions by one billion tons from now to 2030
IV. Reduce the carbon intensity of the economy by 45% by 2030, over 2005 levels
V. Achieve a target of net zero emissions by 2070
VI. Achieve the Net Zero target by 2030 by Indian Railways
VII. Adapt LiFE, or Lifestyle for Environment, which calls for leading a life that is kind to the environment and does not destroy it

The updated NDCs are to be implemented from 2021 to 2030. The Indian Railways alone will reduce emissions by 60 million tons annually by achieving its Net Zero aim by 2030.[71] Similarly, India's extensive LED bulb initiative is cutting 40 million tons of pollution per year.[72]

Current status of NDC's taken by India

I. Based on 2019 data projections, India has fulfilled its 2020 Copenhagen Pledge (A ~27.7% GDP[73] carbon intensity reduction between 2005 and 2019, excluding emissions from forestry, changes in land use, and land use.
II. India is nearly ten years ahead of schedule in achieving its Paris obligations on this objective (33–35% GHG/GDP over 2005 levels).[74]
III. Non-fossil fuels, including hydropower, now account for almost 40% of installed power production capacity, up from 29% in 2010, demonstrating India's significant progress towards meeting this NDC target.[75]
IV. India's total power-producing capacity as of December 2023 is 428 GW with 240 GW (~49%) of coal, 25 GW of natural gas, 46.9 GW of large hydro, 7.48 GW of nuclear, 44.74 GW of wind, 73.32 GW of solar, 10.85 GW of biopower, and 5.0GW of small hydro.[76]
V. In FY23, Total energy generation from thermal was 1206 BU which contributes 74% of overall energy generation.[77]
VI. The majority of electricity is generated by fossil fuels (74%), followed by hydro (10.67%), nuclear (2.82%) and non-hydro renewable sources (about 12.53%).[78]
VII. The Hon'ble Prime Minister has launched the "Pradhanmantri Suryodaya Yojana" with a target of installing rooftop solar on 1 crore houses to further boost the generation of solar energy. This aims to provide electricity to low and middle-income individuals through solar rooftop installations, along with offering additional income for surplus electricity generation.[79]


CO2

05

Decarbonisation of Industry Sector

Decarbonisation of industry sector

Decarbonising the metals sector is imperative for meeting sustainability goals due to its substantial contribution to greenhouse gas emissions, primarily from energy-intensive processes reliant on fossil fuels. These emissions exacerbate climate change, necessitating a shift toward cleaner production methods. Additionally, the traditional extraction of raw materials contributes to resource depletion and environmental damage, emphasizing the importance of adopting sustainable practices such as recycling. Regulatory pressures for environmental compliance are increasing, making proactive decarbonization essential to avoid legal and financial consequences. Beyond regulatory concerns, supply chain resilience is enhanced by minimizing environmental risks, ensuring a stable and sustainable production process. Embracing decarbonization aligns with corporate social responsibility principles, fostering positive corporate images and attracting environmentally conscious stakeholders. Moreover, innovation in cleaner production technologies benefits the industry and contributes to global efforts in combating climate change through international collaboration and the establishment of common sustainability standards.

Why decarbonisation is important?

According to a recent analysis on effect of climate change on different sectors assuming two different scenarios: one with global temperatures rise of 2.8° C by 2100, and second by 4.5° C. it was projected that, higher increase in temperature will cost $520 billion each year to USA alone.[80] The metals industry, and steel and aluminium in particular, are essential for changing our society towards green energy. These metals are used to build renewable energy infrastructure, electric vehicle manufacture, and sustainable construction, to mention a few applications. However, the metals industry as a whole need to become carbon neutral in order to provide real green energy.

The International Resource Panel estimates that the production of metals accounts for 10% of yearly greenhouse gas emissions worldwide, which is only predicted to increase in the absence of any intervention.[81]

The metals sector is one of the "hard-to-abate" sectors, along with the shipping, aviation, cement, road freight, and chemicals industries. It is difficult for businesses in this industry to identify affordable ways to reduce greenhouse gas emissions and accomplish decarbonization due to gaps in technology, innovation, and business models. We may be able to adapt the results of decarbonization for the metals industry to other difficult-to-abate categories.

Challenges faced in decarbonising industrial processes

Decarbonising the metals industry poses unique challenges due to the intrinsic nature of metal production processes:

- Metallurgical processes involving high temperatures traditionally rely on carbon-intensive fossil fuels. It's hard to find low-carbon alternatives.
- Since the metals industry has high energy requirements, it needs scalable low-carbon energy sources, which means large infrastructure and technology expenditures are required.
- Developing effective carbon capture technologies for high-temperature metallurgical processes is a complex challenge.
- Emissions come from the extraction and processing of basic materials like iron ore. It is essential to develop low-carbon methods.
- Because of the industry's global supply chain, coordinating decarbonization initiatives across locations with different rules and energy sources is difficult.
- There are technical and financial obstacles while upgrading or retrofitting old facilities with low-carbon technologies.
- Innovative technologies, such as new smelting techniques, need extensive research and development to be scaled up.
- Maintaining competitiveness in the global market while adopting potentially costlier low-carbon technologies needs balance.
- There are technical challenges to capture and use the significant waste heat produced in metallurgical processes.
- It is essential to retrain the workforce on new technologies in order to facilitate a seamless transition and mitigate the risk of job displacement.

Trending climate-friendly innovations in steel and aluminium sector

In recent years, several innovations in the steel and aluminum sectors have been aimed at improving efficiency, sustainability, and overall performance. Here are some notable innovations:

Steel sector

Hydrogen-powered steel manufacturing: Substituting hydrogen for conventional carbon-based reducing agents in the manufacture of steel could result in "green steel" that emits substantially less carbon dioxide.

Electric arc furnace (EAF): It uses electricity to melt waste steel and create new steel. Comparing this technology to conventional blast furnace procedures results in lower greenhouse gas emissions and increased energy efficiency.

Smart manufacturing and AI: Smart manufacturing techniques, utilizing automation, data analytics, and the Internet of Things (IoT), are being adopted by the steel sector. This makes it possible to monitor production operations in real time, which boosts productivity and lowers waste.

Using high-tech alloys: For usage in the automotive, aerospace, and construction industries, stronger and lighter steel can be produced through the development and deployment of sophisticated high-strength alloys.

The circular economy and Recycling: Steel scrap recycling is becoming increasingly important in the fight against raw material shortages and energy use. The circular economy is something that the steel industry is actively supporting through the reuse of steel products.

Aluminium

Green aluminium production: Similar to "green steel," there is a focus on developing methods for producing aluminium with low carbon footprints. This includes using renewable energy sources in the production process and exploring alternative smelting technologies.

Advanced smelting technologies: Innovations in smelting processes, such as inert anode technology and high-amperage cell designs, aim to improve the energy efficiency of aluminium production.

Aluminium recycling technologies: Advancements in aluminium recycling technologies, including sorting and separation techniques, are making recycling more efficient. Increased recycling contributes to resource conservation and energy savings.

Renewable energy integration: The aluminium industry is exploring ways to integrate renewable energy sources into its operations. This includes using solar and wind energy to power smelting processes, further reducing the carbon footprint of aluminium production.

Sustainable Supply Chain Practices: From responsible sourcing of raw materials to sustainable transportation practices, aluminium producers are increasingly adopting eco-friendly measures throughout their supply chains.

Sweden's experiment for the future – case study for the world[82]

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

Sweden's 'Hydrogen Breakthrough Ironmaking Technology' (HYBRIT) project is a consortium comprising 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 not just forSSAB but also for the world. 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 USD 47 billion for operations.

Zero-carbon H2, combined with an electric arc furnace supplied with zero-carbon electricity, has the potential to reduce emissions by more than 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 expected to benefit India in three areas of cement, steel and automotive sectors in its first phase[83]. ISGTP can prove to be a big driver for India's commitment towards achieving its net zero target by 2070.

Major metal companies decarbonisation initiatives

China Baowu Group

Carbon neutrality

Baowu Steel plans to be carbon neutral by 2050[84], ten years ahead of the national target set by the Chinese government.

Low-carbon metallurgical innovation alliance

China Baowu Steel Group has formed a Global Low-Carbon Metallurgical Innovation Alliance with over 60 partners from 15 nationsto combat climate change and reduce greenhouse gas emissions. The partnership aims to further industrialization and engineering of low-carbon techniques and technological cooperation.

MoU with Rio Tinto

In June 2023, China Baowu Group entered a Memorandum of Understanding (MoU) with Rio Tinto to look into innovative initiatives in China and Australia leading the industries to decarbonise the steel value chain. The MoU refers to the recently disclosed $2 billion[85] Western Range Joint Venture, which involves Rio Tinto and Baowu, in the Pilbara region of Western Australia. The projects comprise:

1. Creating a pilot electric melter at a Baowu steel mill in China for low-carbon steel production using Direct Reduced Iron (DRI) from various ores
2. Improving pelletisation technology for Australian ores as feedstock for low-carbon direct reduction in shaft furnaces
3. Scaling up China Baowu's HyCROF technology to minimise CO2 emissions from blast furnace processes
4. Exploring opportunities for producing low-carbon iron in Western Australia through joint studies

MoU with Vale

MoU between Vale and China Baowu to look for strategies to create steelmaking solutions that reduce GHG emissions. The discussion includes a potential investment by Vale, with an indicative sum ranging from sixty to seventy million renminbi, into China Baowu's pilot biochar plant project. This initiative aligns with Vale's goals to cut 15%[86] of net Scope 3 emissions by 2035. Vale also aims for a 33%[87] reduction in absolute Scope 1 and 2 emissions by 2030 and to achieve carbon neutrality by 2050.

ArcelorMittal

India: Project Trinity

This is a collaborative initiative with Greenko to construct 975 MW[88] of solar and wind power capacity in Andhra Pradesh, India. This project, known as Project Trinity and valued at $0.6 billion[89], aims to address the intermittent nature of solar and wind power by combining it with Greenko's hydro pump storage project. The integrated effort will provide a continuous 250 MW[90] of renewable energy to AM/NS India, a partnership between Nippon Steel and ArcelorMittal. The anticipated outcome is a substantial reduction of 1.5 million tonnes[91] of carbon emissions annually at AM/NS India's primary steelmaking facilities in Hazira, Gujarat.

France

A EUR 1.7 billion investment in decarbonising its French operations, specifically at Dunkirk and Fos-sur-Mer, aiming a 40% reduction in CO2 emissions, about 7.8 million tonnes annually by 2030, with crucial support from the French Government.[92] The plan involves constructing a 2.5 million tonnes-per-year direct reduced iron furnace, two electric furnaces at ArcelorMittal Dunkirk, and an electric furnace at ArcelorMittal Fos-sur-Mer. Expected to be operational by 2027, these new facilities will gradually replace two Dunkirk blast furnaces and one at Fos-sur-Mer. The transition is set to be completed by 2030, resulting in nearly a 40% reduction[93] in ArcelorMittal France's CO2 emissions compared to 2018 levels—equivalent to driving a car around the earth almost 800,000 times.[94]

Spain

An MoU with the Spanish government comprising a €1 billion investment in Gijón plant aiming to cut CO2 emissions within the next five years by 4.8 million tons, or the same amount of GHG emissions as 1,043,904 cars driven for a year.[95] The core of the strategy is 2.3 million-tonne green hydrogen Direct Reduced Iron (DRI) unit, along with a 1.1 million-tonne[96] hybrid electric arc furnace (EAF) marking the Gijón plant's shift from the blast furnace-basic oxygen furnace steelmaking approach to the DRI-EAF production method, known for its substantially lower carbon footprint.

Canada

A CAD1.8 billion decarbonisation project with the participation of the Canadian and Ontario governments at the ArcelorMittal Dofasco facility in Hamilton, Ontario, Canada.[97] This will transition Hamilton from producing steel in a blast furnace or basic oxygen furnace to producing steel using DRI and EAF. Over the next seven years, the project seeks to lower the plant's yearly CO2e emissions by 60%[98], which is expected to substantially impact the environment. Production at the new Electric Arc Furnace (EAF) and Direct Reduced Iron (DRI) sites is expected to begin before the end of 2028.

Belgium

Alongside Gent's blast furnace B, which resumed production in March 2021 after a sizable relining investment of €195 million, a EUR 1.1 billion project was announced in September 2021 to build a 2.5 million-tonne DRI and two new electric furnaces.[99] This means the blast furnace is prepared to accept waste wood and plastics as a substitute for fossil carbon.

Ansteel Group

Carbon Neutrality Plan

Ansteel Group's net neutrality plan is 30·60 i.e., to hit peak emissions by 2030 and carbon neutrality by 2060.[100]

Digital manufacturing

Ansteel unveiled a "digital manufacturing" strategy that placed a premium on cutting emissions, having a steady supply of resources, cutting technology and equipment, and increasing automation. The company's digital transformation necessitates an integrated approach, which entails creating a system that links people, machines, and gadgets. Not only are production plants changing, but other areas like research and development also.

