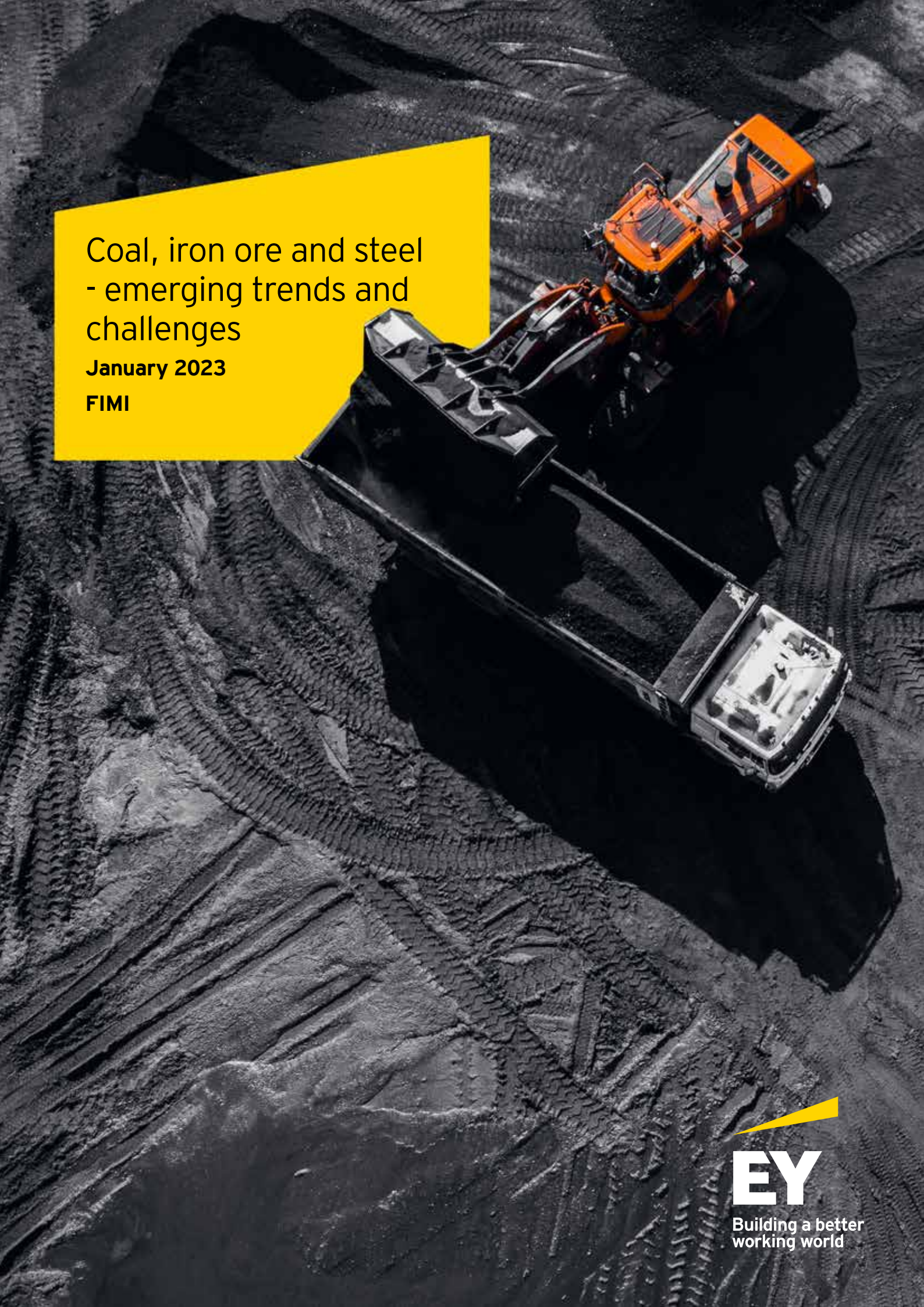

Coal, iron ore and steel - emerging trends and challenges

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FIMI

EY

Building a better working world

Contents

Foreword from FIMI

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Coal, iron ore and steel are critical for continued economic development and are the backbone of global sustainable initiatives, including energy transition. Today, the steel industry is one of the world's most energy intensive, accounting for around 8% to 9% of global carbon dioxide emissions. For steelmakers, reducing emissions and specific energy consumption is critical as the global decarbonization agenda speeds up.

The steel sector relies on the availability of resources like iron ore, coking/metallurgical coal, steel scrap and power. India has adequate iron ore reserves, and utilization of iron ore fines and low-grade iron ore is a key determinant for the success of the industry. India does not have sufficient reserves of coking/metallurgical coal and is dependent on imported coking coal which are subject to wide price fluctuation.

Coking coal reserves in India stands at 34.5 billion tons however it is not of adequate quality to form good coking coal on account of high impurities. With a targeted production of 300 million tons of steel by 2030, the demand for coking coal is expected to rise to 161 million tons. To keep the industry globally competitive, India will maximize the use of its domestic reserves and will need coking coal for reducing iron ore to iron.

The Indian steel industry is facing challenges on multiple fronts relating to resource utilization which includes limited availability of high-grade ore and coking coal, overcapacities, and energy efficiencies. The steel sector employs high temperature furnaces for iron and steel production, which has become the second largest energy consumer in the industry. The increasing international focus on emissions and de-carbonization has led to the imminent requirement to double down on optimizing resource utilization in the production of steel. The industry has undertaken multiple initiatives aimed at optimizing the consumption of critical resources and reducing wastage across the iron and steel value chain.

While there are number of initial steps that have been undertaken by major Indian steel players for R&D, policy intervention by government and industry-user collaboration, there is a persistent need to not only have sustained R&D investment by Indian steel companies but also engage and develop a deeper level of collaboration across different stakeholders within the steel ecosystem. Digitalization of these industries in an integrated holistic fashion will further improve the operating efficiency and quality and reduce the operating cost.

We also present view on the options available to industry players to meet the long-term targets of carbon neutrality. As a first step, a well-planned, stage gated roadmap/pathways will be critical for a successful set up.

All such pathways will represent an informed choice of clean technologies while balancing business risk, quality of end product and capital cost while improving sustainability metrics across the value chain.

Stakeholders like governments, the UN, academia, communities, and steel associations are likely to play an important role in supporting the implementation strategies of industry players. Other than carbon pricing mechanisms, government will need to provide support for R&D and finances to encourage and catalyse change.

India's economy is the fifth largest economy in the world, surpassing the UK economy in 2022. According to the World Bank forcasts, India's economy may grow to 6.9 % and 6.7% in 2023 and 2024, respectively. According to Chief Economic Advisor, India's economy is expected to be $7 trillion and it would be third largest economy.

While services will be a key growth driver of the GDP for India, coal, iron ore and steel, sourced for formation of rail, road, ports, airports, irrigation, energy, housing, mining, oil and gas and creating capacity for manufacturing, construction, mining will be the cornerstone of setting the foundations of immediate and long-term sustainability of meeting GDP growth targets of the future.

With the government helping in providing support to these industry for rapid growth through policy formulation and strict governance on meeting execution of those, industry players have to play their part in demonstrating discipline of capital spends and foresight on investment in the right technologies for expansion. the government and the industry players would need to work in sync to execute existing strategic plan, update it based on emerging issues and opportunities which are unique and relevant to India, and draw up a collaborative game plan to nurture the future of a robust and a sustainable industry.

FIMI and EY have created this joint report after analysing the challenges imposed by raw materials like iron ore and coal on the steel industry. Nearly three tons of raw material are needed in form of iron ore and coke to produce one ton of Steel. Therefore, target production of 300 MT of steel by 2030 will entail raw material movement of over 900 MT. This indicates the high dependence of the steel industry on raw materials. Thus, there is a strong need to ensure uninterrupted supply of raw material and so on.

We hope you enjoy reading the report.

Executive Summary

The mineral resources sector has the potential to contribute significantly to the achievement of the Sustainable Development Goals (SDGs) through socio-economic benefits, foreign exchange earnings, employment and livelihoods, development of infrastructure, communication, provision of vital services, and supply of raw materials for green technologies.

Being a part of the sector, the mining and metals companies have to deal with many variable factors, including rising ESG and societal expectations, decarbonization of value chains, geopolitical risks, digital transformation, and unique challenges to portfolio and capital investment decisions. Due to cumbersome statutory clearance requirements, the mining sector faces penal consequences, and that leads to organizational inefficiencies. The past 12 months have witnessed huge upheaval and change. War in Ukraine, climate events, new governments in key mining regions and shifting relationships in others are all impacting the world's mining and metals companies. Coal and iron ore are key driving factors of the mining sector in India.

Coal is the largest energy source globally for electricity generation and for producing iron, steel and cement. The coal industry plays an essential role in accelerating industrialization and urbanization, as it provides fuel to meet the growing demand for resources. In addition, it contributes to increased foreign capital investment, exports, and employment, key factors in socio-economic development.

According to IEA , global coal production is expected to be 8.3 billion tons in 2022, a new all-time-high and well above the record set in 2019. The rebound growth trajectory for global coal production is expected to reach a peak in 2023, just slightly above the 2022 level.

Thermal coal demand may fall, as many countries focus on developing cleaner energy sources, slowing demand for coal used to generate electricity. In India, coal has to play the anchor role in this transition.

The rise in the prices of coking coal is expected to affect the prices of steel and iron ore, which would also be a hindrance in transitioning to green methods. Higher-priced coking coal increases the cost of producing steel via blast furnaces, both in absolute terms and relative to other routes.

Iron ore makes up 5% of the earth's crust and is the second most abundant metal after aluminum. World crude iron ore resources exceed 800 billion tons and are estimated to contain more than 230 billion tons of iron, dominated by low-grade ore. Iron ore is mined in 50 countries, of which the seven largest accounts for three-fourth of the world production. Australia and Brazil together dominate the world's iron ore exports, each accounting for more than one-third of total exports.

Huge scope and opportunity lie in increasing the capacities of coal and iron ore mines and considerable opportunities for future discoveries of sub-surface deposits. Demand for such metals is expected to increase in the near future since a greater necessity is coming from residential and commercial sectors, which would put a pressure on indigenous mines. The Government of India has also helped in the development of the metals and mining sector in India by launching key policy initiatives and regulatory interventions in the auction process, levy of duties and land availability. Private sector has also adapted with time by adopting new technologies, automation and digitization, though considerable scope of improvement exists in this area.

India is the second-largest crude steel producer in the world and is aiming to increase the capacity of crude steel to 300 million tons (mt) by 2030. To achieve this, it requires capital goods worth US$136b. The Indian steel sector has been vibrant and has been growing at a CAGR of about 5% to 6% y-o-y. With a V-shaped demand recovery post-COVID-19 and the policy announcements made by the government across sectors, including rail, road, aviation, gas pipeline, and housing and changes in global supply and demand equations, the industry has had record production and growth in FY 2021 and 2022.

While large steel plants are investing progressively on green and clean technologies, the MSME/SMEs sector is lagging behind. Steel plants, whether large or small, are one of the major polluters and require significant incentives to cut down carbon emissions and improve dust and water management. Experts believe that the next big wave of cleaner technology will see the use of hydrogen as a fuel substitute for carbon, coupled with use of renewable energy. The sector should actively seek to modernize and adapt to the global developments in management thought on mastering the future for robustness and sustainability.

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1 Introductory Section

1.1 Coal

1.1.1 Overview of coal

Coal is the world's most affordable energy fuel and biggest commodity market for electricity generation. The history of coal mining and excavation is often associated with the industrial revolution, owing its usage in iron, steel, cement production, fertilizers, and steamships. Coal was also used for making gasses, which were further used for gas lights. After the development of electricity in the 19th century, it was evident that coal would remain a crucial source of energy for its generation.

Coal can be prominently classified as coking coal and non-coking coal. Coking coal is the type of coal that is used to produce coke, while non-coking coal is used for other purposes, such as power generation. The difference between the two types of coal is their chemical and physical properties. Coking coal has a higher carbon content and a lower ash content than non-coking coal.

Coal evacuation infrastructure typically comprises the following logistics segments: first mile logistics, trunk mile logistics and last mile logistics. Any coal supply chain can be simplified to the following stages:

1. Mine
2. Coal preparation plant (CPP)
3. Inland and/or seaborne transportation
4. End-user

However, within this simplified chain are many stages of stockpiling, different transportation modes, and where each link meets, and the various ways of transferring the coal from one to the other.

1.1.2 Global overview of coal industry

In 2022, coal trade volume has increased to 1.33 billion tons and a great majority of coal traded in 2021 (93%) was seaborne. The trade of steam coal for power generation and boiler shows the growing dominance of coal as a source of energy.

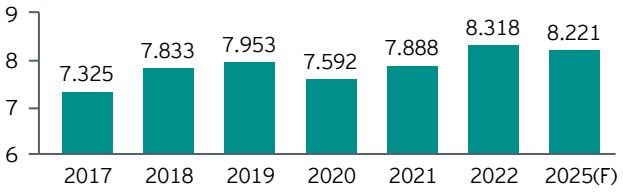
In 2021, worldwide exports of steam coal reached 1024 million tons, and metallurgical coal is 324 million tons. The trade of thermal coal increased by 1.6%, metallurgical (met) coal trading volumes declined by 2.3%.

Coal markets have been shaken severely in 2022, with traditional trade flows disrupted, prices soaring, and demand set to grow by 1.2%, reaching an all-time high and surpassing 8 billion tons for the first time. Russia's invasion of Ukraine has sharply altered the dynamics of coal trade, price levels, and supply and demand patterns in 2022.

Production trend, growth projection and forecast

The global coal reserves, as of 2021, reached around 1,161 billion tons while annual production is about 7.88 billion tons in 2022 with an increase of 3.8% from 7.59 billion tons in 2020.

Figure 1: Total coal production (Billion tonnes)



Source - Coal 2022, IEA

Global coal production is expected to be 8.3 billion tons in 2022, a new all-time-high and well above the record set in 2019. This follows an increase of 3.9% to 7.8 billion tons in 2021 as economies recovered from the pandemic-induced demand drop in 2020. In absolute terms, 2021 growth was mainly driven by production increases of 153 MT in China (4%) and 48 MT in India (~6%).

The rebound growth trajectory for global coal production is expected to reach a peak in 2023, just slightly above the 2022 level. By 2025, coal production will fall to 8.2 billion tons, back below 2022 levels.

Coal used in electricity generation (the largest sector by consumption), is expected to grow by just over 2% in 2022. By contrast, coal consumption in industry is expected to decline by over 1%, mainly driven by falling iron and steel production amid the economic crisis.

Coal demand has risen amid ongoing shortages in gas supply. The reduced availability of gas has meant that countries have switched to coal to meet electricity needs. Operational shortcomings in the European nuclear and hydroelectric power sectors this year have exacerbated the demand for coal.

Table 1: Country-wise production (Million tons)

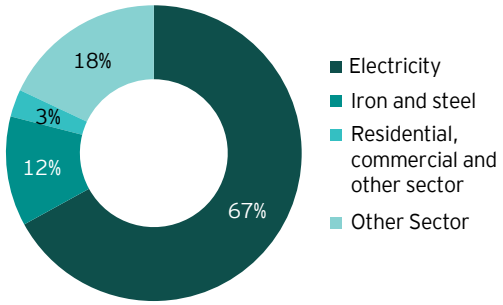
Region	2020	2021	2022
China	3789	3942	4237
India	758	805	893
Australia	474	470	446
Indonesia	566	569	622
USA	486	332	357
Russia	402	437	404
Other	1117	1333	1359
Total	**7592**	**7888**	**8318**

Source- Coal 2022, IEA

Major consumption sector and trend

In 2022, the electricity and heat sector accounted for 67 % of the global demand for coal. This is by far the largest share of coal demand from any sector. By comparison, the iron and steel sector accounted for twelve percent of the coal demand worldwide.

Figure 2: Distribution of coal demand worldwide in 2022



1.1.3
Indian overview of coal industry

India is one of the largest coal producers and the fifth largest country in terms of coal deposits in the world. The coal sector has been a major source of revenue for states and the central government in India. India had a production volume of about 777 million tons of coal as of FY22. However, the domestic production is not enough to meet the increasing demand for coal, and therefore, the country imports coal.

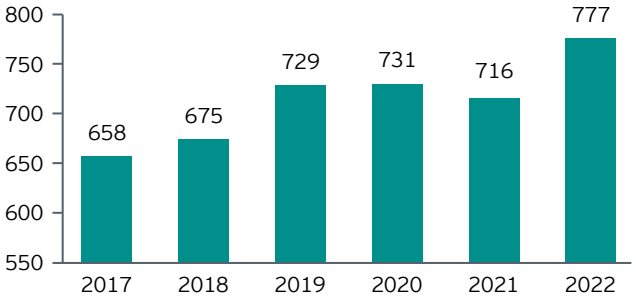
Coal India Limited (CIL) is the largest employer in the mining sector in India, followed by Singareni Collieries Company Limited (SCCL), the second-largest producer. SCCL is a joint venture between the Government of India and Government of Telangana.

Production trend, growth projection and forecast

India's cumulative coal production crossed 777 MT, indicating a growth of around 8.6% during FY22 compared to FY21 and around 6.3% in FY20

India is one of the largest producers of thermal coal in the world after China. India witnessed a growing coal production between 2016-17 to 2019-20. However, the COVID-19 lockdown led to a halt in economic activity which had a significant impact on the overall coal production.

Figure 3: Domestic coal production (Million Tons)



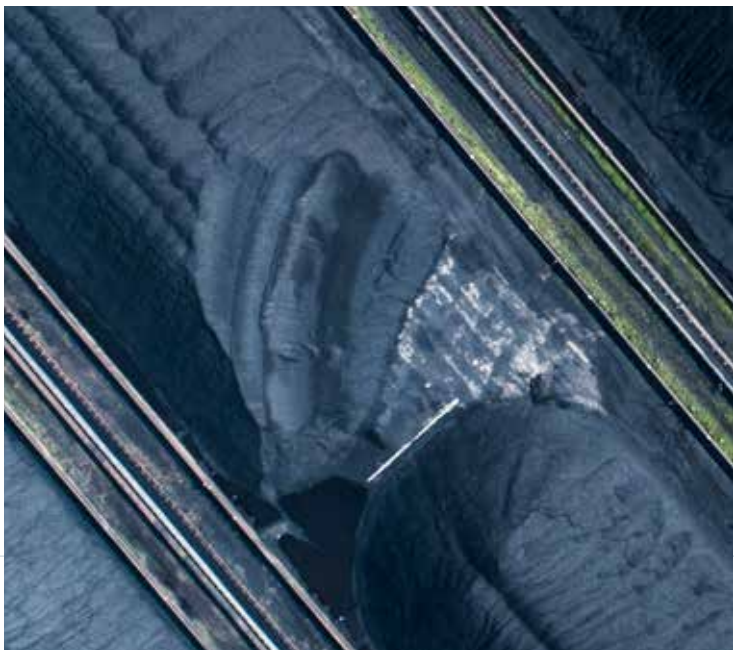
Source: Provisional Coal Statistics, 2022

Of the total coal production, the public sector produced a chunk of approximately 622.6 MT, and the remaining production of nearly 90 MT was from the private sector. Imports also constitute an important part in meeting the total coal demand of the country.

Table 2: Coal Production and Import

Source	FY 2022	FY 2021	FY 2020
CIL	622.6	596.2	602.1
SCCL	65.0	50.6	64.0
Other	89.6	69.2	65.3
Import	209	215	249

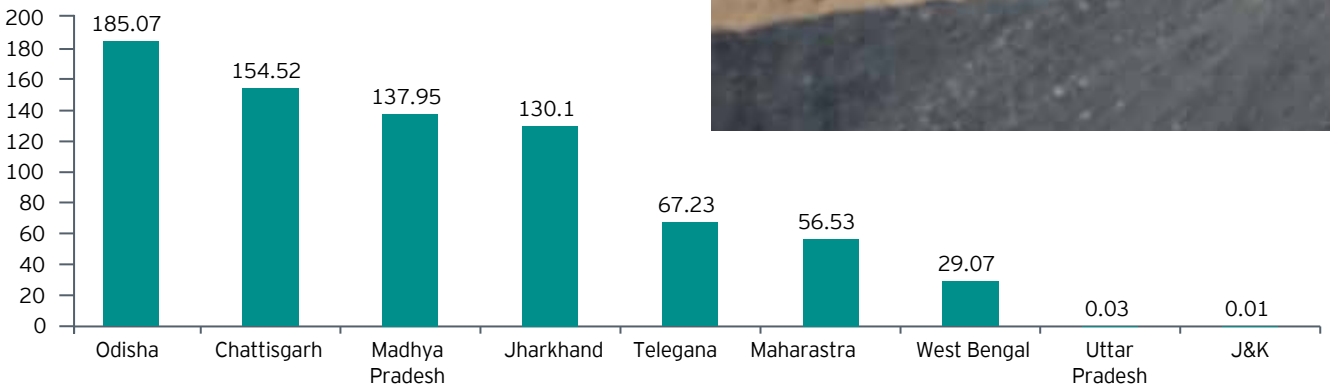
Source: Provisional Coal Statistics, 2022



Key coal producing states

In FY22, Odisha registered the highest coal production of 185.069 MT (23.78%), followed by Chhattisgarh 154.120 MT (19.80%), Madhya Pradesh 137.953 MT (17.73%), and Jharkhand 130.104 MT (16.72%).

Figure 4: Total coal production-State wise (Mt)



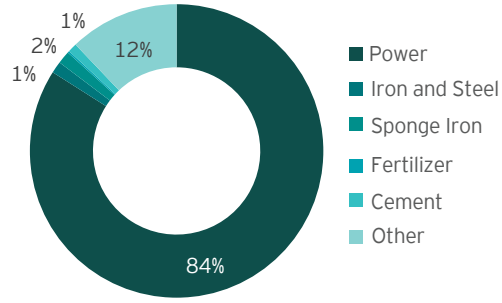
Source: Provisional Coal Statistics, 2022

Top four states contribute for 78 % of the total coal production in the country.

Major consumption sector and trend

Coal consumption in India in FY21 was 1027 million tons. India is the second-largest consumer of coal behind China, and demand is primarily driven by the power sector, which accounted for 84.0% of total dispatches in FY22. In addition, industries like iron and steel, cement, and fertilizers are among those which depend on coal for their energy requirements.

Figure 5: Coal Dispatch Industry wise in India



Source: Provisional Coal Statistics, 2022

As per US EIA, India saw a slowdown in coal consumption in FY21 on the back of a general economic slowdown caused by the COVID-19 pandemic induced lockdowns. Coal consumption growth could witness lackluster growth in the long run, as it faces competition from renewable energy sources. Currently, the steel industry consumes final energy of around 70 million tons of oil equivalent (Mtoe), representing almost 23% of total energy inputs to the industrial sector.

In the year FY22, total coal imports were around 209 MT compared to nearly 249 MT in FY20, thus showcasing a decline of around 16% over FY20. Import of coking coal increased in FY22 and reached nearly 57 MT compared to around 52 MT in FY 20.