Contribution to various projects

1. Ansteel has issued declarations on carbon peak and carbon neutrality, including the "Low-carbon Metallurgy Route," showcasing its dedication to environmentally friendly metallurgy processes. The company is at the forefront of innovation, actively pursuing cutting-edge technologies such as hydrogen metallurgy to further its green initiatives.
2. Increased investments in environmental protection have resulted in the completion of over 200 ultra-low emission upgrading projects[101] , consistently reducing pollutant emissions. In line with the three-year plan for ecological restoration of mines, Ansteel has accelerated implementation, successfully greening and reclaiming over 300 hectares of land.
3. In support of the national strategy goal of "carbon peak and carbon neutrality," Angang Steel Company Limited has supplied 39,700 tons[102] of materials for the Petrochina Guangdong Petrochemical Company's Integrated Refining project.

Partnerships

In order to advance low-carbon smelting technologies, Ansteel and Anshan Iron and Steel Group signed the Joint R&D on Green Hydrogen Energy Smelting Technology agreement with Shanghai University, Dalian Institute of Chemical Physics of the Chinese Academy of Sciences, and the Institute of Process Engineering.

Nippon Steel Corporation

Carbon neutrality plan

Nippon Steel plans to attain carbon neutrality by 2050 and cut greenhouse gas emissions by 30% by 2030[103] compared to 2013. The company is investing in large-scale Electric Arc Furnaces and hydrogen-based steelmaking to achieve this goal.

Five priority areas for achieving the Sustainable Development Goals

- Promotion of climate change measures
- Promotion of environmental risk management
- Promotion of environmental management system
- Promotion of environmental relation activities
- Contributing to creation of a circular economy

R&D and capital investments

Significant capital and research investments are needed to achieve carbon neutrality in the steel industry. R&D costs of about ¥0.5 trillion and capital expenditures of ¥4-5 trillion[104] are anticipated for Nippon Steel. Long-term, ongoing government support is essential for "discontinuous" innovation and other R&D initiatives, as well as the implementation of equipment, if Japan is to remain at the forefront of the globe and preserve and enhance its total industrial competitiveness.

Raising efficiency in logistics

Nippon Steel strives to lower CO2 emissions by improving logistics efficiency, such as through the use of large vessels, and maintains a high modal shift rate of 97%[105]. New initiatives as part of the efforts, such as "Utashima," a hybrid cargo ship with lithium-ion batteries that won the 2019 Ship of the Year Award for Small Cargo Vessel. It is also, working to introduce ships that use innovative alternative fuels, including hydrogen and ammonia, in order to reduce the amount of greenhouse gas generated by sea transport, in collaboration with the Ministry of Land, Infrastructure, Transport, and Tourism as well as other organizations.

Cement production

The amount of lime and fuel needed to produce cement can be decreased by 40% by employing blast furnace slag, which also results in 320 kg less CO2 emissions per ton[106] of cement produced—a significant reduction when compared to regular cement.

ShaGang Group

Emission reduction targets

Shagang has pledged to strive for a peak in carbon emissions in 2030 and cut emissions by 30% by 2035[107].

Investments

1. Shagang Group will enhance its steel production using EAFs in order to meet the nation's carbon neutrality target through scrap recycling, raw material optimization, green logistics, carbon-emission oversight, and other strategies.
2. Shagang upgraded its steel production facilities to meet the highest emissions standard during the course of the last five years, spending more than CNY10 billion[108]. With an annual capacity exceeding 6 million tonnes (mt), it is the largest steel facility in China based on electric arc furnaces (EAFs). Compared to conventional furnace-basic oxygen furnace (BF-BOF) plants, this increases operating flexibility and lowers carbon emissions.
3. To maintain its position as the industry leader in environmental protection, Shagang intends to invest 8.5 billion Yuan in four environmental upgrade projects: waste water, exhaust gas, noise, and slag which mainly include 83 projects.[109]

MoU with Vale

An MoU with Vale to look for opportunities in developing steelmaking solutions to cut CO2 emissions with an aim to develop feasibility studies on using lower carbon footprint goods in the ironmaking process, such as high-grade iron ore products, and working together on technology-enhanced facilities are what Vale and Jiangsu Shagang seek to create.

MoU with Air Liquide

Air Liquide and Jiangsu Shagang Group have inked a new extended agreement for the provision of industrial gases in Zhangjiagang City, Jiangsu Province, China. Under a 20-year contract, Air Liquide will be responsible for constructing, owning, and operating a cutting-edge ASU with a daily oxygen production capacity of 3,800 tonnes and a substantial investment of approximately 100 million euros[110]. Designed to operate with low-carbon energy, this facility aims to significantly reduce CO2 emissions over its operational lifespan.

HBIS Group

Carbon neutrality targets

To achieve carbon peak by 2022, reduce carbon emission by 30% or above as compared to carbon peak by 2030, and reach carbon neutrality by 2050[111]

Collaboration with BHP

BHP and China's HBIS Group have partnered to trial direct reduced iron (DRI) production using BHP iron ores in blends and enhance a lump stage 2 trial to reduce carbon emissions in blast furnaces (BF). The collaboration includes a commercial-scale DRI production trial at HBIS's newly commissioned plant, using BHP iron ores and hydrogen-rich gas by products. Simultaneously, the lump stage 2 trial focuses on lowering carbon emissions by increasing direct charge lump usage. This collaboration builds on a previous Memorandum of Understanding (MoU) with a joint investment of up to US$15 million over three years[112], signifying continued cooperation.

Carbon Asset Management Corporation

The company is strategically positioned to leverage the asset attributes of carbon quotas, utilizing financial tools to sustain and enhance their value while aligning with the group's low-carbon development strategy. Significant efforts have been made, encompassing personnel training, refining management and control systems, and establishing a carbon data management platform, to effectively prepare for participation in the national carbon trading market.

Partnership Agreement with Danieli

The partnership's initial focus will be on HBIS's Shijiazhuang Iron & Steel (Shigang) new steelworks. The agreement comprises development of highly innovative technologies, sustainable steel manufacturing, robotics, automation, and artificial intelligence. The HBIS plant by Danieli will be the greenest industrial DRI plant in the world, releasing as little as 250 kg of CO2 per ton of DRI.[113]

POSCO Holdings

Carbon neutrality targets

POSCO plans to reduce its carbon emissions by 10% by 2030, 50% by 2040, and net-zero by 2050.[114]

Greenate

POSCO created Greenate to effectively represent its efforts and results in order to attain carbon neutrality. POSCO's premier green brand, Greenate, is divided into three categories: Steel, Tech & Process, and Infrastructure. It includes low-carbon steel technology and processes, particularly next-generation hydrogen reduction iron and steel making, as well as POSCO's green steel products, which are led by e Autopos, INNOVILT, and Greenable.

Partnership with CF Industries

CF Industries and POSCO are collaborating to assess the feasibility of a joint venture, targeting the establishment of a low-carbon clean ammonia plant at CF Industries' Blue Point Complex in Ascension Parish, LA. The objective is to secure a long-term supply of low-carbon clean ammonia for South Korea. As a crucial step in project evaluation, CF Industries and POSCO will undertake a front-end engineering and design (FEED) study, focusing on autothermal reforming (ATR) ammonia production technology. The ATR technology, coupled with carbon capture and sequestration (CCS), is anticipated to yield a significant reduction in carbon dioxide (CO2) emissions from the ammonia production process, surpassing a 90% reduction[115] compared to conventional ammonia plants without CCS. This reduction aligns with meeting the South Korean government's Clean Hydrogen Energy Portfolio Standard requirements for the resulting low-carbon clean ammonia.

Investments

By 2026, POSCO Group intends to invest KRW 53 trillion (USD 41.9 billion)[116] worldwide to make its operations more sustainable and eco-friendly.

KRW 33 trillion of the total investment will be used in South Korea, of which KRW 20 trillion[117] will go toward the manufacturing of environmentally friendly steel, or "green" steel. A new electric arc furnace, "eco-friendly facilities," and the advancement of steel product technology for electric vehicle motors are among the projects that will be funded with the Won 20 trillion.

In order to increase its ability to produce 23.1 million metric tons of crude steel annually by 2030—a roughly five-fold increase from 5.1 million metric tons annually in 2021—POSCO plans to invest Won 12 trillion.[118]

POSCO intends to increase its total capacity for producing crude steel worldwide from roughly 46 million metric tons in 2021 to 68 million metric tons in 2030.[119]

JSW Steel[128]

Project SEED (Sustainable Energy Environment and Decarbonisation)

JSW Steel has taken a bold step to further its decarbonization agenda with the launch of project SEED (Sustainable Energy Environment and Decarbonization), a large scale operational transformation program at its Vijayanagar & Dolvi plants since last year.

While the company is strategically directing capital towards large scale projects (e.g. deployment of Renewable Energy generation); the management felt it is also important to emphasize comprehensive change and engagement at all levels – the SEED program was introduced towards meeting this objective.

The program has followed a bottoms up approach identifying all possible opportunities to reduce emissions. Over 20 divergence workshops were conducted with shopfloor teams to identify operational improvement initiatives that can help reduce emissions across themes such as fuel and power consumption, circularity, alternate feedstock, efficiency etc. The program has helped develop a clear decarbonization roadmap for 2030, with over 200 initiatives, and a combined annual savings potential of ~18 Mn T CO2 once fully implemented.

The program has become a part of JSW ethos by involving 400+ employees in driving execution. Implentation is actively being driven through 20 dedicated Climate Action Centers which serve as a platform to track progress & celebrate achievements. As a result of the program, over 50 de-carbonisation initiatives have been succesfully implemented so far.
What makes this program truly special is that it has helped drive a mindset shift by engaging and sensitizing employees on sustainability and emission metrics. By engaging the shop-floor, SEED has ensured a mix of operational improvements and shop-floor innovations that have now been brought to the forefront for deployement across the organisation.

The SEED initiative has been recogined as one of the Change Maker in the heavy emissting sector at COP28, Dubai for its unquie aspects of diversity, scalebility and inclsuivity while driving operatrional efficieny to decarbonise.

Carbon Reduction Commitment:

JSW Steel has set an ambitious objective of curbing specific carbon dioxide emissions to approximately 1.95 tCO2/tcs, by 2030. To fulfil this, the company has pledged to address the root causes of climate change, diminish and adapt to the repercussions, and fortify resilience against climate change impacts. Responsible for 23% of India's steel production, JSW Steel and its subsidiaries have a significant role 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.

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.

Internal carbon pricing

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

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 CO2 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.

Gajraj Singh Rathore
Chief Operating Officer
JSW Steel Ltd.

Decarbonising steel setor, which contributes to about 2% of India's GDP while accounting for about 10-12% of GHG emissions, is a vital step towards India's net-zero goal. At JSW Steel, we believe it is our responsibility to contribute to India's growth while reducing emissions from our operations. We aim to reduce our carbon emission intensity by 42% by 2030 and achieve net zero by 2050.

Tata Steel

Carbon Neutrality Targets

ZEREMIS: short for zero emissions, is TATA Steel's promise to the planet to become carbon neutral by 2045. It is a commitment to act now.[120]

Collaboration with LeadIT[121]

Tata Steel confirmed its partnership with the Leadership Group for Industry Transition (LeadIT), a project supported by the World Economic Forum, the governments of Sweden and India. Tata Steel has strengthened its standing as a global leader in net-zero industrial transformation by becoming the first Indian steel manufacturer to join LeadIT. With this partnership, it intends to use the LeadIT platform to disseminate information about the nuances of the Indian steel industry, with a particular emphasis on the sector's projected expansion in the ensuing decades.

Carbon Negative Technologies[122]

Tata Steel is actively incorporating advanced carbon-negative technologies into its operations as part of its commitment to decarbonization. Employing a dual strategy, Tata Steel focuses on Carbon Direct Avoidance (CDA) and CO2 Capture and Use.

Within the Carbon Direct Avoidance approach, Tata Steel is conducting a trial injection of hydrogen gas, particularly targeting the blast furnace—a significant contributor to global CO2 emissions in heavy industries. This initiative is integral to Tata Steel's goal of achieving Net Zero Emissions by 2045. The trial involves injecting 40%[123] hydrogen gas into the 'E' Blast Furnace at its Jamshedpur Works, marking the first global instance of such a substantial hydrogen gas injection into a blast furnace. The potential benefits of this trial include a projected 10% reduction[124] in coke rate, translating to approximately a 7-10%[125] decrease in CO2 emissions per ton of crude steel produced in the furnace. Moreover, the trial aims to establish Tata Steel's capability to develop necessary safety protocols and gain process control insights for injecting pure hydrogen into the blast furnace.

Tata Steel has achieved a significant milestone by successfully testing unprecedented levels of hydrogen gas injection into its Blast Furnace in Jamshedpur. Other notable initiatives in their decarbonisation journey include the injection of coal bed methane (CBM) and commissioning a carbon capture plant.

Tata Steel commissions floating solar power project in Jamshedpur works

Tata Power commissioned the solar project under an agreement with the steel major for the installation of a total of 41MW with a combination of rooftop, floating and ground-mounted solar panels across its locations.