Table 3: India coal import (MT)

Coal Type	FY 20	FY 21	FY 22
Coke	51.8	51.1	57.1
Non-Coking Coal	196.7	164.1	151.7
Total Coal Import	**248.5**	**215.3**	**208.9**

Source: Provisional Coal Statistics, 2022

A large chunk of India's imported coal is from Indonesia and Australia. In FY22, around 72 MT of the total coal was imported from Indonesia and 66 MT from Australia. Indonesia and Australia contributed nearly 67% India's coal imports.

Indicative demand supply scenario in view of transition

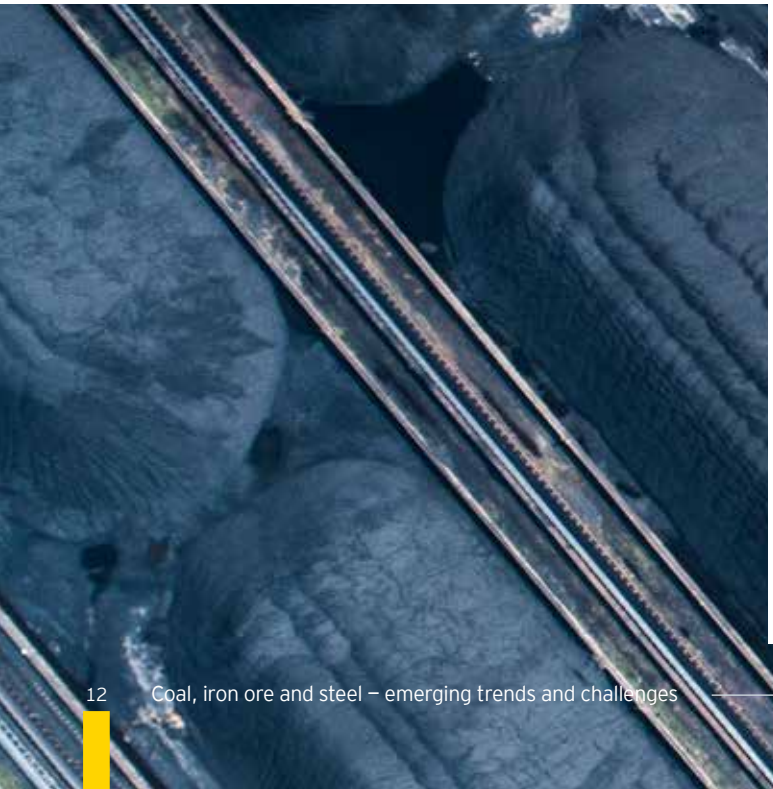
In recent years, there has been a significant shift in India's energy policy toward the promotion of cleaner and renewable energy sources. The government has introduced several policy initiatives to reduce the country's reliance on coal, including the National Action Plan on Climate Change and the National Electricity Plan.

One of the key initiatives in this regard is the promotion of coal gasification, liquefaction, and hydrogen production as alternate uses for coal. These technologies allow for the conversion of coal into gaseous or liquid forms, which can be used as feedstock for various chemical and industrial processes.

The demand for these technologies is expected to increase in the coming years as the government continues to focus on reducing emissions from the power sector. However, the supply of coal will also need to increase to meet this demand, which may require the expansion of existing coal mines or the development of new ones.

Overall, it is likely that the demand-supply scenario for coal in India will see a shift towards cleaner and more efficient uses of the resource, with a focus on meeting the growing demand for cleaner energy sources. However, coal would be important natural resources for upcoming transition. The Central Electricity Authority (CEA), Ministry of Power projects gross electricity generation (BU) during the year 2029–30 likely to be 2,518 BU comprising 1,393 BU from Thermal (Coal, Gas and Lignite), 801 BU from RE Sources, 207 BU from Hydro, 4.4 BU from PSS and 113 BU from Nuclear.

This indicates that coal will have a major role to play in India's power generation mix even in 2030 with almost 54% (1358 BU) of energy being generated by coal, even though its capacity is expected to be reduced to one-third of the total mix.



Industrial processes like production of steel, cement, iron, fertilizers, etc. also require coal primarily for thermal purposes. Industrial coal demand is expected to grow between 350MT and 458 MT by 2030 (3.7–5.9 percent CAGR) based on the range of outcomes in manufacturing growth and energy efficiency, with a mid-value of nearly 400 MT (4.7 % CAGR)

The growth of domestic non-coking and imported coking coal will be the dominant drivers of industrial coal demand. It is also assumed that about 50% of the coal used for industrial processes is expected to be imported by 2030 due to non-availability of high-quality coal domestically, which is consistent with the current trends.

Based on reports, we can say that the domestic coal production requirement is only expected to grow in the coming years from approximately 716MT in 202 1 to 1067-1121 MT in 2030.

Table 4: Demand of coal

	Power	Industry
Coal Demand	2030	2030
Domestic	892	175-229
Imported	0	175-229
Total	**892**	**350-428**
Domestic %	100%	50%

Source- Skill action plan to fuel transition from coal to renewable energy in India, EY

Enhanced focus on the role of private sector and MDO in Indian coal industry

In the Indian coal industry, the role of the private sector has increased in recent years, with the government allowing for greater participation of private companies in coal mining. Private companies can now participate in coal mining for commercial purposes, as well as in the development of coal mines and coal-fired power plants.

MDOs, or mine developer operators, are private companies that are contracted by coal companies to undertake the development and operation of coal mines. These companies are responsible for carrying out various activities related to coal mining, such as exploration, planning, development and production.

The Government of India has also encouraged the use of MDOs in the coal industry as a way to improve efficiency and productivity. MDOs are able to bring in new technologies and management practices, and they are typically more agile and able to adapt to changing market conditions.

Overall, the increased involvement of the private sector and the use of MDOs have the potential to bring in new investments, technologies, and management practices to the Indian coal industry, which could help to improve its efficiency and competitiveness.

Community and social impacts

The closure of coal mines in India as the country transitions to renewable energy sources can have both positive and negative impacts on the community and society as listed under:

Positive impacts

1. The transition to renewable energy sources can lead to a reduction in air pollution and greenhouse gas emissions, improving public health and the environment.
2. The closure of coal mines can lead to the reclamation of land, returning it to its natural state or allowing for other uses such as agriculture or eco-tourism.
3. The transition to renewable energy can lead to the creation of new jobs in the renewable energy sector, providing employment opportunities for those previously employed in the coal mining industry.

Negative impacts

1. The closure of coal mines can lead to a loss of jobs and income for those employed in the industry, potentially causing economic hardship for the community.
2. The closure of coal mines can also lead to the loss of infrastructure and services that were supported by the industry, such as transportation and housing.
3. The transition to renewable energy can also lead to a rise in electricity prices, potentially impacting low-income households.

Remediation measures

- To mitigate the negative impacts of the closure of coal mines, the government can provide financial assistance and retraining programs for those affected by the loss of employment.
- The government can also invest in infrastructure and services in affected communities to mitigate the loss of these resources.
- To address the potential rise in electricity prices, the government can implement policies such as subsidies or discounts for low-income households.
- The government can also invest in renewable energy research and development to create more efficient and cost-effective renewable energy technologies.

1.1.4
Challenges in coal industry

Major risks in the mining sector are:

- **Environmental** - For mining and metals companies, navigating ESG is becoming increasingly challenging, given the breadth of issues the sector faces, as well as the myriad of reporting standards to which they need to adhere.
- **Decarbonization** - The past year has seen miners and investors accelerate conversations and actions around decarbonization, which is now a major disrupter in the sector. Financial institutions, including banks, pension funds and insurance companies, have been declining to finance thermal coal-related investments since as early as 2013. But this trend has gained momentum and even broadened over the last 12 months.
- **Social** - Coal mining, despite the very substantial benefits they bestow on society, stirs strong emotions. A great ongoing social challenge for the mining industry is sustainable development and community acceptance of its role in society. The problem of mining-induced displacement and resettlement (MIDR) poses major risks to societal sustainability.
- **Geopolitics** - As political frictions within and between regions heat up—accompanied by a rise in resource nationalism in many of the resource-rich nations—there is a growing likelihood that this dynamic will affect a miner's operations, supply chain, performance, or people. Such a trend would intensify the challenges created by geopolitical risks
- **Low productivity** - Mining productivity peaked in the 1990s, and since then, it has fallen by more than 30%. This is a critical issue for miners. Unfortunately, for many, digital and analytics have not delivered their full potential, and extra value remains to be captured. Moreover, further value can be generated in additional areas, such as carbon emissions, end-to-end mine planning, and operation

1.1.5
What is to be done

Coal is the most important and abundant fossil fuel in India. It accounts for 55% of the country's energy need.

- **Government** - India energy requirement depends on coal. According to CEA, 54% of the electricity production would be from coal and lignite. To maintain an adequate supply of coal in the future, the government should work on better coal supply chain and coal auctions. Government of India has come up with a single window clearance system for fast-track clearance of new mines. Indian government has come with up with the National coal gasification mission to achieve 100 MT coal gasification by year 2030. With environment concerns and development of renewable energy, diversification of coal for its sustainable use is inevitable. A roadmap for implementing National coal gasification mission should be prepared.
- **Producer** - For producers, keep up with demand for coal would be challenge. More usage of automation and digitization would increase productivity. Also, to reduce the carbon emission, coal needs to be stored in Silos/Bunkers; and should be loaded onto wagons directly through belt conveyors/ rapid loading system.
- **User** – Currently, Coal India and SCCL are a major supplier of coal in India. Creation of coal exchange having multiple coal producer and coal supplier would better supply chain and price discovery.

1.2 Iron ore

1.2.1
Overview of iron ore

Iron ore is regarded as the second most important commodity behind oil. It is an essential input to produce crude steel. Iron ore makes up 5% of the earth's crust and is the second most abundant metal after aluminum. 98% of the iron ore mined is used for steel making. Pig iron is produced from the smelting of iron ore and is further processed to remove impurities and reduce carbon content to produce steel.

Iron ore is also used in ferro-alloy, cement, foundry, and glass factories and has three types:

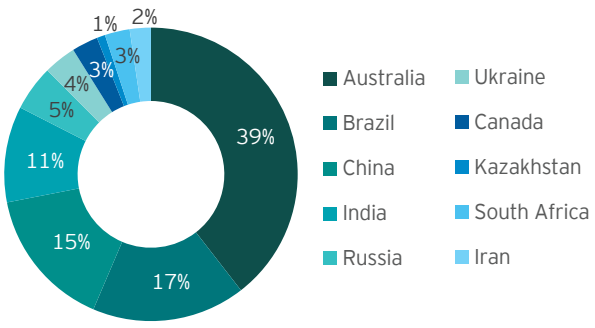
- **High-grade ore** - has >60% Fe content, like the Brazilian and Australian hematite. Historically, it has provided a direct feed to smelters either as a raw lump or fines, or in a processed form as sinter or pellets.
- **Medium grade** - ores having 55% to 60% Fe content.
- **Low-grade ore** - iron-rich rocks having lower than 55% Fe content.

1.2.2
Global overview of iron ore industry

Iron ore is the source of primary iron for the world's iron and steel industries. It is therefore essential to produce steel, which in turn is essential to maintain a strong industrial base. Almost all (98%) iron ore is used in steelmaking. Iron ore is mined in about 50 countries. The seven largest of these producing countries account for about three-quarters of total world production. Australia and Brazil together dominate the world's iron ore exports, each having about one-third of total exports.

As an essential input to produce crude steel, iron ore feeds the world's largest trillion-dollar-a-year metal market and is the backbone of global infrastructure. To meet the growing demand for steel products, world iron ore production has increased dramatically over the last decade. As a result, traditional high-grade iron ore reserves are being significantly depleted and many new iron ore deposits of lower grade and more complicated mineralogy are being mined.

Figure 6: Key iron producing countries FY22



Production trend, growth projection and forecast

- Global iron ore supply increased modestly in the quarter owing to better weather in some mining locations. Iron ore production in Australia remained flat at 201 MT in 3Q22, whereas Brazilian production increased by 18% q-o-q to 92 MT.
- Iron ore demand declined in the quarter as the Chinese steel sector was impacted by a weaker property sector and zero-COVID-19 lockdowns. European iron ore demand reduced in 3Q22 due to sustained inflation, resulting in a slowdown of industrial activities.
- Prices corrected sharply in the third quarter, averaging US$103/t, down 25.6% q-o-q and reached a low of US$80/t in November. The premium for high-grade iron ore (65% Fe) was also down 27.6% q-o-q to US$117/t.
- Despite lower profitability, miners remained committed to reward shareholders through dividends and share buyback programs. Moreover, miners included in the analysis continued with investment activities on exploration and expansion projects.
- The near-term outlook is for subdued global iron ore demand. A weaker economic outlook and rising interest rates indicate declining steel consumption over the next few quarters. This will be partly offset by Chinese stimulus to fund stalled construction policies, and an easing of COVID-19 lockdowns.

Global iron ore market to reach 2.7 billion metric tons by 2026.

- The industry is likely to gain from eventual stabilization of ongoing COVID-19 waves along with vaccination programs, facilitating gradual return of primary steel-consuming nations to normalcy. The steel industry has experienced faster-than-expected recovery from the impact of lockdowns and production disruptions amid the COVID-19 outbreak.
- The rebound can be attributed to the strong contribution from major end-use sectors like construction and automotive. Representing the primary steel consumer, the global construction sector reported a drop in output in 2020, considerably higher than the 2% decline experienced during the 2009 financial downturn. However, the sector is anticipated to recover quickly and attain the 2019 levels.
- Amid the COVID-19 crisis, the global market for iron ore estimated at 2.4 billion metric tons in the year 2022. It is projected to reach a revised size of 2.7 billion metric tons by 2026, growing at a CAGR of 3% over the analysis period.
- Fines, one of the segments analyzed, is projected to grow at a 4% CAGR to reach 1.3 billion metric tons by the end of the analysis period. After a thorough analysis of the business implications of the pandemic and its induced economic crisis, growth in the HBI/DRI segment is readjusted to a revised 3.4% CAGR for the next seven-year period. This segment currently accounts for a 27.3% share of the global iron ore market.
- The US iron ore market is estimated at 33.5 million metric tons in 2022, while China is forecast to reach 1.6 billion metric tons by 2026. Pellets segment is expected to reach 426.3 million metric tons by 2026.

Top Iron Ore producing companies in the world

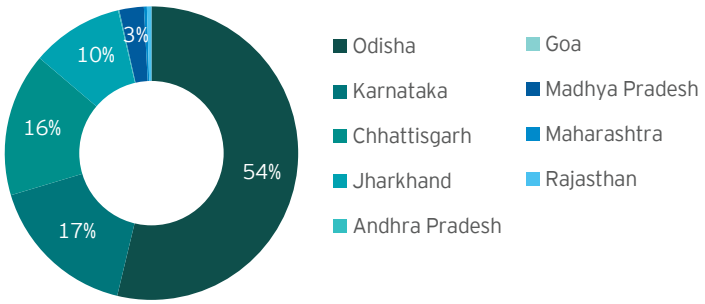
1. Vale
2. BHP Group
3. Rio Tinto
4. Ternium
5. Fortescue Metals Group Ltd.
6. Arcelor Mittal SA

Source: Global Iron Ore Market to Reach 2.7 Billion Metric Tons by (globenewswire.com)
Source: Iron Ore Statistics and Information | U.S. Geological Survey (usgs.gov)

1.2.3
Indian overview of iron ore industry

- India has large reserves of iron ore, bauxite, chromium, manganese ore, baryte, rare earth and mineral salts. India is home to fifth-highest reserves of iron ore in the world.
- Easy availability of low-cost labor force and presence of abundant iron ore reserves make India competitive in the global set up.
- The iron and steel industry in India is among the most important industries in the country. India ranks fourth globally in terms of iron ore production. Production of iron from FY22 in India stood at 204.48 million tons (mt).

Figure 7: Key iron producing states



Source: Top 10 Iron-producing Countries (Updated 2022) (investingnews.com)

- Majority (over 85%) of iron ore reserves are of medium- to high-grade and are directly used in blast furnace and direct reduced iron (DRI) plants in the form of sized lumps or sinters or pellets.
- For example, SAIL, with the approval to sell 25% fresh fines and 70 MT dumps and tailings, accelerated sale of iron
- The State-wise production of iron ore is provided above. Total production of iron ore in India increased by 27% during FY22 as compared to the same period of the previous year

Growth projection and forecast

- It is imperative to note that iron ore growth projections are directly linked with steel demands, as 98% of iron ore is used in the process of making steel.

Rise in steel production and demand

- Rise in infrastructure development is a driver of demand and supply.
- Demand for iron and steel will continue, given the strong growth expectations for the residential and commercial building industry.

In FY21, steel imports to India were ~30% lower y-o-y while steel exports increased by ~50% y-o-y. The growth in exports during the last two years has predominantly been on account of subdued domestic demand. India is cost competitive with respect to finished steel production but loses this advantage once the material moves out of

the plant due to higher logistics cost, associated taxes and levies, resulting in a price differential with respect to international prices. With a focus on rationalization of logistics cost and appropriate governmental intervention, Steel demand will rise locally, further boosting the iron ore demand.

1.2.4
Challenges in the iron ore industry

- Mining and metals companies have to deal with many variable factors, including rising ESG and societal expectations, decarbonization of value chains, geopolitical risks, digital transformation, and unique challenges to portfolio and capital investment decisions.
- Cumbersome statutory compliances requirements leading to organizational inefficiencies and penal consequences.
- As per NSP, 2017, the Ministry of Steel has set up a target to achieve 300 MT crude steel capacity with 255 MT crude steel productions by 2030-31 and for this there is a need of 437 MT of iron ore in the FY 2021-22
- With the envisaged increase in production of iron ore for targeted steel production, there is a need to go for large-scale mining operations. Larger and deeper mines will have to be operated at higher rate of production. This will call for greater bench heights, larger blast-hole diameters and larger machinery. Desired grade control of ROM feed to the processing/ beneficiation plant for treating the ore in its totality will be required. This will also bring into play greater considerations required for minimal environmental impact and degradation due to large-scale operations.
- India is almost self-sufficient in terms of resources. But with the envisaged crude steel production capacity and requirement of iron ore, including exports, there is a need to exploit the resources judiciously for sustainable growth. If the dependence on high grade ore is continued, the resources would get depleted in another 15 to 20 years.
- Depleting high grade reserves coupled with increasing demand poses huge challenges for the geological, mining and beneficiation activities.
- It is in this regard that the mining threshold has been revised to 45% Fe and 35% Fe for hematite ore and siliceous hematite ore, respectively. It is now obligatory for the mine operators to exploit and utilize low-grade ores which until now was not happening. In fact, there is a need for starting exploitation of Banded Hematite Quartzite/ Banded Hematite Jasper and magnetite ore.

Inordinate delays in operationalization of greenfield-auctioned iron ore blocks

1. Cumbersome compliance requirements: There are a lot of additional compliance requirements and various studies/activities, including airborne geophysical surveys, ground based geological, geochemical, and geophysical mineral prospecting and interpretation, exploration targeting, for greenfield iron ore mines.
2. Complex process with risk of lower productivity: Development of a greenfield mine is viewed as a complex, difficult, and high-risk venture since there is no guarantee that a new mine will have a higher productivity than many existing mines. Whereas the risk in brownfield exploration is considerably lower than in greenfield exploration since geologists are able to use already existing data and where necessary infer and extrapolate. It must be understood that the facilities for mining and processing the ore have already been built and paid for in a brownfield exploration and also the additional capital cost for processing the new-found ore is very low.

However, If greenfield exploration is done correctly, it could provide sustainable revenue, cash flow, profit and a significantly elevated status as a mine owner, developer, and supplier of minerals in the global mining industry. Developing a greenfield mine could make or break the entire company, its existing portfolio, cash reserves, reputation, executives, and sustainability, though today the risks are much higher due to fluctuations of commodity prices.

Interventions for early operationalization

To expedite the sale process and operationalization of mineral blocks, the union government has asked mineral-bearing states to identify at least five new mining projects in their respective jurisdictions for auction with pre-embedded clearance on a pilot basis.

As per the new guidelines of the Ministry of Mines, the state government will set up a project monitoring unit (PMU) to complete the preparatory work for obtaining requisite clearances, approvals and related work.

The PMU will obtain all the clearances for starting a mining project and complete the process and obtain the forest clearance stage-I clearance. The mining plan will be approved by the Indian Bureau of Mines (IBM) within 15 days.

Impact of the challenges

- Application of appropriate technology and proper mines design can help overcome the above-mentioned challenges. On the technology side, continual advancement in equipment design has made possible deployment of high-performance equipment. Feasibility of innovative techniques like continuous surface miner for harder formations, high angle belt conveying system and In-pit crushing and conveying system (IPCC) both semi- mobile and mobile needs to be studied for various deposits, particularly new ones.
- There is vast scope for implementation of automation and control, like automatic truck dispatch system in the Indian mining industry. Advancement in the blasting techniques and explosives system need to be leveraged. On the mine design side, it is imperative to go for detailed mine design with scheduling for the life of the mine to get the desired ROM ore output.
- Following the recent amendment for exploitation of low-grade ore, the resource base would increase and help in sustainable growth
- The approach to process/ beneficiate the ore depends to a very large extent on the requirements of the iron and steel making industry which now accepting more agglomerates in its iron making feed. The national Steel Policy envisages steel production through Blast Furnace and DRI routes in the foreseen in India. Hence, there is great potential for sinters and pellets, particularly pellets. The lower grade ores, both hematite and magnetite, can be exploited for production of sinter fines and pellets fines or pellets fines only.
- ESG remains the top risk and opportunity for mining and metals companies in 2023. The issue is now firmly integrated within corporate strategies due to its impact on almost every aspect of operations. Some of the greatest areas for ESG improvement are not new – improving diversity, equity and inclusion is still a major challenge, and mine closures and rehabilitation require a longer-term, more strategic view.

Impact of auctioning of iron ore mines

Effective tax rate (ETR) on mining in India ranges from 45% to 50%, while the global average ranges from 34% to 38%. At present, in addition to MMDR Act requirement of royalty, payment towards DMF and National Mineral Exploration

Trust (NMET), a mine-operator is also required to pay other fees and levies for use of forest-land under the Forest Conservation Act, 1980 and the Indian Forest Act 1927, including forest tax levied on forest produce procured from forest areas and compensatory afforestation charges.

The amendments in the MMDR Act in March 2021 were aimed to bring out transformative reforms in Indian mining sector. Odisha having huge iron ore resources, completed its first phase of iron ore auctions in 2020.

The 2020 auction gave rise to high winning bids. It witnessed bids in terms of revenue sharing premiums ranging from a low of 90.9% to the highest of 155%.

In Odisha, of the 1,942 million tons (MT) of iron ore reserves auctioned in the first phase, about 319 MT have been surrendered. Of the remaining 1,623 MT, end-users have bagged almost 1,450 MT, accounting for 85% of the total reserve. Merchant, or standalone, miners who had 100% of these reserves in the pre-auction regime, now account for only 15%. Five out of the 21 auctioned mines in Odisha having been surrendered or taken back by the government. All these mines were in the open category. Six bidders have not been able to commence production till date. This leaves only 10 mines wherein production could be commenced.