OPTEMIS: Tata Steel UK's journey to net-zero for a brighter, greener future. Tata Steel's UK business is committed to reducing its emissions, aiming to achieve CO2-neutral steel making by 2045 and achieving at least a 30% reduction in CO2 emissions by 2030 (compared to 2018 levels). To achieve this we are looking at a range of technology options and are holding detailed discussions with the UK Government.

Acknowledgement and recognition

The company strengthened its leadership position in sustainability when its Jamshedpur Plant became the first location in India to acquire the ResponsibleSteelTM Certification. Tata Steel has gained international recognition for its sustainability initiatives. The company has been recognized among the top steel companies in the DJSI Corporate Rankings and has received the World Economic Forum's Global Lighthouse accreditation for several of its plants.[126]

Hindustan Zinc Limited[127]

Hindustan Zinc, India's largest & only integrated producer of Zinc, Lead & Silver has chosen GreenLine Mobility Solutions Ltd (GreenLine), a part of Essar Group and a pioneer in green mobility solutions, as its sustainable logistics partner and is set to deploy GreenLine's LNG-powered fleet in its supply chain and transportation operations.

LNG-powered vehicles significantly reduce emissions compared to diesel and align perfectly with the sustainability goals of both organizations. This initiative will not only reduce the carbon footprint associated with transportation but also set new industry standards for green logistics.

Hindalco

Hindalco Industries Limited, Aditya Birla Group's metals flagship, and Greenko Energies Private Limited, India's leading energy transition company, have entered into a commercial arrangement to set up a renewable energy (RE) project for supply of 100 MW round-the-clock carbon free power.[129] The arrangement covers the development of 375-400 MW of solar and wind capacity. The RE project will be set up as a captive generation facility under a 25-year offtake arrangement and will supply power to Hindalco's Aditya Aluminium smelter in Odisha, enabling reduction of CO2 emissions by 680,000 tonnes annually. The project will be one of the world's first for the aluminium sector with over 85 per cent reliability from the solar and wind power without dependence on grid electricity. Hindalco will also be the first aluminium company in India to use such round the clock carbon free power for smelting

Ayana Renewable to Develop 330 MW Capacity for Hindalco[130]

Ayana Renewable Power, a renewable energy Independent Power Producer (IPP) has signed a power purchase agreement with Hindalco Industries Limited, the metal company of the Aditya Birla Group for the supply of 100 MW of Round-the-Clock (RTC) renewable energy to Hindalco's smelter plants in Odisha.

With this captive power project, National Infrastructure and Investment Fund (NIIF) backed company aims to become a demand-driven energy solution provider. It bolsters Ayana's cumulative capacity under management to nearly 5 GW, encompassing operations, maintenance, and development.

The project aligns with the company's vision to become India's lowest cost power supplier leveraging the combination of solar, wind and pumped hydro technologies.

Jindal Stainless[131]

Jindal Stainless to generate ~1.9 billion units of Clean Energy per annum via Renewable energy initiatives

According to its newly released Sustainability Report, Jindal Stainless, India's largest stainless-steel manufacturer will generate over 1.9 billion units of clean electricity per annum through its wind-solar hybrid, floating and roof-top solar plants. The initiatives have the potential to reduce carbon emissions by over 13.52 lakh tonnes per annum.

The company has already partnered with ReNew Power to deliver 100 megawatt (MW) round-the-clock (RTC) renewable energy. It is also in discussions to establish separate 100 MW RTC renewable energy projects at both its manufacturing units, in Jajpur and Hisar. This effort aims to achieve a combined capacity of 300 MW RE-RTC for both units.

Jindal Steel and Power[132]

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

JSPL has partnered with Greenko to secure 1,000MW of green power for its steel production activities in Angul, Odisha, emphasizing its commitment to clean energy. This collaboration promises a substantial reduction in CO2 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.

06

Role of Circular Economy

Role of circular economy

According to the United Nations Environmental Protection Agency (US EPA), "A circular economy reduces material use, redesigns materials, products, and services to be less resource intensive, and recaptures "waste" as a resource to manufacture new materials and products." A circular economy is an economic system designed to eliminate waste and promote the continual use of resources. In a circular economy, products and materials are reused, repaired, refurbished, and recycled to extend their lifespan, reduce environmental impact, and minimise the generation of waste. It represents a departure from the traditional linear economy, which follows a "take, make, dispose" model.

Principles of circular economy: Reduce, reuse, recycle

In the quest for sustainability, the adoption of circular economy principles has become imperative, particularly in industries with significant environmental footprints, such as the metal industry. The core tenets of the circular economy — Reduce, Reuse, and Recycle — are instrumental in reshaping the traditional linear model of production and consumption.

Reduce[133]: Reducing the consumption of raw materials and minimising waste is a pivotal aspect of circular economy principles. In the metal industry, advanced manufacturing technologies and material-efficient design are driving initiatives to decrease the overall demand for virgin resources. Companies are increasingly adopting leaner production processes, optimizing material use from the outset of manufacturing. This not only aligns with environmental goals but also contributes to cost savings and enhanced efficiency.

Reuse[134]: The concept of reuse is gaining prominence in the metal industry as companies focus on extending the life of products and components. Rather than discarding metal items after their primary use, there is a growing emphasis on refurbishing, remanufacturing, and repurposing. The refurbishment of metal products not only reduces the environmental impact but also aligns with the circular economy's objective of maximising the value derived from materials.

Recycle[135]: Recycling is a cornerstone of circular economy principles in the metal industry, contributing significantly to sustainability goals. Recycling scrap metal is a well-established practice, with the industry continually improving technologies for efficient separation and processing. The recycling loop helps mitigate the environmental impact of primary metal production, conserves energy, and reduces the need for extensive mining activities.

Circular economy: Responsibility towards the future generation with emphasis on solid and liquid waste recycling

In addition to making efforts to keep metals from ending up as waste when a product's life is coming to an end, the industry must make sure that these materials are extracted and managed responsibly to support a just transition to a circular economy that is not developed at the expense of producing countries and regions.

The global population increase and the push for cleaner energy technologies are driving a substantial increase in the demand for minerals and metals. Projections indicate a potential twentyfold rise in demand for nickel and cobalt and copper demand is expected to double by 2050.[136]

Addressing this increased demand requires a shift towards a circular economy. This involves enhancing material productivity, minimizing waste, and fostering the regeneration of nature. It is crucial to strike a balance between the

indispensable nature of durable materials like metals, capable of multiple life cycles, and ensuring a just transition for producing countries and regions to prevent any disparities. Circular practices are not new in the mining and metals industry. Over the years, circular principles have been integrated at the site level, driven not only by the aim to reduce the negative impacts of extraction but also due to the sound business rationale. Efforts to minimize waste, optimize water usage, regenerate closed mine sites, and recycle various materials have been central to industry strategy.

Integral Link Between Process and Product: Achieving true circularity in materials requires aligning both production and usage in a circular way. In the case of mining, this means to establish operations with a net positive contribution to the environment and society. Collaboration across the metals supply chain is essential to promote responsible usage and the recovery of metals post-market entry.

Innovation for True Circularity: Achieving genuine circularity requires continuous innovation. By simultaneously focusing on both process and product circularity, mines can contribute value to communities and nature at the site level, while the materials they produce become resources capable of repeated use. The International Council on Mining and Metals (ICMM) is actively working to create a collaborative space to ensure that various circular strategies succeed. This includes considerations such as regulations, technology availability, and market incentives, aiming to foster a systematic approach to circularity on a global scale.

By 2050, the metal demand for wind turbines is expected to rise by 300%, solar panels by 200%, and energy storage by 1000%.[137] The technologies driving clean energy, like wind, solar, hydrogen, and electricity, need more metals than traditional fossil fuel-based energy systems. As per the OECD Global Forecast, the shift towards green energy is predicted to boost the global demand for non-ferrous metals more than any other raw material – from 7 to 19 gigatons annually by 2060.[138] Electric vehicles, crucial for meeting EU emissions targets, will require additional materials not needed for regular cars. For instance, over 100,000 tons of copper will be necessary to build 40 million charging points for new electric vehicles entering the market by 2027.[139] Copper is used in charging cables, chargers, and wiring. Aluminium, being lightweight, is also gaining recognition in transporting renewables. A car made of aluminium uses less fuel, and the energy it consumes initially is compensated by significant energy savings during use and recycling.

Indian context

The increase in global economic growth, along with the growth of urbanization and industrialization, has led to a surge in the use of critical metals. Future expansion is expected to be centred on metals, including platinum group metals (PGMs), copper, lithium, nickel, cobalt, gold, and silver. The increasing need for these metals will be driven by their application in various fields, including industrial automation, rare-earth metals in renewable energy infrastructure, lithium-ion batteries for electric vehicles, and electrical and electronic equipment. The demand for essential raw materials is expected to rise in tandem with India's economic expansion. Currently, India is highly dependent on imports, obtaining 90% of its gold, 64% of its silver, 30% of its copper, and 99% of its PGMs from overseas sources.[140]

Since resource securitisation is essential to promoting long-term growth, it becomes critical for India. Reuse and recycling become extremely promising options when dealing with growing demand and a shortage of essential metals. Adopting the concepts of the circular economy transforms into a business imperative, driving the recycling of waste materials such as printed circuit boards (PCB), wasted Li-ion batteries, autocatalytic converters, electronic trash (e-waste), etc., in order to recover key metals.

For example, mobile phones contain precious metals such as gold, silver, and palladium; special metals, e.g., cobalt, indium, and antimony and metals such as copper and tin. About 10,000 mobile phones yield as much as 160 Kg of copper, 3 Kg of silver, 300 grams of gold (in a gold mine, one can get only 5 grams per tonne of rock), and 150 grams of palladium. Together, the metal value would be about INR 2.4 million.[141] Considering that an estimated 5 billion mobile phones are discarded globally every year, the substantial potential of material recovery and financial benefit in recycling becomes apparent.

The key question is whether India has the ecosystem and technology necessary to recover these precious metals. Modern infrastructure has been built in nations like Germany and Japan to collect and recycle various waste streams. Ten to fifteen percent of the total input feed used by large-scale industrial smelters is made up of e-waste, which is primarily used PCB trash from servers, laptops, and mobile phones. For them, one of the most profitable waste sources is e-scrap. Using the appropriate extractive metallurgy method, they can recover products including base metals, precious metals, PGMs, special metals, and rare-earth metals. The majority of global recyclers are copper smelters, with 300,000–900,000 TPA capacity in operation.[142] Some multinational recyclers solely accept e-waste as their raw material.

There are different ways to use technology to make the process of recycling PCBs more efficient. Some of these routes focus on the Pyrometallurgy process, followed by Electrorefining/ Electrowinning and then selective Leaching to get Gold, Silver, Palladium, Platinum, etc. Another way focuses only on hydrometallurgy, which includes copper leaching and electrowinning, followed by selective leaching to get Gold, Silver, Palladium, Platinum, etc. Before putting the material into the process, each route needs the material to be pre-processed. Pyrometallurgy-based technology routes have higher CAPEX costs but lower OPEX costs. Only the hydrometallurgy method (without pyro) is cheaper on the CAPEX side, more expensive on the OPEX side, and hard to scale up.

India mostly has L2 recyclers who only recycle the whole electronic equipment, and use mechanical processes to dismantle, segregate and sort into individual items like steel, copper and mixed-metal fraction, aluminium, plastic, glass, PCB, etc. L2 recyclers generally segregate up to a certain level and the segregated output is sold to specialized recyclers. As a result, the high-value PCB fraction of e-waste, which has recoverable precious metals, is exported to countries like Belgium, Germany, Sweden and Japan for L3 recycling and extraction.

Currently, the penetration of L3 recycling technology is limited in India, and most of the prominent recyclers are in possession of lab scale or pilot scale technology for PCB recycling. L3 technology is relatively expensive, which limits Indian recyclers, who are mostly small and medium scale entities, from investing in them. However, this also creates a huge opportunity for large organizations to explore this domain and set up integrated e-waste and PCB recycling in India. Some of the better technology is capital-intensive but also offers lower running expenses and scalability.

Even years after the introduction of e-waste related rules in India, more than 90% of the e-waste generated is handled by the unorganised informal sector.[143] India generates close to 3 million tonnes of e-waste per annum, with an inherent material recovery value of INR 60,000 crore.[144] Similarly, spent Li-ion batteries and auto catalytic converters also have a good recycling market. With the right technology and a combination of multiple waste streams in an integrated recycling facility, 98-99% recovery is possible.[145]

India must close the circular economy loop to establish sustainability and ensure that surging demand in industries like EVs and electronics is not hobbled by supply of raw materials. Increased policy support and investment in technology by large organisations can make the recycling ecosystem more mature. Circular economy in critical metals is going to be one of the major contributors in India achieving its net-zero target even as industries such as EVs, renewable energy and electronic equipment prosper.