The tender stipulation is that in the first two years the successful bidders should produce at least 80% of average production of the last two years have not been met by any of the bidders. This has led to the violation of the Mine Development and Production Agreement in states like Odisha. A rough estimate indicates that against the current EC capacity of about 56 MT iron ore of such auctioned mines in Odisha, only 20 MT was produced during FY21, which is expected to increase to around 38 MT in the coming year. Standalone miners have reduced to a great extent. Mining may no longer be an independent industry, which is inconsistent with global practice.

An analysis shows that the total statutory liability, after factoring additional royalty, as a percentage of the sale price, is very wide across various categories of mines mentioned above, ranging from as low as around 20% to as high as 175%.

1.2.5
What is to be done

Beneficiation – achieving a higher Fe content

The rapid upward trend in steel output has put pressure on the availability of quality ore for steel production. In order to consume lower grade ore for steel making, beneficiation of ore is required. Iron ore extraction in India yields lumps to fines in the ratio of 2:3 – 60% of the ore generation is in the form of iron ore fines. For efficient utilization of ore produced, it is imperative to consume the iron ore fines.

Beneficiation efficiently removes silica, alumina, clay, and other contaminants from feed material to increase the Fe value in the final ore.

Silica requires very high temperatures in the kiln, therefore, increasing energy costs when it is present in the feed to the kilns. Both alumina and silica build up in the kilns as a coating, reducing the efficiency of the kilns over time. This requires that the kilns be shut down in order to facilitate the removal of this material build up.

Iron ore beneficiation plants target these contaminants and ensure their effective removal from the feed to the kilns. This has the effect of increasing the Fe value of the iron ore, allowing for a more efficient steel production process.

Modular mining equipment for low-grade iron ore

- Modular in design, our solutions can be easily upgraded in capacity as your production requirements increase. This modularity makes our iron ore mining equipment ideal for integrating with your existing mining equipment or relocating to another site once works are complete. The modularity also provides a more compact footprint on the mine site.

How CDE helps unlock value in iron ore mining

- **Gravity separation:** Hydro cyclone technology uses gravity separation to help remove clay and other contaminants prior to fine and coarse spiral gravity separation
- **Primary wash and fine ore recovery:** The introduction of the M-series modular wash plant helps to wash the coarse feed and de-slime and de-water any fine material, resulting from the gravity separation process.
- **Exceptional scrubbing power:** The Xtryl paddle design within scrubbing and attrition equipment delivers unrivaled wear protection from the abrasive material and efficient scrubbing of the ore through its helical arrangement.
- **Coarse ore recovery:** A hydraulic jig completes gravity separation of the coarse ore from reject and the remaining process water is removed using our range of patented screening solutions.

1.3 Steel

1.3.1
Overview of steel

Steel industry, the business of processing iron ore into steel, which in its simplest form is an iron-carbon alloy, and in some cases, turning that metal into partially finished products or recycling scrap metal into steel. The steel industry grew out of the need for stronger and more easily produced metals. Critical for economic development, steel is the backbone of global sustainable initiatives, including energy transition. As an industry, steel is:

- One of the world's most sustainable material – permanent, forever reusable and the most recycled material on the planet
- Widely used in construction works, transportation, packaging, and the energy sector
- One of the world's most energy intensive and accounts for around 8% to 9% of global carbon dioxide emissions

As the steel industry is one of the energy-intensive industries, major efforts are underway to reduce carbon footprints from the steel industry.

Steel is such a powerful element, coming in several distinct grades and holding unique chemical compositions. As per the World Steel Association, there are over 3,500 different grades of steel, encompassing unique physical, chemical, and environmental properties. Steel can be broadly categorized into four groups based on their chemical compositions:

1. Carbon steel
2. Alloy steel
3. Stainless steel
4. Tool steel

Carbon and stainless grade steel are the two most essential commodities which will be part of economic growth as they can be used in a wide range of applications, majorly driving the infrastructure/construction sector, automobile, and consumer goods sector.

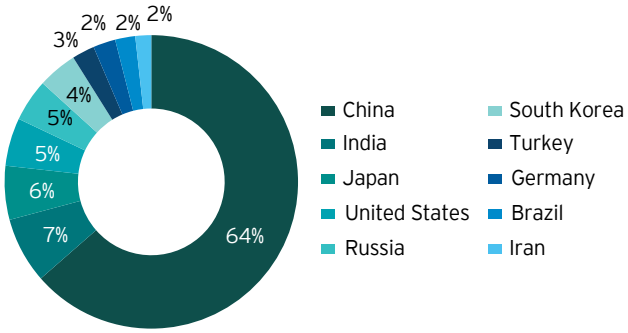
Production of 300 MT of steel by 2030 will entail raw material movement of over 900 MT. While multiple projects have been unveiled towards infrastructure creation and upgradation, these need to be expedited for faster growth of the country

1.3.2
Global overview of steel industry

- The global steel market reached a value of US$874.6b in FY22. The market is predicted to reach a value of US$1,052.25b (Source-IMARC) by 2027, exhibiting a growth rate (CAGR) of 3.02% from 2022 to 2027.
- The world crude steel production reached 1951 million tons (mt) in FY22, showing a growth of 3.6% over CY 2020.

Top 10 steel-producing countries in the world – million tons (Mt) as of FY22

Figure 8: World steel association



- China remained world's largest crude steel producer (1032.8 mt) followed by India (118.2 mt), Japan (96.3 mt) and the US (86.0 mt), based on rankings released by the World Steel Association in FY22.
- Per capita finished steel consumption in FY22 was 233 kg for world and 667 kg for China.

China has been a leader in this industry for quite a long time now, but India has the potential to emerge as a leading global leader with the right strategy and action plan.

Global trend, growth projection and forecast

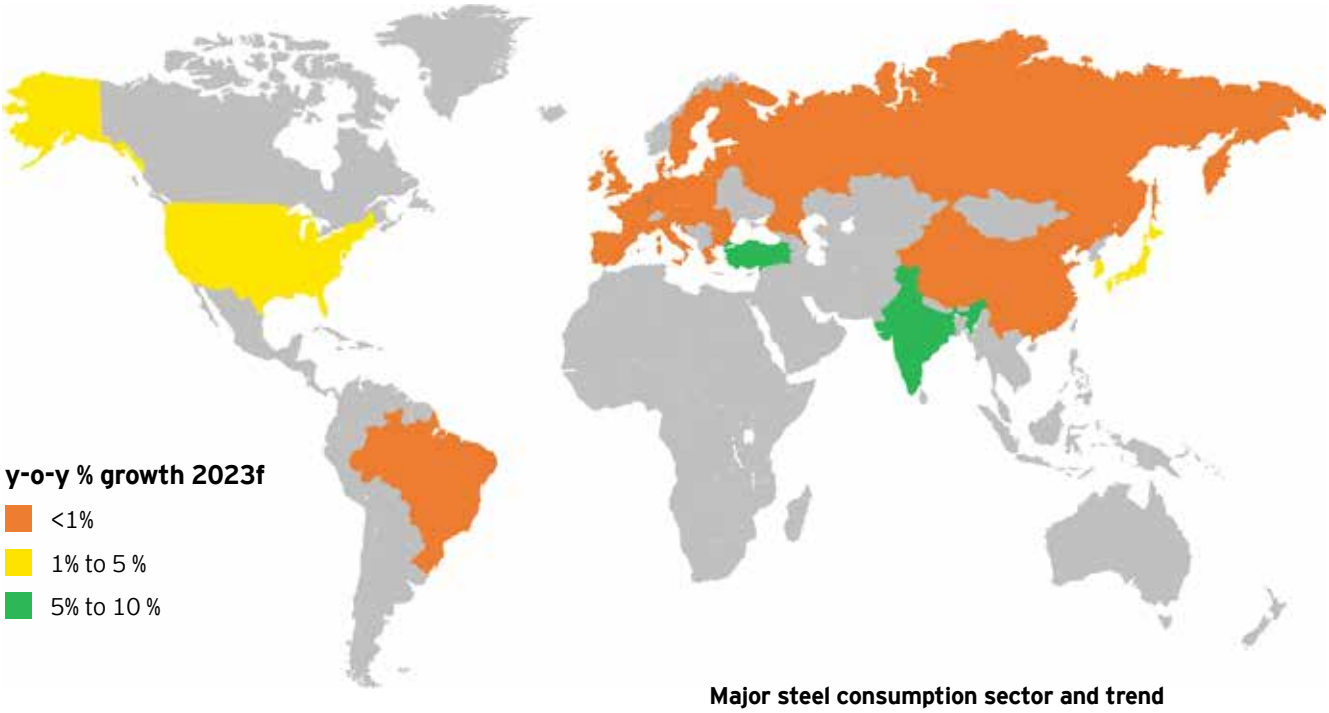


Table 5: Steel demand outlook by country (2020-2023f)

Country	2020	2021	2022	2023f
China	995	952.0	952.0	961.6
EU	140.8	163.6	161.5	167.9
India	89.3	106.1	114.1	120.9
US	80	97.1	99.8	102.1
Japan	52.6	57.5	58.2	58.8
S. Korea	49	55.6	56.2	56.8
Russia	42.4	43.9	35.1	35.1

Source: EY-steering-india-into-a-us-5-trillion-dollar-economy-with-steel

- Consumption continued to grow in FY22 and is still increasing, driven by pent-up demand from different sectors.
- In the US, strong recovery in automotive and durable goods sectors drove up steel demand.
- Demand continued recovery in the EU, Japan, South Korea, and India owing to improvements in steel using sectors. In the near-term, demand growth is likely to be modest, while supply is expected to ease.

Major steel consumption sector and trend

- The world average steel per capita has steadily increased from 150kg in 2001 to around 233kg in 2022. With this continuing trend, the growth and demand will increase.
- Steel is used in every important industry, energy, construction, automotive and transportation, infrastructure, packaging, and machinery.
- By 2050, steel use is projected to increase by around 20% compared to present levels to meet the needs of our growing population.
- Skyscrapers are made possible by steel. The housing and construction sector is the largest consumer of steel today, using more than 50% of steel produced.

Steel and cement are an integral part of the modern world. Steel is found in everything, from major infrastructure to kitchenware, while cement, as the principal ingredient in concrete, is the most widely consumed resource in the world after water. Approximately 3 metric tons of cement are used annually for every person in the world.

Moreover, demand for cement and concrete is set to increase by more than one-third by 2050, when the global population is expected to reach 9.7 billion, 70% of which will be living in cities. To accommodate this massive urban expansion, an equivalent of another New York City will be built every month for the next 40 years.

Today, it is estimated that the global steel industry used about 2 billion tons of iron ore, 1 billion tons of metallurgical coal and 575 million tons of steel scrap to produce about 1.7 billion tons of crude steel.