07

Role of Mining Sector in Upstream Mitigation of Carbon Footprint

Role of mining sector in upstream mitigation of carbon footprint

India ranks third in the world for coal mining emissions and is the second-largest producer of coal worldwide. The mining and quarrying industry contributed 1.80% of GDP in FY2021.[146] Since the mining sector affects the environmental effects of metal production from the starting of the supply chain, it is essential to the upstream mitigation of the carbon footprint in the metals sector. The world's resolve to reducing CO2 emissions, government laws, and the cost of renewable energy have all contributed to the shifts that have made low-carbon technology the norm. unknown to many, sustainable energy technologies—like wind, solar, and batteries—actually require more materials than the conventional energy systems that are already in use that run on fossil fuels. In the meanwhile, as low-carbon technologies become more prevalent, demand for minerals and metals including nickel, copper, lithium, cobalt, graphite, and cobalt will increase. Sustainable and dependable extraction and production methods will be necessary to meet this need. By 2050, it is anticipated that the production of essential minerals for low-carbon technologies would increase by 965% in lithium, 585% in cobalt, 383% in graphite, 241% in indium, and 173% in vanadium on a worldwide scale.[147] From resource extraction to sustainable practices, the mining value chain is a transforming process. The value chain from mine to market is made up of related activities and interdependent steps.

Improvements in mine-to-market performance are intended to release more potential than if operations, the value chain, or commercial services were optimized separately. By optimising throughput, product margins, and operating costs, mine-to-market optimization can increase earnings before interest, taxes, depreciation, and amortization (EBITDA) margin, which includes mining companies across national boundaries and product categories.

Sector's contribution to reducing carbon emission:

Efficient Resource Extraction: The energy intensity and emissions related to raw material extraction can be decreased by implementing more environmentally friendly and efficient mining practices. Technological advancements like electrified and automated mining equipment help extract resources in a more sustainable way.

Renewable Energy Integration: Using renewable energy sources, such wind and solar electricity, in mining operations reduces the need for fossil fuels. Mining sites can reduce their overall carbon footprint and contribute to a cleaner energy mix by implementing renewable energy options.

Carbon capture and storage (CCS): Mining enterprises can capture, and store carbon dioxide emissions produced during extraction processes by integrating CCS technologies. This lessens the amount of greenhouse gases released into the environment, which helps to reduce carbon emissions overall.

Innovative processing technologies: Investments in advanced eco-friendly ore processing technology lowers the emissions linked to the conversion of raw materials into metals. Cleaner and more sustainable processing techniques make a substantial contribution to reducing the upstream carbon footprint.

Circular economy practices: The mining industry can support a circular economy by encouraging the responsible and effective use of resources. This entails material recycling and reuse, lowering the demand for fresh extraction, and lowering the environmental effect of producing raw materials.

Supply chain transparency: Implementing transparent and sustainable supply chain practices helps detect and address environmental hotspots, ensuring that mined minerals are acquired responsibly and ethically. This transparency improves sustainability efforts because it covers the whole lifecycle of the metals.

Collaboration with stakeholders: Addressing environmental issues related to mining operations can be done more cooperatively when local communities, governments, and environmental organizations are involved. Various stakeholders are frequently involved in and cooperative with sustainable mining techniques.

Rehabilitation and land restoration: After mining operations end, implementing efficient land rehabilitation and restoration measures helps reduce the long-term environmental impact. This covers soil remediation, reforest, and conservation of biodiversity.

To seize the opportunities presented by decarbonization in the next five years, mining companies should continue to:

1. Establish and communicate targets for reducing Scope 1 and 2 emissions, involving stakeholders in efforts to diminish Scope 3 emissions
2. Deploy renewable energy technologies on mining sites and experiment with novel, lower-carbon processing solutions
3. Explore partnerships with customers to collaboratively reduce emissions and actively engage with them on sustainability initiatives

Suggestions for miners:

1. Collaborating with processors to minimise emissions throughout the downstream value chain
2. Expanding the use of renewable technologies at mining sites
3. Scaling up both new mining operations and low-carbon refining processes
4. Undertaking the commissioning of full-scale co-located mining and refining plants
5. Integrating renewables into power and transport applications while phasing out the use of fossil fuel equipment

In order to ensure supply, miners will also need to collaborate through joint ventures, partnerships, and offtake agreements with other industries, including automakers and battery manufacturers acting as original equipment manufacturers (OEMs). OEMs are expected to invest more directly in mining and processing assets as governments provide incentives for the extraction and processing of essential minerals.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NET ZERO

08

Innovative Technology

Innovative Technology

Innovation in metals production is imperative due to various factors, with environmental sustainability being the topmost. Traditional methods of producing major metals like steel and aluminium have historically been associated with substantial environmental impacts. For instance:

Steel: Conventional steel production results in significant carbon dioxide emissions. Primary steel production is the process of turning iron ore into iron and then into steel; secondary steel production is the process of using scrap or a combination of scrap and iron. About 95% of all emissions in the Iron and Steel value chain, from mining to steelmaking, are caused by the production of iron and steel alone.[148] Nowadays, though, it's harder to tell the difference between primary and secondary because scrap is increasingly being used to improve metallic output. India produces steel primarily via two routes:

Route 1: Integrated steel manufacture, which uses limestone, recycled steel, coal as a reducing agent, and blast furnaces (BF) and basic oxygen furnaces (BOF) as its main raw materials. One ton of crude steel requires, on average, 1.37 tons of iron ore, 0.78 tons of metallurgical coal, 270 kg of limestone, and 125 kg of recycled steel, according to the WSA.[149] India's specific consumption of iron ore as a raw material in the primary route is significantly more, since less scrap is used. In India, on average, one ton of crude steel is produced using 1.5–1.7 tons of iron ore.[150]

Route 2: The secondary steel makers produce crude steel using an EAF that uses electricity, direct reduced iron (DRI), or hot metal, and recycled steel. According to WSA, to manufacture one ton of crude steel, the recycled steel-EAF route normally requires 0.71 tons of recycled steel, 0.59 tons of iron ore, 150 kg of coal, 88 kg of limestone, and 2.3 GJ of electricity.[151] But in India, the availability of scrap is a constant problem.

Aluminium: Production of aluminium from the mining of bauxite, bauxite to alumina and then smelting into aluminium is energy-intensive, and the carbon anodes release carbon dioxide during their consumption. Most significant source of emissions in this process is the smelting step. For per tonne of finished aluminium produced, bauxite mining emits 0.4 tonnes CO2e/tonne bauxite, refining emits 2.6 tonnes of CO2 per tonne of aluminium.[152] While it is the primary method for primary aluminium production globally, ongoing efforts focus on developing more sustainable methods and increasing the recycling of aluminium to reduce environmental impact and energy consumption.

Need for innovation

The need for innovation arises to develop cleaner, more sustainable processes that minimize the industry's overall environmental footprint. Resource efficiency is another critical consideration, as conventional methods often rely on finite resources, such as high-grade iron ore for steel production.

Current trends

Metal fabrication has undergone significant transformations due to emerging trends and technologies in recent years. These advancements include automation and robotics, 3D printing, computer-aided design and manufacturing, additive manufacturing, advanced materials, and the integration of IoT and Industry 4.0 technologies. These innovations have resulted in heightened efficiency, precision, cost-effectiveness, and the ability to create intricate designs in the metal fabrication industry.

- Collaborative robots in metal fabrication are used to address safety concerns and labour shortages. These robots work alongside human workers, particularly in tasks deemed dangerous or repetitive, contributing to increased efficiency and reduced costs.
- **3D printing** enables the quick and cost-effective production of metal parts, casting molds, and prototypes. Metal powder bed fusion, a specific 3D printing method, minimizes waste and facilitates the creation of intricate designs.
- **Automation integrated into computer numerical control (CNC) machines eliminates repetitiveness, enhances efficiency, and reduces** the risk of repetitive stress injuries.
- The integration of IoT devices and sensors into metal fabrication equipment enables real-time data monitoring, optimizing equipment performance and maintenance. Predictive maintenance based on machine and sensor data reduces downtime, enhancing machine longevity.
- **CAD and CAM** software usage in metal fabrication allows precise and efficient design and manufacturing processes. Simulation and testing before fabrication reduce errors and material wastage.
- The metal fabrication industry is slowly **adopting digitisation** to increase efficiency and productivity. Digitisation doesn't replace human workers but enhances overall operations. Embracing technology and implementing cybersecurity measures is crucial for industry stakeholders.
- The utilisation of **advanced materials** such as high-strength steels, aluminium alloys, titanium alloys, copper alloys, and composites enhances the strength, durability, and versatility of final products. These materials cater to specific applications, leading to improved performance in aerospace, automotive, medical, and energy sectors.

Beyond 2023, the metal fabrication industry is expected to continue evolving. Trends like digitisation, collaborative robots, and 3D printing will persist, making the industry more efficient and productive in the coming years. The adoption of new technologies may pose challenges, but the benefits for the industry are substantial.

There is a need for innovative technologies to balance progress with environmental responsibility. New technologies are essential to changing the metals industry towards a more sustainable and cleaner future. By using these technologies, the sector may lessen its carbon footprint and develop a more environment-friendly metals ecosystem. The metals industry may drastically reduce harmful greenhouse gas emissions by adopting innovative and creative solutions, such as better recycling techniques and greener production processes. These developments lead to a more sustainable use of resources in addition to making the production of metals more environmentally friendly.

Digital technology: AI and Blockchain in pollution control and environmental monitoring

Artificial Intelligence (AI) and the integration of blockchain has the potential to completely transform environmental monitoring and pollution management while providing cutting edge solutions for a more sustainable future.

By adding intelligence to data analysis, AI can identify pollution sources and trends more quickly and precisely. Large volumes of environmental data can be processed using machine learning algorithms, which aid in predicting pollution trends and evaluating the effects of different factors on the quality of air, water and soil. This real-time information makes proactive decision-making and more efficient pollution management strategies easier. On the other hand, blockchain improves environmental monitoring security, traceability, and transparency. It creates a distributed, unchangeable ledger for storing and exchanging environmental data. By eliminating tampering and offering a trustworthy record of pollution levels, emissions, and regulatory compliance, this protects the integrity of the data. Blockchain is especially helpful for tracing the origin and environmental impact of items and improving supply chain transparency.

Current technologies in use

World Environment Situation Room (WESR), by the United Nations Environment Programme (UNEP), is a digital platform harnessing the power of artificial intelligence (AI) to analyze intricate and diverse datasets. WESR compiles, synthesises, and visually presents the most reliable earth observation and sensor data for near real-time analysis and future predictions for factors like atmospheric CO2 concentration, shifts in glacier mass, and sea level rise.

One initiative within the WESR is the **International Methane Emissions Observatory (IMEO)**, that utilises AI to transform the way we monitor and address methane emissions. The platform employs AI to interconnect data with science, transparency, and policy actions, facilitating data-driven decision-making.

GEMS Air Pollution Monitoring platform[153], co-founded by UNEP AND IQAir, world's largest global air quality information network gathers data from over 25,000 air quality monitoring stations in more than 140 countries and employs AI to provide insights into the real-time impact of air quality on populations.

IBM Blockchain utilised to improve transparency and traceability in supply chain management, emissions monitoring, and carbon credit trading. It is used to build transparent, safe systems that track environmental data and sustainable practices.

An open source blockchain platform **Hyperledger Fabric** has been applied to supply chain transparency, sustainable sourcing, and pollution control initiatives.

The underlying public corporate ecochain, **Waltonchain** combines blockchain technology with the Internet of Things (IoT) and uses RFID technology. All information regarding tangible goods in circulation is automatically recorded to blockchain by means of the self-developed reader chip and tag chip. As a result, Waltonchain reduces the risk of data manipulation, stays away from human intervention, and builds a trustworthy, transparent, traceable, and equitable new-generation business ecosystem.

What new can India do?

India may explore and put into practice several modern digital strategies to improve environmental monitoring and pollution management-

Public Engagement- Provide smartphone apps that let people help with environmental monitoring. The public may share images, report pollution events, and participate in crowdsourced data collection projects by using these apps.

Utilise social media analytics to track public opinion and concerns about environmental matters- This can help government agencies better grasp public opinion, respond to complaints, and encourage community involvement in pollution control initiatives.

Use virtual reality for training programmes on pollution management and environmental monitoring - Virtual reality (VR) simulations can offer realistic settings for emergency response and professional training, improving readiness for environmental crises.

Develop predictive models for changes in the environment by utilising machine learning techniques and artificial intelligence (AI). By predicting pollution patterns, these models assist companies and government agencies in taking pre-emptive steps to reduce or eliminate pollution.

Blockchain and artificial intelligence work well together. Blockchain guarantees the dependability and transparency of environmental data, while AI's analytical powers increase the accuracy of that data. This integrated strategy supports the public, businesses, and regulators take informed decisions by fostering a more reliable and efficient pollution management system. The integration of these technologies has siginificant potential to develop a pollution control and monitoring strategy that is more ecologically sensitive and sustainable.

Alternative energy: Alternative energy route for decarbonisation

The metals sector, known for its energy-intensive processes, is exploring alternative energy routes as a key strategy for decarbonisation. Reducing the carbon footprint of metal production primarily involves switching from conventional fossil fuel-based energy sources to alternative and renewable energy sources. Though greener energy sources are gaining headway, fossil fuels still produce more than 80% of the world's energy, renewable energy sources account for about 29% of electricity production.[154]

Why accelerating the transition to clean energy?

Around 6 million people, i.e., approx. 80% of world population resides in nations that rely on the import of fossil fuels[155], making them susceptible to geopolitical uncertainties and crises. Renewable energy is now the most economical power option globally, with solar and wind costs plummeting by 85% and 56-48%, respectively, from 2010 to 2020.[156] Projections suggest renewables could provide 65% of global electricity by 2030 and decarbonise 90% of the power sector by 2050, significantly reducing carbon emissions and mitigating climate change.[157] Switching to renewable energy sources like solar and wind contributes to addressing air pollution, health issues, and climate change. As per studies, three times as many jobs are created for every dollar invested in renewable energy as in the fossil fuel sector.[158] Crude steel's emission intensity can be cut by 28% with the help of energy efficiency and renewable energy production.[159] By blending alternative fuels, including biomass and green hydrogen, in small amounts with traditional fuels 6% less fuel can be used. Other carbon management strategies, such afforestation, must be used to offset the remaining 10% of emissions.[160]

Alternatives available:

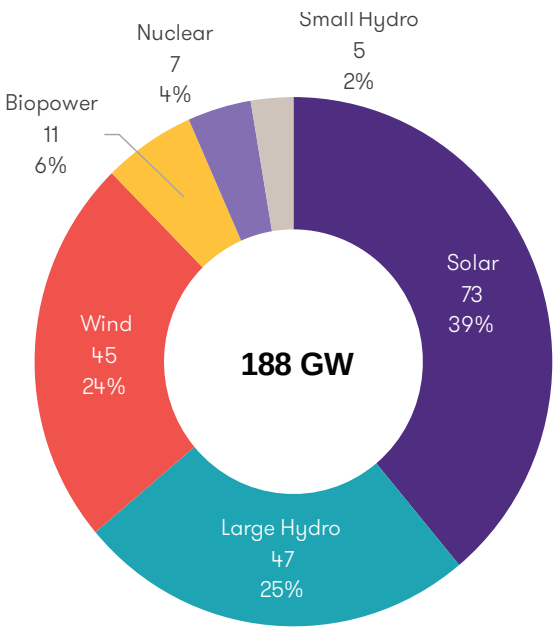
Solar energy is one well-known alternative energy source. Solar energy can be used by the metals industry to generate electricity, offering a clean and sustainable power source. By 2050, renewable energy will account for the majority of the world's energy supply, with solar energy being the single largest source.[161] Furthermore, **wind energy** is a feasible alternative since wind turbines can transform wind energy into electricity to meet the energy requirements of the sector. Another option is **hydroelectric power**, which uses the energy of flowing water to provide electricity for plants that process metals. In addition, technological developments are making it possible to incorporate **hydrogen** as a clean energy source, providing a possible substitute for industrial activities that require high temperatures. Adopting these alternate energy sources is a major step toward accomplishing environmental goals in the metals industry as it not only helps with decarbonisation but also fits in with worldwide efforts to move towards a greener and more sustainable energy picture.

Current position of renewable energy sources in India:

India is the world's third-largest generator of renewable energy, obtaining 40% of its installed power capacity from sources other than fossil fuels.[162]

India has led the International Solar Alliance (ISA), an action-oriented, member-driven, cooperative platform for more significant deployment of solar energy technologies, as a result of its significant success in solar energy solutions.

Installed Capacity: India



Safety management system: Safety Management system in metal industries towards green sustainability

A group of organised, corporate-wide procedures that enable efficient risk-based decision-making for routine business operations is known as the safety management system (SMS). The metal industries need to implement a strong SMS to encourage green sustainability.

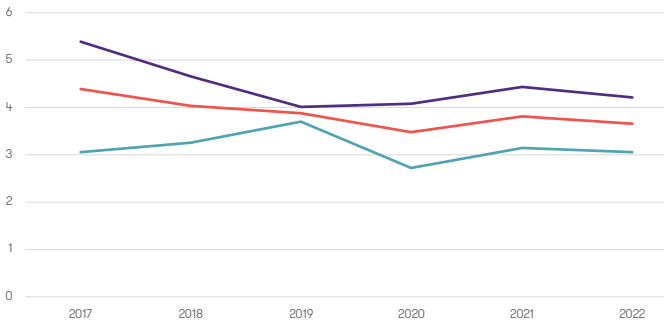
Purpose of an SMS

The SMS aims to identify, assess, and mitigate potential hazards and risks in the workplace to prevent accidents and injuries to workers. A thorough SMS goes above and beyond standard safety precautions; it incorporates environmental factors into safety procedures, in line with the industry's pledge to reduce its environmental effect. The SMS makes sure that worker health and environmental preservation are given equal priority in safety procedures. Implementing an effective SMS helps in reducing costs associated with workplace accidents, including medical expenses, compensation claims, and potential legal liabilities.

Safety and health data in the steel industry

Research suggests that approximately 20% of incidents have the potential to result in significant injuries or fatalities.[163] In the year 2022, 91% of the surveyed sites reported using Process Safety Incident Frameworks (PSIFs), while 9% did not utilise such frameworks.[164] The Total Recordable Injury Frequency Rate (TRIFR) demonstrated improvement, decreasing from 3.82 in 2021 to 3.66 in 2022.[165]

Recordable injury frequency rate



Any injury sustained at work that prevents the worker or contractor from reporting for duty on their next scheduled shift counts as lost time injury. Major reasons for lost time injury are slipping, tripping and falling, use of manual tools, moving machinery, product handling, falling from height, etc. The number of lost time injuries reported in 2022 amounted to 2247.[166] Furthermore, the total reported fatalities to world steel during 2022 were 90. Notably, the fatality frequency rate saw a decline, dropping from 0.029 in 2021 to 0.020 in 2022.

SMS in metals sector

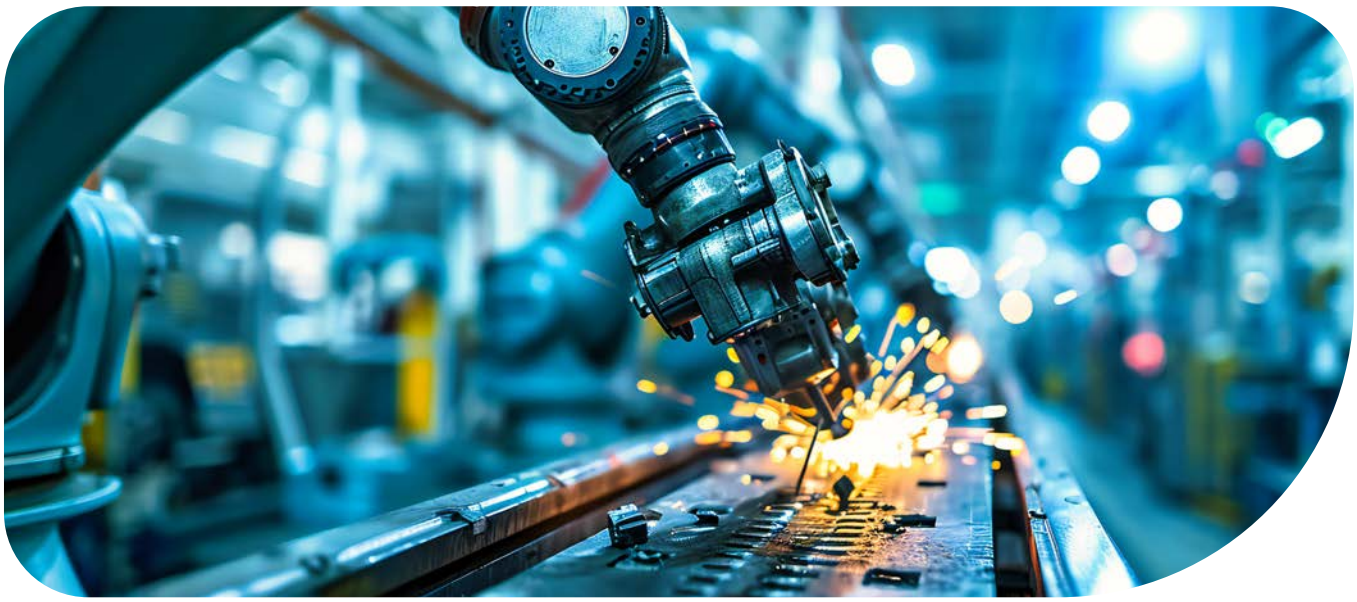
Metal industries may lessen events like chemical spills and emissions that could harm the environment by implementing green ideas into their safety practices. Risk evaluations that consider environmental and safety considerations can be included in the SMS, which can result in proactive steps to avert accidents. Frequent training sessions can teach employees about environmentally friendly procedures, promoting an environmentally conscious culture at work.

Furthermore, the SMS can track and assess how operations affect the environment, allowing for ongoing sustainability performance improvement. Metal companies may advance toward a safer and more environmentally friendly future by recognising and mitigating any risks that could endanger both workers and the environment. This integrated approach to environmental management and safety demonstrates a dedication to ethical and sustainable behaviour, which advances the overarching objective of attaining green sustainability in the metals business.

The SMS in the Indian metal sector

SMS in the Indian metal sector is a comprehensive framework designed to ensure the safety and well-being of workers, protect the environment, and prevent accidents and incidents. Key aspects-

- Ensure that metal industries comply with relevant laws, standards, and guidelines governing occupational safety. Main Occupational Safety and Health legislations in India:
  - The Factories Act, 1948
  - The Mines Act, 1952 and Mines Rules, 1955
  - The Dock Workers (Safety, Health and Welfare) Act, 1986 followed by notification of the Dock Workers (Safety, Health and Welfare) Regulations, 1990
  - The Building & Other Construction Workers (Regulations of Employment and Conditions of Service) Act, 1996
- Identify potential hazards in metal processing and manufacturing, such as evaluating risks associated with machinery, materials, and operational processes.
- Conduct training programmes to educate workers on safety protocols, proper equipment usage, and emergency response procedures.
- Prepare plans for responding to emergencies such as fires, chemical spills, or accidents by way of regular drills and simulations
- Deploy health monitoring programmes to track the well-being of workers exposed to occupational hazards through regular health check-ups and surveillance
- Have safety inspections and audits to assess the compliance of facilities and operations with safety standards
- Ensure that all incidents, including near misses, are reported, investigated, and corrective actions are implemented to prevent recurrence



09

Role of Stakeholders

Role of Stakeholders

The collaborative efforts of various stakeholders are crucial in determining the industry's environmental effect and future course as it aims to create a more sustainable metals ecosystem. The creation of laws and policies that encourage sustainable practices and provide a framework for ethical metal production is mostly the responsibility of governments. Businesses and industry leaders contribute by embracing greener technology, innovating, and incorporating the circular economy into their daily operations. Investors and financial institutions can influence by funding projects that prioritise environmental sustainability, thereby, leading the sector towards more environment- friendly practices. Academic institutions and research centres contribute by developing technologies that lessen the environmental impact of the metal production process. Local communities can advocate for responsible and community-sensitive operations, thereby exerting influence over the industry's practices as stakeholders.

Green skill for future talent cultivation, capacity building, and R&D for climate friendly technology

Building future talent's green capabilities is crucial in the dynamic metals ecosystem because it will spur innovation, capacity building, and research and development (R&D) for climate-friendly technologies. A variety of abilities that are in line with sustainability principles, environmental awareness, and the implementation of eco-friendly methods in the metals sector are together referred to as "green skills." Equipping people with knowledge on topics like sustainable resource management, circular economy principles, and the integration of renewable energy sources is part of the talent cultivation process.

The goal of capacity building is to increase the industry's overall ability to accept and apply climate-friendly technologies. This includes educational activities, training programmes, and workshops that equip professionals with the know-how to manage the shift to a greener metals industry. Building a workforce with experience in environmental sustainability becomes strategically important as climate considerations become increasingly integrated into corporate plans. Within the metal's ecosystem, research and development is essential to the development of climate-friendly technology. Supporting research projects to lower emissions, increase energy efficiency, and optimising resource use advances sustainable practices. This entails working together across academic institutions, business leaders, and research centres to develop technical innovations and investigate novel approaches that support environmentally friendly objectives.

The metals ecosystem can accomplish sustainability targets, handle environmental concerns, and establish itself as a leader in environmentally conscious and responsible industrial processes by incorporating green capabilities into talent cultivation, capacity building, and R&D initiatives. This comprehensive strategy not only prepares the business for a future moulded by climate concerns, but it also instills in its workforce a culture of innovation and environmental care.

Financing to achieve Net Zero NDCs

A crucial component of global efforts to address climate change is financing the shift to Net Zero NDCs. Significant investments in energy efficiency, renewable energy, environmentally friendly infrastructure, and other low-carbon technologies are needed to achieve net-zero emissions. Key considerations for financing this transition are:

Public and Private Investment: To finance climate-related projects, governments must entice both public and private capital. Public funds can act as financial inducements and risk mitigators to draw in private investment.