Regulations to control emissions have led to lower Chinese steel production, causing a decline in iron ore demand and prices, as elaborated below:

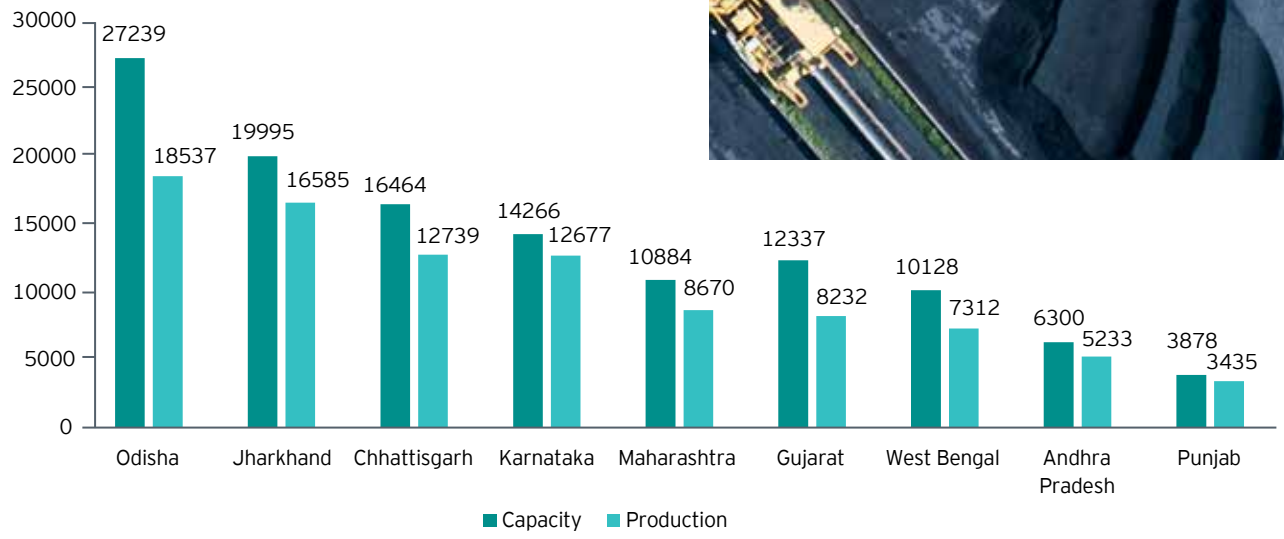
- Iron ore demand is likely to decline in China as it limits steel output and a structural shift in demand to Europe and other Asian countries is expected
- Brazilian iron ore supply is likely to gain market share as China seeks to reduce its reliance on Australia
- China is considering diversifying its iron ore supply amid tension with Australia
- Iron ore prices corrected in August as supply recovered while Chinese demand declined
- Grade premiums are expected to rise in the near future due to increase in demand for high grade as ultra-low emissions standards are introduced
- Met coal prices remained high, averaging US$376/t in Nov 2021, due to supply-related constraints, and the ongoing reorganization of trade routes in light of the Chinese ban on Australian coal.

1.3.3
Indian overview of steel industry

India is currently the world's second largest producer of crude steel, producing 118.20 million tons (mt) crude steel with growth rate 17.9% over the corresponding period last year (CPLY). India's finished steel consumption is anticipated to increase to 230 MT in 2030-31 from 133.596 MT in FY22.

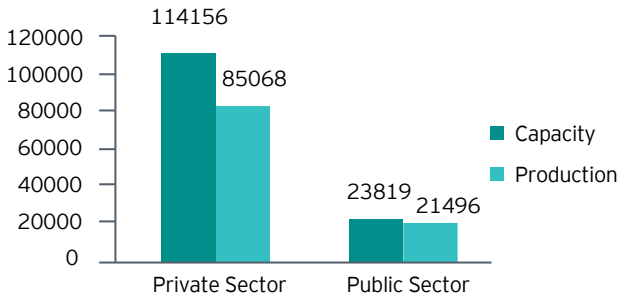
Key steel producing states in FY22 - Top 10 states

Figure 9: Ministry of Steel



Private vs. Public (production vs. capacity) in FY22

Figure 10: Ministry of Steel

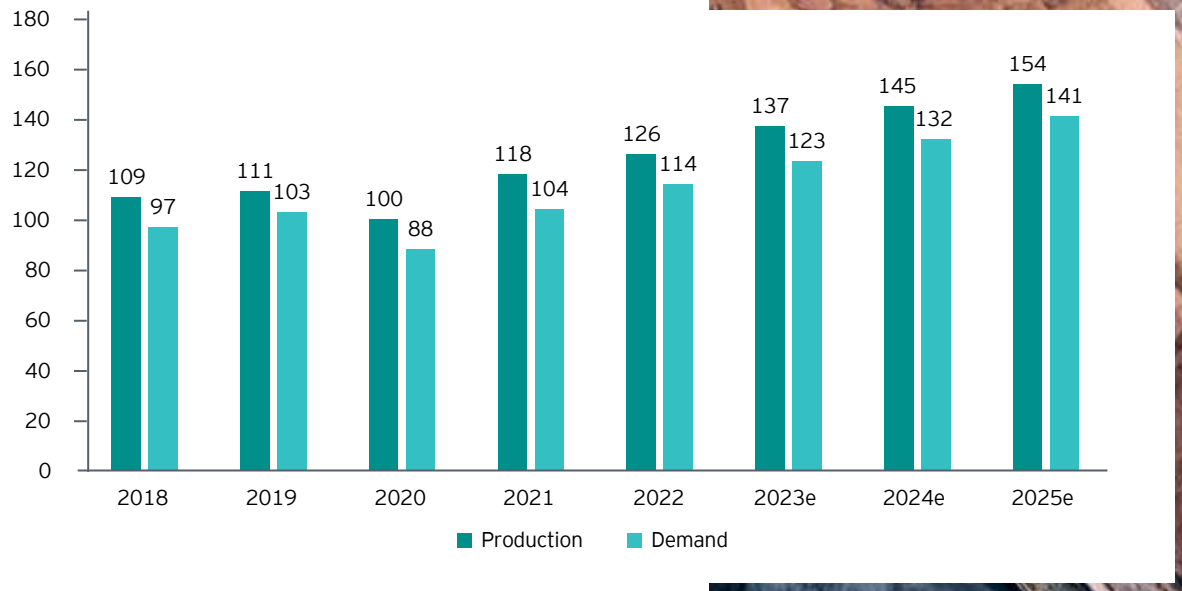


- Odisha, Chhattisgarh, and Gujrat need to increase production so that they can use the available capacity to full potential.
- The availability of iron ore remained a concern in the State of Karnataka due to closure of Donimalai mines, which had an overall negative impact
- As can be seen from above, India needs to increase its production to utilize on the capacity to its full potential.

Production trend, growth projection and forecast

Steel production and demand in India (2018-2025e)

Figure 11: Morgan Stanley



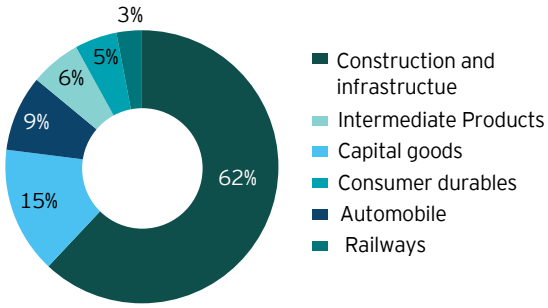
Note: Demand – finished steel, Production – crude steel

- India's crude steel production rose to 8.8%, reaching 63.2 mt in the first half of 2022, driven primarily by demand from construction and manufacturing sectors
- Government support is incentivizing planned capacity expansion e.g., the Production Linked Incentive (PLI) scheme introduced, with an outlay of US$847m, is likely to incentivize the industry to invest in building specialty steel capacity
- Major players like Tata Steel and JSW are strengthening R&D capability to produce high grade steel, thereby reducing import dependence.
- While India produces value added steel, the steel product portfolio is tilted toward the low to mid-range of value-added products. India is dependent on imports of high grade/ special steels for some advanced applications because the country does not either have the technology know-how for steel grades or has not been able to create a sizable market for manufacturing such grades on an economic scale.

Major steel consumption sector and trend

Being a core sector, it tracks the overall economic growth in the long term. As steel demand is derived from other sectors like automobiles, consumer durables and infrastructure, its fortune is dependent on the growth of these user industries. This provides major cost advantage to the domestic steel industry.

Figure 12: Sector wise steel consumption



- India is looking to modernize, expand and accommodate the aspirations of a growing population through urbanization and industrialization. Thus, steel consumption growth is expected to rise on account of government expenditure on infrastructure and manufacturing in the long run.
- The infrastructure industry is expected to increase to 11% in 2025-26. Since the construction industry is a major consumer of steel, expansion across the industry will translate into the growth of the steel sector.

Public sector:

- Steel production giants such as SAIL, NMDC, CIL face several issues varying from workers boycott to political and licensing challenges. Similar issues are faced by other players, license related issues and delays in clearances are still common problems faced by them.

- Labor policies and laws have also continued to impact the production capacity. Earlier last year, around 35000 workers went on a strike against such policies due to which the production took a big hit.

Private sector:

- JSW, TSL, JSPL, AML are all making steel which is also getting exported across Europe for special applications like modern day electric vehicles, high-speed railways, advanced building materials, and marine vessels.
- Companies are reluctant to invest in R&D for new materials. The industry often looks to license the technology, which have end-use restrictions and thus cannot be accessed without government intervention. Otherwise, the innovation is limited to the big four to five players in steel.

The overall share of these materials, when compared to the larger picture, is tiny. India is not the most preferred supplier and there is a major gap between the top exporter and India, especially in high grade steel, which is a major opportunity for the country.

A sustainable plan backed by government support can help fill this gap in the medium to long run.

Industry trend:

- The automobile industry, increasing capacity addition in the automotive sector, demand for steel from this sector is expected to be robust.
- The capital goods sector is expected to increase to 14-15% by 2025-26. It also has the potential to increase tonnage and market share. Corporate India's capital expenditure is also expected to generate greater demand for steel.
- The Oil and gas sector is one of the largest end users of steel. The steel demand will rise with the expansion of city gas distribution network for covering 70% of India's population, refining capacity augmentation, roadmap to set up 10,000 CNG stations, and exploration and production activities.

Examples:

- Companies in the steel industry also invested heavily in expanding their capacity. JSW Steel announced plans to expand the capacity of its Vijayanagar plant from 13 MTPA to 18 MTPA with an investment of INR 7500Crores.
- Attracted by the growth potential of the Indian steel industry, several global steel players entered the market. Arcelor Mittal completed the acquisition of Essar Steel at INR 420,000 Crores and formed a joint venture with Nippon Steel Corporation.
- GFG Alliance acquired Adhunik Metaliks and its arm, Zion Steel for INR 420 Crores, marking its entry into the Indian steel market.
- JSW Steel USA Ohio Inc, a US subsidiary of JSW Steel, has signed a long-term agreement with local steel producer Allegheny Technologies Inc. to convert JSW's locally produced carbon steel slabs into hot rolled coils.
- Tata Steel has also signed up with leading steel manufacturers of Europe to form JVs, namely Thyssenkrupp AG, to make high grade specialty steel. Tata Steel has also tied up a five-year alliance with the Indian Institute of Technology Madras, in advanced materials.

1.3.4 Challenges in steel industry

As the world limps back into the resumption of economic activity, through the waning phase of COVID-19, the impact of the pandemic shall be visible across many sectors, including Steel, As the number suggests, the steel industry, at large, has taken preventive measures on people and processes to minimize the impact on production. Where possible, the industry has sustained economies of continuous production during the peak COVID-19 periods. Major reasons for a large shrink in developed economies is due to manufacturing recession coupled with distress in auto and machinery industries discouraged energy sector investments. Developing countries, including India, are the hardest hit in terms of steel demand owing to stricter lockdown measures and longer lockdown phase impacting all major consumer industries of Steel.

The inherent construct of supply chains of steel for capital goods creates a base inefficiency for the Indian capital goods manufacturers. Setting up a capital goods hub or building capabilities around specialty steel has inbound cost challenges. The advantage of cheap labor gets negated with lack of skilled workers. Moreover, lack of continuous electricity supply, last mile connectivity and high cost of transportation of material are additional challenges for companies operating with thin margins.

To cope with such issues, players have been devising new strategies to stabilize the production capacities by transforming their supply chains. The primary objective of the transformation is to get better access to new markets, aligning with emission regulations, to have better coordination with customers at a lowered cost.

Demand constraints

- Slowing global economic growth has forced cross imposition of duties by major steel producing nations.
- India had also imposed duties to safeguard its domestic Steel industry, especially against dumping of flat products in the country.
- The real estate sector is witnessing a demand slump due to excess inventory and severe price pressures.

The sector has a severe liquidity crunch, particularly with small developers.

- The auto sector is caught in a cyclic downturn, uncertain demand sentiments and uncertainty regarding electric vehicle launches and higher environmental standards.

Input prices

- The government has reversed the export duty on iron ore with grades less than 58 percent to zero and export duty on iron ore with grades more than 58 percent has been reduced to 30 percent. This will pump up the exports at a time when the largest consumer, China is battling COVID-19 and there is a global slowdown.
- Limited availability of some of the essential raw materials such as high-grade lumpy Manganese ore and Chromite, coking coal, etc.
- Due to vagaries of weather and conflict between Russia-Ukraine, there has been huge fluctuations in coking coal as well as steel supply.

Raw material availability

- The rapid upward trend in steel output has put pressure on the availability of quality ore for steel production.
- Coking coal in India is not of adequate quality to form good coking coal on account of high impurities.
- Blending ratio for coal in countries such as the US is 40% whereas in India it is only 10% at present.

Logistics and infrastructure

- The Steel plants in India are in the inlands, often in remote areas with severe logistics challenge.
- Steel transportation till now has been heavily reliant on railways as it meets more than 70% of the Steel industry's transportation needs
- High cost is resulting from the compulsion of Indian railways to subsidize passenger carrying cost of freight earnings.
- The capacity of Indian railways is constrained with a lot of delays and issues in rake availability and rake placements, creating bottleneck points in the entire supply chain.
- Ports suffer from low productivity, slow unloading, delayed stevedoring, and other myriad issues.
- Lack of appropriate digitalization of the supply chain nodes, like document processing and clearances at ports, tracking and tracing of goods etc., result in inefficiency and bottlenecks.
- The COVID-19 impact has triggered a sharper digitalization adoption curve, which needs to be sustained and taken forward.

Power cost

- Energy represents one of the key challenges for today's Steel industry and the efficient use of energy has always been one of the Steel industry's key priorities.
- Over the last 40 years, the Steel industry has reduced its energy consumption per ton of Steel by 50%. Still, the cost of energy accounts for 15 to 20% of the total cost of Steel production and energy consumption is directly related to the environmental impact of the industry.
- India's specific consumption of energy per ton of Steel produced is approx.7.2 giga calories per ton (according to IBEF) of crude Steel is way higher than the global best figures of 5.38 giga calories per ton of crude Steel.
- This indicates that Indian Steel plants need to invest more in energy efficient systems to remain competitive.

Finance cost

- Steel industry is a capital-intensive sector requiring an investment around INR 6000 to INR 8000 crore to set up 1 ton of Steel production capacity through greenfield initiatives.
- The cost of financing for expansion or new capacity addition is majorly through borrowed capital.
- Overall, the share of bank credit to the iron and steel sector has declined between 2011 and 2020. Further, in India, the cost of finance is higher as compared to the cost of finance in countries like China, Japan and Korea.

Challenges faced by specialized steel

Large portions of Indian steel exports comprise hot rolled coils/plates and billets, which are on the lower end of the steel value chain. These products are further value added by the importing countries / regions and are either locally consumed or exported. India lacks sufficient capacity for value added steel like galvanized, color coated, and Restriction of Hazardous (ROHS) compliant galvanized products.

Impact of the challenges

The high costs for logistics in India can be attributed to:

- Unfavorable inter-modal mix: road transport far exceeds rail transport, despite the latter being cheaper by 45%.
- Inefficient fleet mix: Indian fleet mix comprises smaller, more inefficient trucks –16T and 25T trucks are the highest selling categories in India. In China, 26 to 40T trucks lead the market.
- Freight costs on smaller trucks have substantially higher freight costs. Adding to this, there is a lack of logistics hubs for consolidation and disaggregation, resulting in higher point-to-point costs.

- Underdeveloped road infrastructure: poor road infrastructure leads to inefficient freight movement. There is a lack of 4/6 lane roads. Coupled with inconsistent infrastructure, there is congestion across key routes leading to added costs.

The energy usage challenge:

- Steel is an energy intensive industry. Energy makes up 15% to 20% the cost of production of steel
- Energy consumption in most Indian integrated steel plants is higher i.e., 6 to 6.5 Giga Calories per ton of crude steel compared to 4.5 to 5.0 Giga Calories (World average)
- Improvements could be achieved by saving energy during (primary energy) or after the manufacturing processes (secondary energy).

The challenge of shifting to cleaner process routes:

- Most of the steel produced in the country is through the BF- BOF route.
- With the increasing focus on the environment, the share of steel through the scrap- EAF route is increasing.
- More effort is still required to enable scrap collection and processing centers to feed the estimated future demands of scrap in the country.

Raw material challenges:

- Currently, ~85% of the coking coal requirements are imported due to which end product is higher in cost.
- To consume lower grade ore for steel making, beneficiation of ore is required. For efficient utilization of ore produced, it is imperative to consume the iron ore fines.

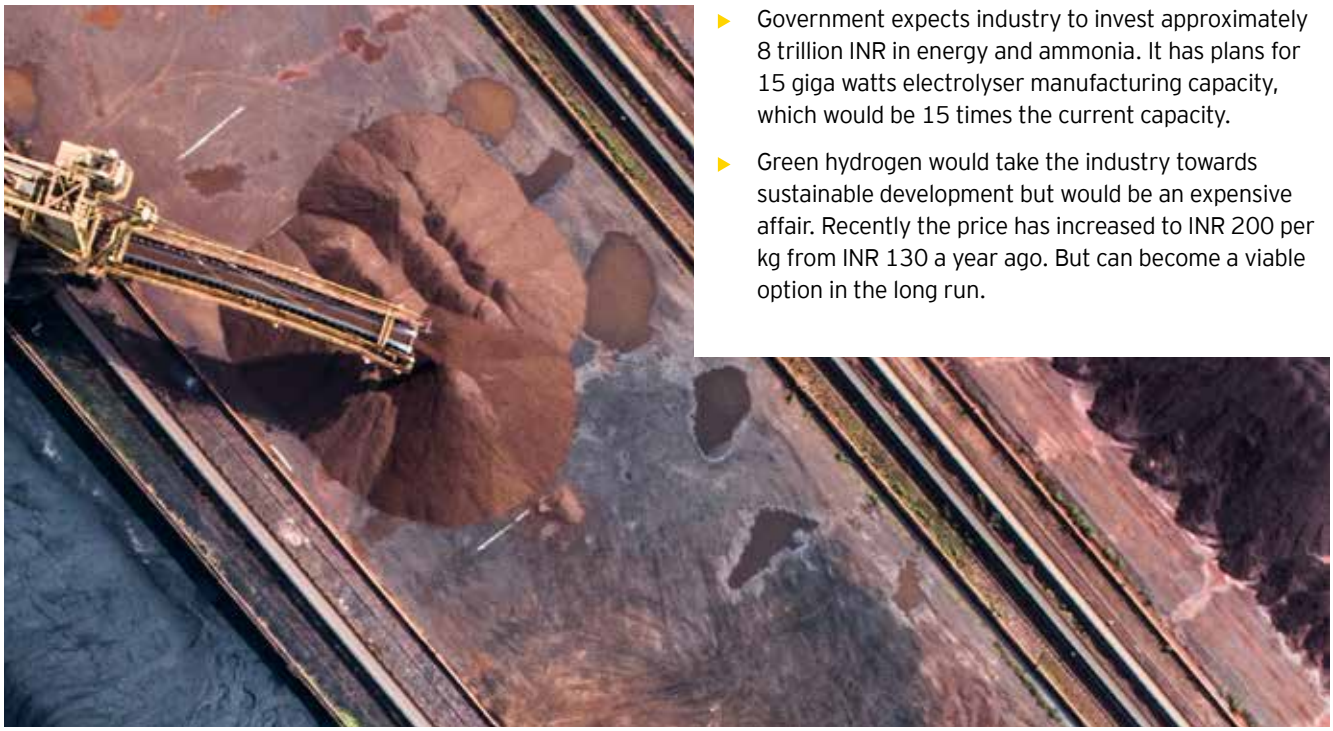
Demand for Iron ore and coal

- There is a big shortage of iron ore due to iron ore exports. The per ton price of iron ore has increased by INR 700, while that of steel pellets has gone up by INR 300 to 350. In addition, iron ore fines and lumps have gone up by INR 200 to INR 4300 per ton.
- Iron ore prices jumped 85 per cent in July and August, and to absorb the cost, there was an increase in Steel prices.
- Due to shortage of domestic coking coal, both in terms of quantity and quality, pig iron producers/ BF operators in India must significantly depend on import of coking coal. India largely fulfils its coking coal requirements through imports from Australia.
- In 2022, FIMI requested the government to reconsider their proposal of beneficiation of low grade Iron Ore. The federation is careful of the fact that establishment of beneficiation plants would require huge investment for land and for tailings disposal, that will be beyond the financial capability of small and medium private mining firms.

1.3.5
What is to be done

For India to make credible commitments to significantly reduce carbon emissions, there is an urgent need to create a detailed roadmap for increasing consolidation, increasing share of EAF, and investing in robust recycled steel supply for steelmaking. A realistic assessment and options based of adoption of clean technologies balancing risk, capital cost and quality considerations in the need of the hour.

- Indian companies like RIL, NTPC, JSW Energy have plans on green hydrogen.
- Government expects industry to invest approximately 8 trillion INR in energy and ammonia. It has plans for 15 giga watts electrolyser manufacturing capacity, which would be 15 times the current capacity.
- Green hydrogen would take the industry towards sustainable development but would be an expensive affair. Recently the price has increased to INR 200 per kg from INR 130 a year ago. But can become a viable option in the long run.