International cooperation: In order to raise the money needed for countries, particularly developing ones, to implement their NDCs, there must be widespread cooperation. Developed countries can assist developing ones through climate financing structures, such as the Green Climate Fund and other international financial institutions.

Green bonds and sustainable finance: These two strategies offer ways to raise money for initiatives that promote environmental sustainability. Green bonds are issued, and procedures for sustainable finance are developed. Sustainable investments are becoming more and more important to investors, and green finance tools facilitate the flow of capital into climate-related projects.

Carbon pricing: By implementing carbon pricing mechanisms like carbon taxes or cap-and-trade programmes, funds can be generated to finance climate-related projects. This generates income for climate finance in addition to offering a financial incentive for emission reductions.

Novel financial instruments: Investigating novel financial instruments might draw in fresh funding sources. Examples of these are impact investment funds and climate insurance. These tools can aid in mitigating the risks connected to climate-related initiatives and increase investor attractiveness for investments.

Banks for multilateral development (MDBs): When it comes to funding climate programmes, MDBs are essential. These organisations can help nations implement their NDCs by offering loans, grants, and technical assistance. Working together with MDBs can help get more funding for climate-related projects.

Initiatives for corporate sustainability: By interacting with the private sector through corporate sustainability programmes, companies are encouraged to make investments in low-carbon technologies and implement eco-friendly procedures. Sustainable business practices can encourage innovation and help achieve NDCs.

Deependra Kashiva
Director General
Sponge Iron Manufacturers Association

In the last couple of years, SIMA has worked closely with the Ministry of Steel and sponge iron manufacturers to implement low-hanging opportunities for decarbonization in the sector. The association has been advocating on issues such as material efficiency, energy efficiency, the use of renewable energy, and steel melting scrap. It is now important for the sponge iron industry to explore multiple pathways for decarbonization and collaborate with various stakeholders, such as technology and equipment suppliers, etc. SIMA also provides a platform to its members to interact with such novel technology providers through multiple seminars, conferences. SIMA will continue to play a catalysing role in the decarbonization of Indian steel industry in the coming years.

Fiscal policies: To encourage investments in sustainable practices and renewable energy, governments can enact fiscal policies like tax breaks and subsidies. These regulations foster an advantageous business climate that encourages companies to shift to low-carbon operations.

Building institutional capacity and offering Technical Assistance: For efficient finance management and project execution, countries must receive technical assistance and capacity building. This assistance guarantees the effective use of money and the alignment of projects with long-term climate goals.

Accountability and transparency: Putting in place structures for accountability and transparency guarantees that funds are spent wisely and that the NDC targets are being met on time. This transparency increased he confidence of stakeholders and investors.

In summary, financing for achieving Net Zero NDCs requires a multifaceted approach, involving a combination of public and private investments, international cooperation, innovative financial instruments, and supportive policies. A coordinated effort among governments, businesses, financial institutions, and the international community is essential to mobilise the necessary resources for a sustainable and climate-resilient future.

10

Green Steel Market in India

Green Steel Market in India

With its lower carbon emissions and dedication to environmental care, green steel has become a major focus in India's industrial landscape. The Indian steel industry is changing creatively to adopt greener and more sustainable production techniques as a result of rising awareness of climate change and the need to reduce carbon footprints.

Challenges:

1. Green steel production plants necessitate a **large initial financial outlay** for infrastructure and new technology. For businesses, especially smaller ones, the large upfront expenses can be problematic. To encourage adoption, financial assistance or other incentives may be necessary.
2. The manufacturing of green steel **depends on cutting-edge technology** like electric arc furnaces and hydrogen-based processes. It is still difficult to guarantee that these technologies are developed, scalable, and profitable; this calls for constant research and development.
3. **Building new infrastructure**, such as installations for renewable energy sources and hydrogen manufacturing facilities, is necessary to switch to green steel. Building this infrastructure at scale can be logistically and financially challenging, necessitating coordinated efforts from multiple parties.
4. Green steel manufacturing relies on a consistent and plentiful **supply of clean energy**, such as green hydrogen or renewable electricity. It can be difficult to guarantee the availability of these energy sources, especially in areas where conventional energy is now the main source of energy.
5. Incorporating green steel into the current markets and supply chains can be difficult. The industry must manage the change while preserving the competitiveness, consistency, and quality of its products.
6. The growth of the green steel market depends on the existence of a clear and encouraging **policy and regulatory environment**. Unclear or inconsistent rules may hamper investment and adoption of green steel technology.

Opportunities

1. Steel is among the **ecol friendly and sustainable items in greater demand worldwide**. Indian producers can address this need and obtain a competitive advantage in the market by producing green steel.
2. India has enormous **potential for renewable energy**, especially in solar and wind power. In addition to meeting the industry's energy needs, utilising these resources for green steel production can establish India as a pioneer in environmentally friendly steel production.
3. The adoption of green steel technologies can be aided by **government support** in the form of subsidies, incentives, and policy frameworks. Going forward, an environment favourable to the development of green steel can be established by the government and industry working together.
4. Bringing in knowledge and funding for green steel projects can be achieved through working with **international partners** and drawing in **foreign investments**. The implementation of sustainable steel production technologies can be accelerated through joint ventures and technology transfers.
5. The switch to environmentally friendly steel production opens up **employment and skill development opportunities** in fields like technology, renewable energy, and sustainable practices. This may support the growth of the economy and a trained labor force.
6. By encouraging **recycling** and lowering dependency on virgin resources, green steel complies with the principles of the circular economy. Introducing **circular economy principles** into the steel industry can create new revenue streams and business models.
7. Businesses that use green steel technology can set themselves apart from the competition by emphasising their dedication to sustainability. This can **increase brand value** and draw in companies and customers who care about the environment.

11

Way Forward

Way Forward

India is uniquely placed among other countries both in terms of growth potential or investment potential. As Jeff Bezos 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 target to become a developed nation during "Amritkal" by 2047. By implementing these recommendations and forging a collaborative path forward, stakeholders can contribute to the broader goal of decarbonization and environmental sustainability in the face of climate change.

Key Initiatives	Description	Nodal Agency
Financial Incentives[167] [168]	• Government should provide financial incentives, tax credits, and subsidies to Indian industries adopting sustainable practices in metal production. • Government should adopt global best practices to support viability gap funding of such programs, at least for PSUs. • Explore the integration of green financing mechanisms and sustainable investment practices to attract capital towards environmentally friendly metal projects. • Establish a Green Industry Certification program to recognize and reward companies demonstrating exceptional commitment to sustainability.	Ministry of Finance, Ministry of Commerce and Industry
Policy making for development and regulation of Green metal[169] [170] [171]	• Collaborate with policymakers to design frameworks that promote responsible sourcing, circular economy principles, and environmentally friendly practices in the metal industry • Explore import mechanisms similar to EU's CBAM policy for cost advantage to Indian Steel players • 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).	Ministry of Mines, Ministry of Steel, NITI Aayog and Industry players
Research and Development[172] [173] [174] [175] [176]	• Increase funding for R&D in the field of sustainable green metals, with a focus on innovative technologies that reduce environmental impact and energy consumption. • Encourage public-private partnerships (PPP) to accelerate the translation of research findings into practical applications. • Innovate and Integrate circular economy principles into the manufacturing processes of metal products, emphasizing recycling, refurbishment, and extended product lifecycles. • Collaborate with industries to develop circular economy business models that minimize waste and resource consumption. • Regularly update policies and strategies based on the latest research findings and industry advancements. • Implement comprehensive waste valorization programs to encourage the recycling of metal waste in collaboration with the informal recycling sector. • Promote the establishment of recycling infrastructure and centers across the country to efficiently collect and process metal scrap. • Government should fund the development of coal gasification for steel industry as a special focus area within its recently declared coal gasification program support	Department of Science and Technology & Ministry of Steel

Key Initiatives	Description	Nodal Agency
Stakeholder Collaboration for Green Mining[177] [178]	• Develop frameworks to promote ethical sourcing, transparency, and responsible mining practices • Facilitate collaboration between industry stakeholders, research institutions, and governments to foster knowledge exchange, technology transfer, and the adoption of best practices • Collaborate among Indian and International mining industry to encourage adoption of eco-friendly and sustainable mining practices, including the use of advanced technologies and equipment to minimize environmental impact.	NITI Aayog, Ministry of Steel and Ministry of Mines
Capacity Building and Training[179] [180] [181]	• Invest in training programs to build the capacity of industry professionals, policymakers and researchers in sustainable practices related to green metals. • Develop educational initiatives to raise awareness among consumers about the environmental impact of metal consumption, principles and benefits of circular economy practices. • Promote a circular economy mindset, emphasizing the importance of resource efficiency, waste reduction, and sustainable product design. • Establish centers of excellence and research hubs to facilitate the development and dissemination of knowledge on sustainable metal production.	National Skill Development Corporation, Ministry of Skill Development and Entrepreneurship
Life Cycle Assessment & Renewable Energy Integration[182] [183] [184] [185]	• Incorporate life cycle assessments into industry practices to evaluate the environmental impact of metal production from extraction to end-of-life. • Embed circular economy principles in the design and production of green metals, emphasizing the importance of recycling, refurbishment, and remanufacturing. • Advocate for the inclusion of extended producer responsibility (EPR) programs, making producers accountable for the entire life cycle of their products. • Incentivize the integration of renewable energy sources, such as solar and wind power, into the energy-intensive processes of metal extraction and production. • Encourage the establishment of closed-loop systems where the end-of-life products can be efficiently collected, disassembled, and recycled, reducing the reliance on raw material extraction.	NITI Aayog, MoEF&CC and Ministry of Steel
Digitalisation and Technology Adoption[186] [187]	• Adopt blockchain and other advanced technologies to track the origin, processing, and distribution of metals, promoting accountability and responsible sourcing. • Facilitate the development of digital platforms to connect stakeholders, share information, and monitor the environmental and social impact of metal production.	Niti Aayog, Ministry of Steel
Consumer Awareness Campaigns[188] [189]	• Launch public awareness campaigns to educate consumers about the environmental implications of their metal consumption choices. • Empower consumers to make informed decisions by promoting products with eco-friendly certifications and sustainable sourcing practices. • Launch targeted public awareness campaigns to educate Indian consumers about the environmental impact of their metal consumption choices. • Include public policy for mandatory procurement of green metals for Infrastructure development to increase demand.	Ministry of Steel and MoEF&CC

Key Initiatives	Description	Nodal Agency
Continuous Monitoring and Reporting[190] [191]	• Establish transparent reporting frameworks to enhance accountability and facilitate data-driven decision-making. • Implement robust monitoring and reporting mechanisms to track the progress of the metal industry in adopting sustainable practices. • Encourage the adoption of certified products by consumers and industries through awareness campaigns highlighting the importance of choosing responsibly sourced and produced metals.	Ministry of Steel and Ministry of Mines
Safety Standards and Practices[192] [193] [194]	• Prioritize the development and enforcement of stringent safety standards in all phases of sustainable green metal production, including extraction, processing, and manufacturing. • Establish industry-wide forums for sharing safety best practices, lessons learned, and emerging technologies that can improve safety outcomes.	Ministry of Labour

Note: Nodal Agency mentioned here are indicative agencies for driving the respective initiatives however, involvement of various other departments, institutes and Industry players will be required for successfully developing and driving these initiatives.

Role of Biju Patnaik National Steel Institute (BPNSI):

1. Research and Development: Leads research for sustainable green metals, driving innovation for eco-friendly technologies
2. Training and Capacity Building: Trains industry professionals, policymakers, and researchers in sustainable green metal practices
3. Policy Advocacy: Collaborates with government bodies and industry to advocate policies incentivizing sustainable metal production
4. Technology Adoption: Drives the adoption of advanced technologies within the steel & other metals industry for enhanced environmental sustainability

Role of State Pollution Control Board:

1. Regulatory Oversight: Enforces environmental laws and regulations related to pollution control in the state
2. Emission Monitoring: Monitors and regulates industrial emissions, ensuring compliance with air quality standards.
3. Water Quality Management: Oversees water pollution control, monitors water quality, and enforces measures to prevent water contamination.
4. Waste Management: Regulates and manages the disposal and treatment of industrial and hazardous waste to prevent environmental harm.
5. Environmental Impact Assessment (EIA): Conducts EIAs for industrial projects, ensuring adherence to environmental norms and sustainable practices.
6. Public Awareness: Educates the public on environmental issues, pollution prevention, and sustainable practices.
7. Licensing and Compliance: Issues permits and licenses to industries, ensuring compliance with pollution control standards.
8. Enforcement Actions: Takes legal actions against entities violating environmental regulations, including penalties and shutdowns if necessary.
9. Collaboration with Industries: Works with industries to promote cleaner production methods and sustainable environmental practices.
10. Data Collection and Reporting: Collects and analyzes data on environmental quality, generating reports for government and public awareness.

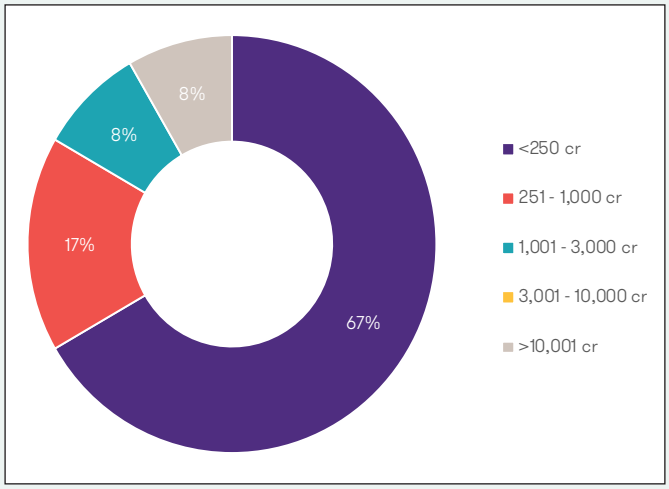
12

Survey by Grant Thornton to understand current status of decarbonisation initiatives in Odisha Steel Sector

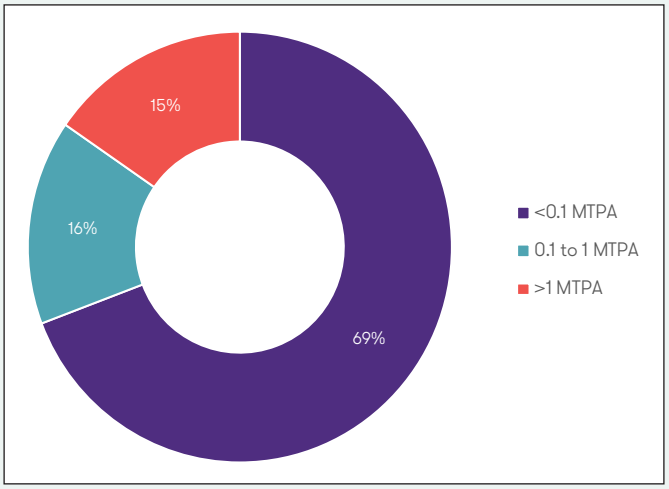
Survey by Grant Thornton Bharat to understand current status of decarbonisation initiatives in Odisha Steel Sector

Grant Thronton Bharat, with the help of Biju Pathnaik National Steel Institute and Odisha State Pollution Control Board, conducted a survey where 13 prominent companies in the iron and steel industry in Odisha participated and provided their views on current decarbonisation initiatives. Out of 13, three companies are listed on stock exchanges in India.

Revenuewise distribution

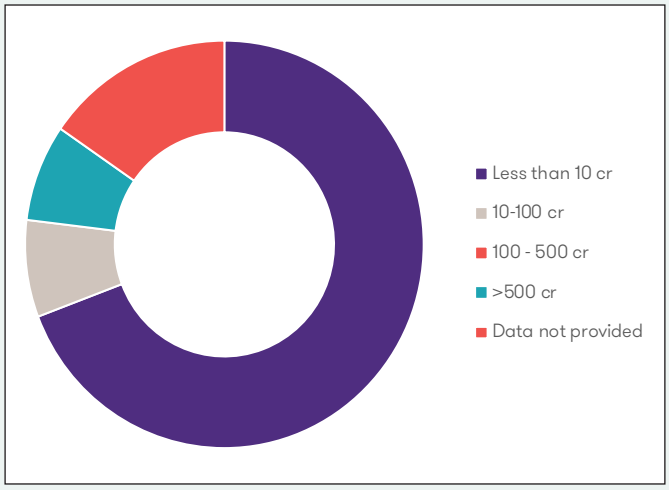


Iron making capacity (Hot Metal + DRI) (in MTPA)

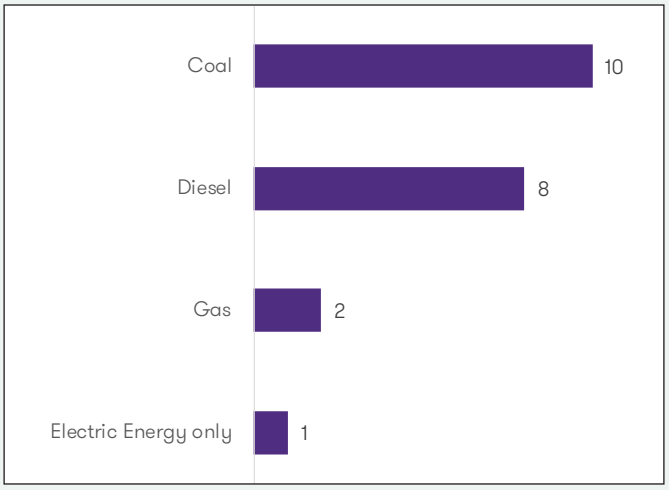


The companies participated in the survey have a diverse range of revenue from small companies having less than INR 250 cr revenue to large conglomerates having >INR 10,000 cr revenue. The surveyed companies have diverse range of capacities in iron making, encompassing both Hot Metal and Direct Reduced Iron (DRI) production. Majority of companies who have participated have annual energy requirement less than INR 10 cr and most of the companies use coal as a fuel (~77%) followed by diesel, gas and electrical energy.

Annual expenditure on Energy in FY 23



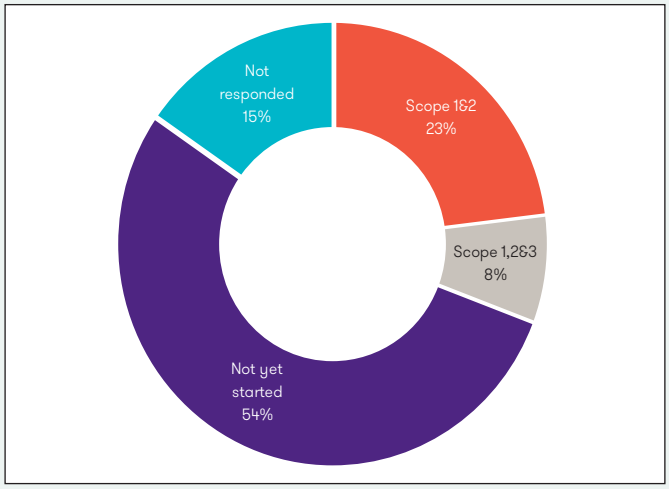
Fuel dependency



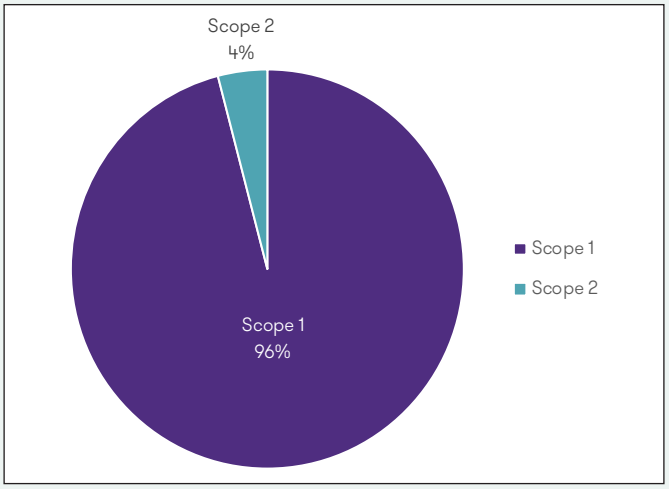
Emission monitoring:

Majority of the companies has not yet started monitoring of emissions across Scope 1, 2 &3. 36% of the companies have responded that have started monitoring Scope 1 & 2 emissions out of which only one company has started monitoring all emissions including Scope 3. This shows that, very few steel companies has started recording Scope 1 and 2 data and scope 3 data is not being sufficiently captured.

Emission Monitoring



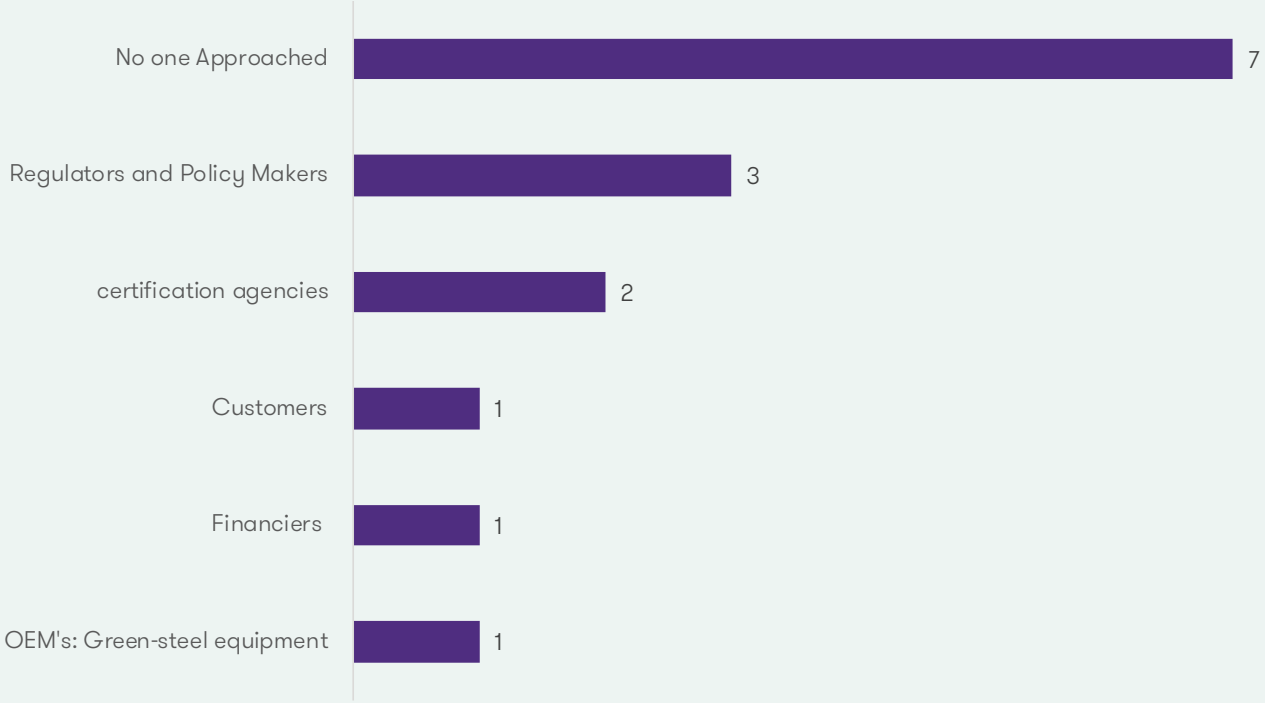
Distribution of Scope 1&2 emissions



Agencies push for Green Steel

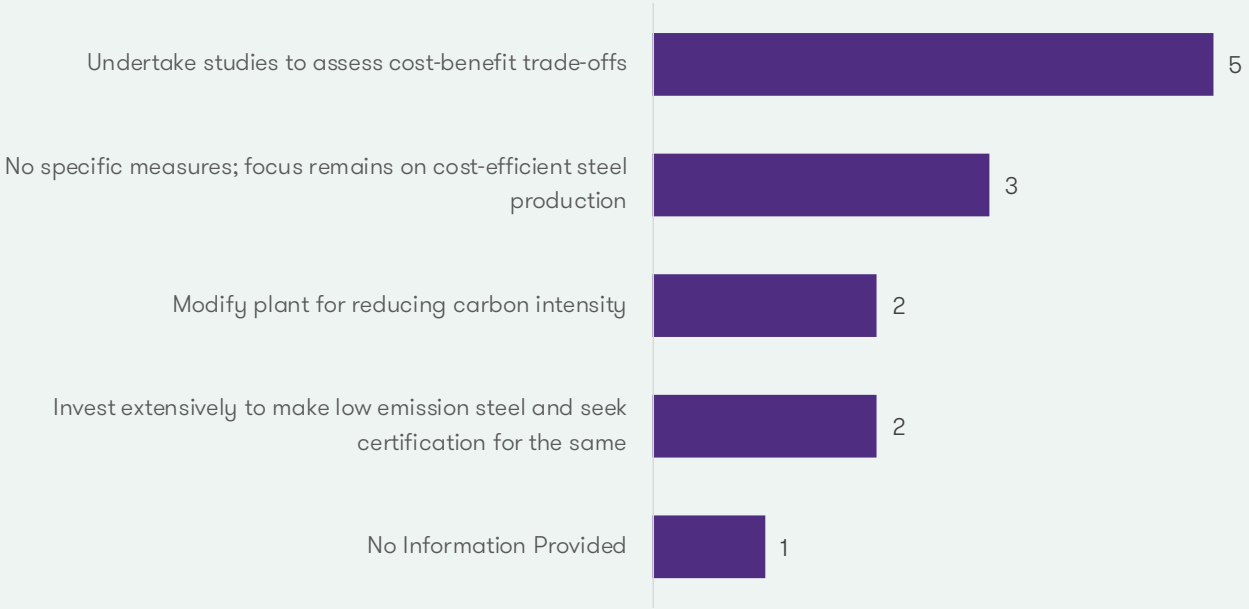
Further around 46% of companies informed that they have been approached for making Green and clean Steel in which maximum Companies have been approached by Regulators and policy makers followed by Certification agencies. Out of total companies who was not approached by anyone for decarbonatisation, around 43% have started on their own.

Annual expenditure on Energy in FY 23



Decarbonisation strategy: When asked about their decarbonisation strategy for next three years, there was mixed response however majority of them will undertake studies to assess cost-benefit trade-offs in next three years. This shows that Indian steel manufacturers are actively looking for decarbonisation strategy, but cost factors are the major constrains.

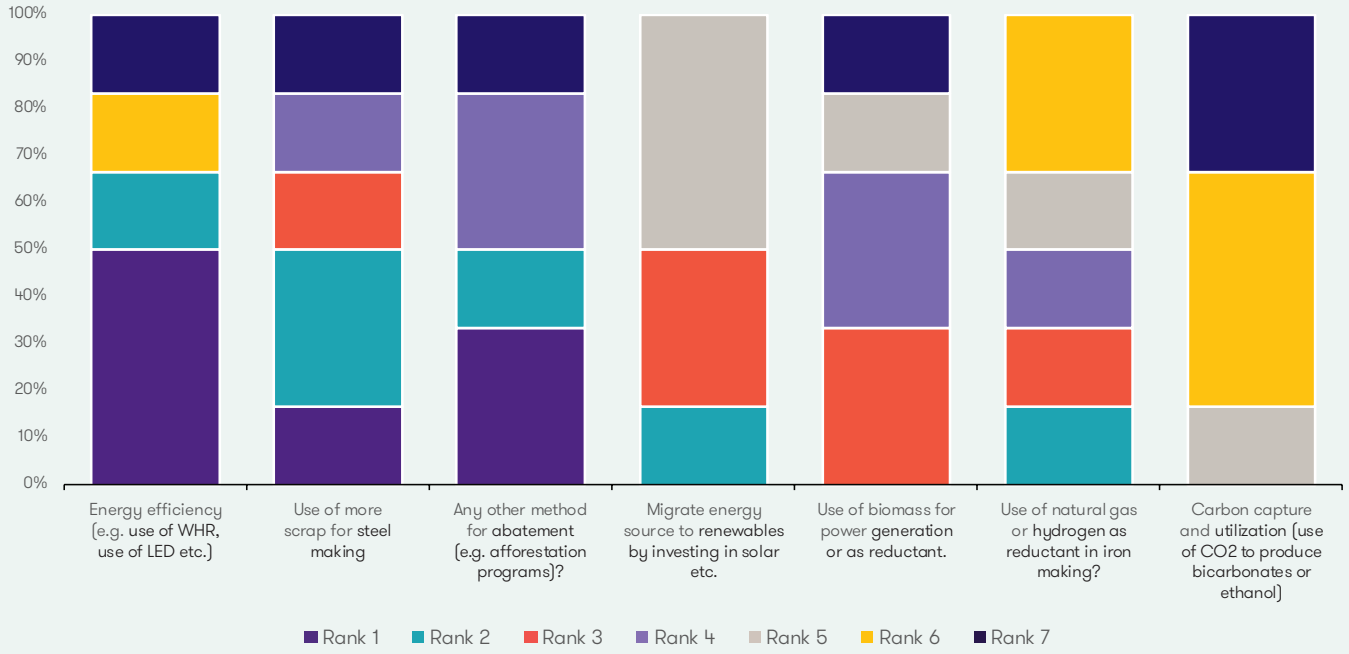
Companies' staretegy for decarbonisation in next 3 years



When asked about what kind of de-carbonisation projects have already been taken, almost 46% of companies have stated the path using various initiatives like Afforestation, Control Emission Through ESP, Improvement of the process yield and Improvement of the raw material quality etc.

Ranking of various abatement method

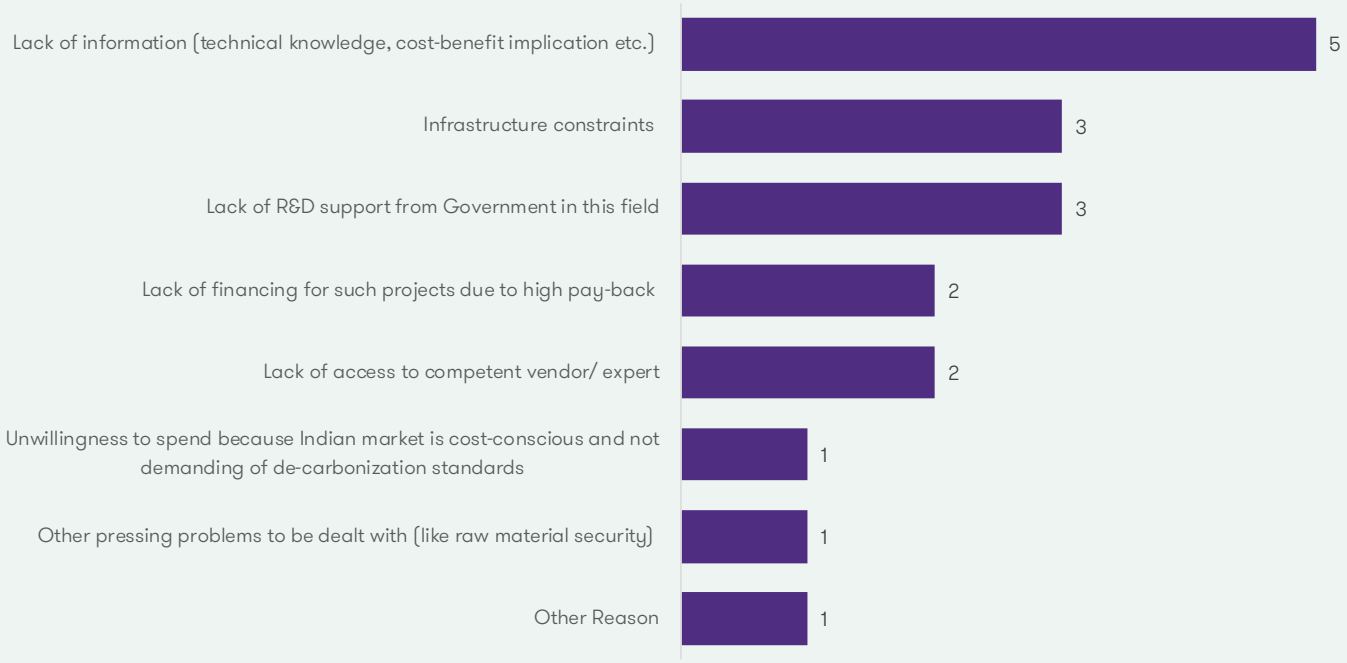
Majority of companies have identified Energy efficiency (e.g. use of WHR, use of LED etc.) is most promising way for Decarbonisation Path. Apart from this use of more Scrap for steel making, afforestation programmes and migrating energy source to renewables by investing in solar etc. are also their current choices for decarbonisation pathway.



The most companies have recognised that technology like CCUS, Use of Biomas, Hydrogen or Natural gas as redundant will take time to develop at scale and in current scenario is least preferrable.

Major Bottleneck to start decarbonisation Journey:

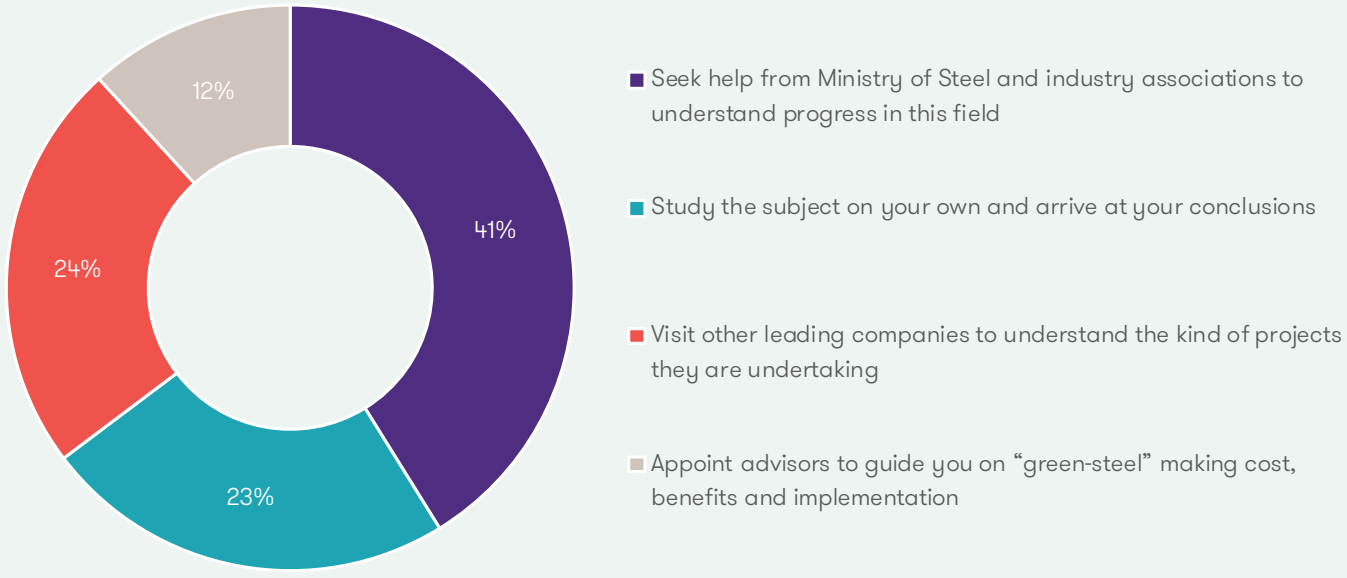
When asked about the reasons for not starting the path of decarbonisation or major issues in progress, most of the companies have informed that one o the major challenges is Lack of information (technical knowledge, cost-benefit implication etc.) followed by Infrastructure constraints and Lack of R&D support from Government in this field.



Plans to start Decarbonisation Journey

To made significant progress for decarbonisation, Majority of the companies are planning to seek help from Ministry of Steel and industry associations to understand progress in this field. Apart from this many companies are also planning to visit other leading companies to understand and study the subject on their own to arrive at conclusion.

Plans to start Decarbonisation Journey



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Abbreviations

AI	Artificial Intelligence
ASU	Air Separation Unit
ATACH	Alliance for Transformative Action on Climate and Health
ATR	Autothermal Reforming
B	Billion
BF	Blast Furnace
BOF	Basic Oxygen Furnace
C	Celsius
CAD	Computer-Aided Design
CAGR	Compound Annual Growth Rate
CAM	Computer-Aided Manufacturing
CAPEX	Capital Expenditure
CBM	Coal Bed Methane
CCS	Carbon Capture and Storage
CDA	Carbon Direct Avoidance
CHAMP	Coalition for High Ambition Multilevel Partnerships
CNC	Computer Numerical Control
CNY	Chinese Yuan
CO2	Carbon Dioxide
COP	Conference of the Parties
CPLY	Corresponding period last year
DJSI	Dow Jones Sustainability Indices
DRI	Direct Reduced Iron
EAF	Electric Arc Furnace
EBITDA	Earnings Before Interest, Taxes, Depreciation, and Amortization
EL	Exploration License
EU	European Union
EV	Electric Vehicle
FDI	Foreign Direct Investment
FEED	Front-End Engineering and Design
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GW	Gigawatt
ICMM	International Council on Mining and Metals
IEA	International Energy Agency
ILO	International Labour Organization
IMEO	International Methane Emissions Observatory
IMF	International Monetary Fund
INR	Indian National Rupee
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
IPHE	International Partnership for Hydrogen and Fuel Cells in the Economy
ISA	International Solar Alliance
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature
IPHE	International Partnership for Hydrogen and Fuel Cells in the Economy
ISA	International Solar Alliance
ISO	International Organization for Standardization
IPHE	International Partnership for Hydrogen and Fuel Cells in the Economy
ISA	International Solar Alliance
ISO	International Organization for Standardization

MMDR	Minerals Development & Regulation Act
MoES	Ministry of Earth Sciences
MoU	Memorandum of Understanding
MT	Million Tonnes
MtCO2e	Metric tons of carbon dioxide equivalent
NAP	National Adaptation Plan
NBSAP	National Biodiversity Strategies and Action Plan
NDC	Nationally Determined Contributions
OECD	Organization for Economic Co-operation & Development
OEM	Original Equipment Manufacturer
OPEX	Operating Expenditure
PCB	Printed Circuit Boards
PCI	Product Complexity Index
PGM	Platinum Group Metals
PSIF	Process Safety Incident Frameworks
R&D	Research & Development
RE	Renewable Energy
RFID	Radio Frequency Identification
SMS	Safety Management System
TCP	Technology Cooperation Programme
TMT	Thousand Metric Tonnes
TPA	Tonnes per Annum
TRIFR	Total Recordable Injury Frequency Rate
TWh	Terawatt Hours
UAE	United Arab Emirates
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
US EPA	United Nations Environmental Protection Agency
USD	United States Dollar
VR	Virtual Reality
WESR	World Environment Situation Room
WMO	World Meteorological Organization
WSA	World Steel Association

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