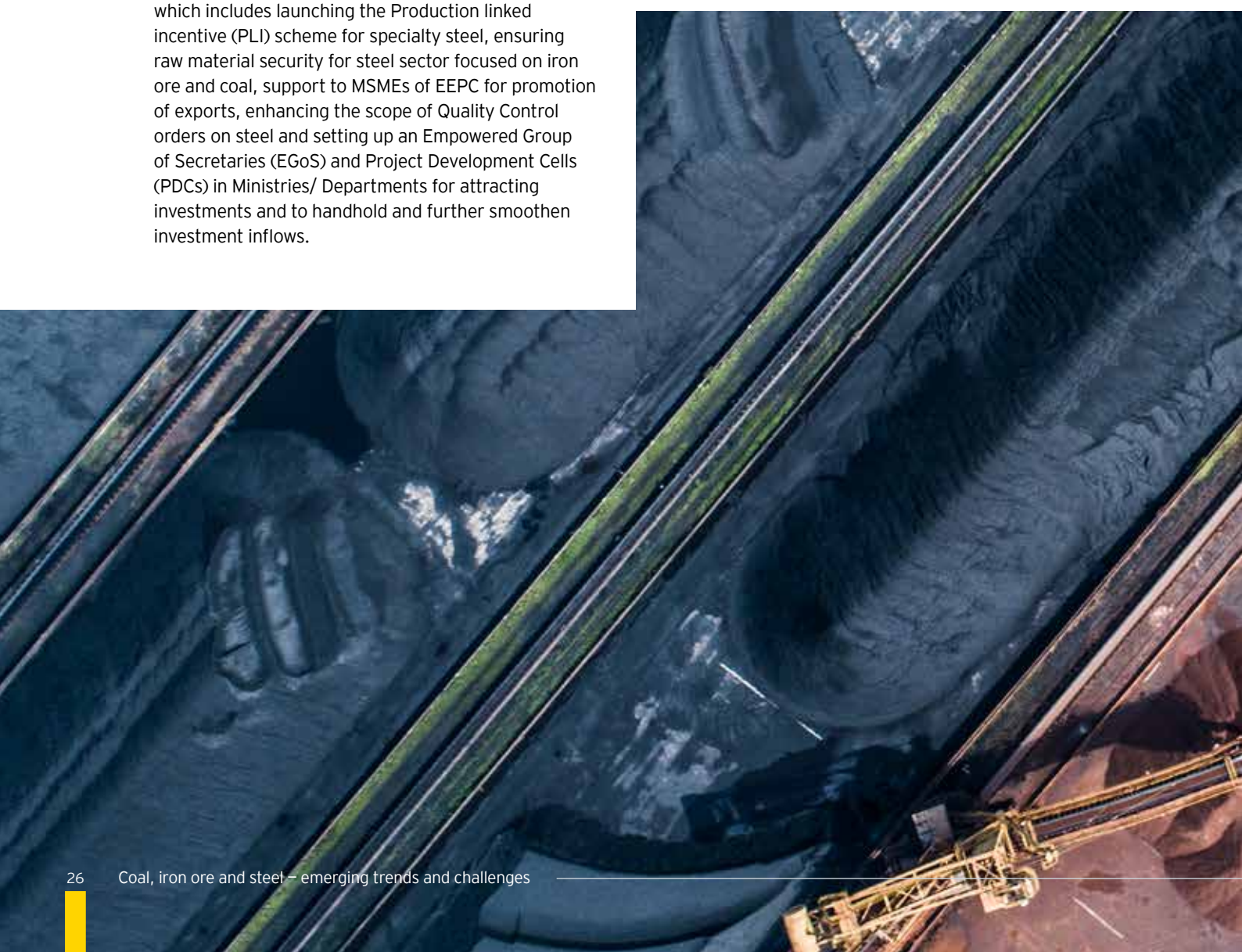
- Steelmakers need to adopt an accelerating decarbonization agenda and the growing importance of ESG performance represent both a challenge and an opportunity.
- Reduction in the energy intensity and environmental impact of the industry will require a significant effort across the lifecycle of steel. Players will need to commit to deploying energy efficient measures, adopting and investing in circular economy principles, improving material efficiency and waste management and investing in low-carbon emission technologies for steel production. To improve on these parameters, the usage of high-quality iron ore and coal will increase to achieve higher efficiency.

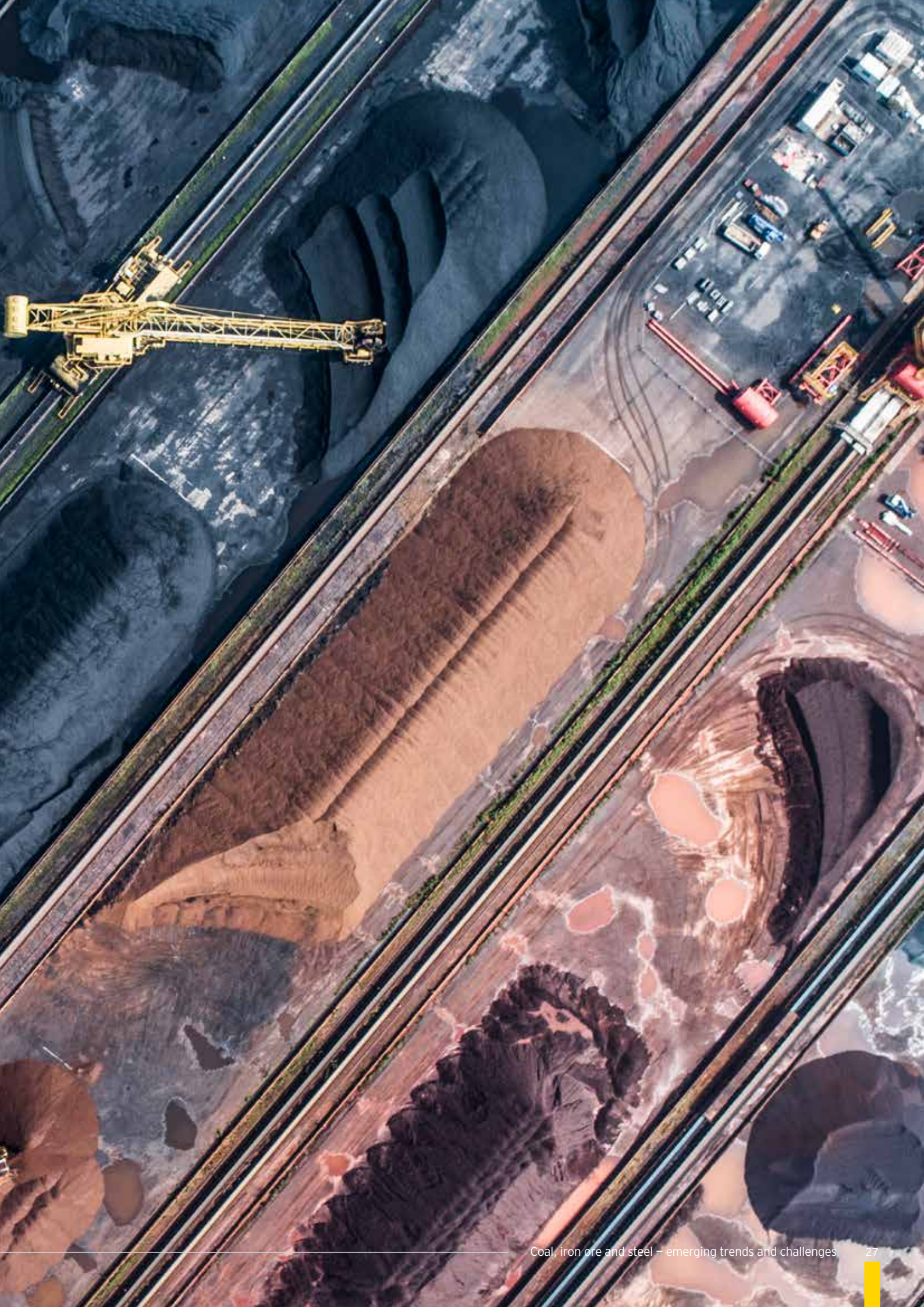
Capacity planning and augmentation coupled with value addition

- With a clear-cut strategy defined for export of steel products along with growth plans across product market combinations, production capacities must be aligned and augmented. The steel industry should give more emphasis on producing value added steel products for new age applications as well as production of engineering goods.

Regulations and norms for raw material

- Indian government has announced a host of initiatives which includes launching the Production linked incentive (PLI) scheme for specialty steel, ensuring raw material security for steel sector focused on iron ore and coal, support to MSMEs of EEPC for promotion of exports, enhancing the scope of Quality Control orders on steel and setting up an Empowered Group of Secretaries (EGoS) and Project Development Cells (PDCs) in Ministries/ Departments for attracting investments and to handhold and further smoothen investment inflows.
- National Steel Policy 2017 (NSP-2017) aims to develop a globally competitive steel industry by creating 300 MTPA Steel production capacity by 2030, of which 35 to40% is estimated to be from EAF/IF route. Although scrap is the main raw material for the secondary sector, the primary sector too uses scrap in the charge mix of BOF to the tune of 10% to15% to improve efficiency, minimize cost of production and other process needs. The availability of raw materials at competitive rates is therefore imperative for the growth of the industry and to achieve the NSP-2017 target. Thus, the availability of the right quality of scrap, in adequate quantity, is one of the critical factors for the future growth for both EAF/IF sector and primary sector.
- As most carbon capture projects are still at an early stage of development, the affordable cost of deploying these technologies will materialize only over the next several years. Moreover, scaling up of operations will require investments in transportation and storage, with the associated improvements in technologies of geological storage capacity and reduced risk of leakage. India could be well served to explore this route to decarbonization of BF and DRI routes to steel manufacturing.





2

External effects and developments in the Indian industry

Effects of macroeconomic environment on steel manufacturing industry

- Global Steel industry is undergoing a subtle shift across dimensions of technology of steel manufacturing, raw material sourcing, finished steel quality, green field capital investments and environmental sustainability.
- The CAGR of demand of steel has been about 4% for the last 5 years and is expected to be at the same level soon.
- Effects of digital and innovation on steel manufacturing industry

Effects of digital and innovation on steel manufacturing industry

Carbon capture

- Top gas recycling combined with carbon capture storage and/or utilization (CCUS) technology may offer a solution to significantly reducing emissions.
- Top gas recycling can recycle up to 90% of the exhaust gas from BFs, reusing it for combustion with the remaining highly concentrated CO2 stored and/or used.

Effects of sustainability on steel manufacturing industry

- Steelmakers need to take a pragmatic approach to implementing cleaner alternatives. Ensuring overall production capacity remains in line with demand to maintain profitability and competitiveness will require companies to balance risk, cost, quality and their chosen trajectory to decarbonize steel production.
- Controlling emissions will be the central challenge of steelmakers over the decades to come, and those that find the capital to invest in greener production will ultimately emerge as winners. All new steel production should adopt greener alternatives, although companies will need to make judicious choices around when and where to adopt clean technologies
- A key consideration for integrated steel mills currently in production will be the need to factor in the costs of relining blast furnaces.

Effects of macro economy environment on coal mineral industry

- The mining industry plays an essential role in accelerating industrialization and urbanization, as it provides raw materials to meet the growing demand for resources. In addition, it contributes to increased foreign capital investment, exports, and employment, key factors in socio-economic development. Industry revenue is primarily a function of the yearly production of coal alongside coal prices, which themselves are subject to significant fluctuations due to changing global supply and demand conditions.
- Over the years, the industry has exhibited very high volatility, falling sharply prior to the period due to declining global production, before rising prices contributed to industry growth during the start of the current period. Furthermore, the COVID-19 (coronavirus) pandemic furthered pressured mining companies.

Effects of price changes on coal mineral industry

- Coking coal, also recognized as metallurgical coal, plays an important role in steel manufacturing industries as an input to production. When coal prices are elevated, industry operators have a greater economic incentive to search for and extract coal that may be too expensive to mine in a low-price environment.

Effects of macroeconomic environment on iron mineral industry

- Rising inflation, higher interest rates coupled with deteriorating downstream sector demand impacted iron ore market
- Global inflation continued to rise in 3Q of 2022 and is now estimated at 7.9%, currently compared to 4.3% in 2021. Central Banks across nations have responded by increasing lending rates, which are now at a multi-decades high.

- Inflation has led to contraction in the steel market. Consequently, steel output was down 13.2% q-o-q in the EU to 32.1mt and remained flat q-o-q in the US to 21.1mt, impacting iron ore consumption
- Chinese steel production was down 10% q-o-q to 252.3mt in 3Q22 due to slowdown in real estate market and lockdown related to new COVID variants.
- However, the Chinese Government restarted stalled property construction in the end of 3Q which might reflect the actual impact on iron ore demand in 2023.

Effects of prices on iron mineral industry

Lower steel production reduced iron ore demand resulting in lower prices:

- Iron ore prices declined in 3Q22 to US$103.7/t, down 25.6% q-o-q due to weakening global steel demand, in particular due to slowdown in the property market and COVID related disruptions in China.
- Lower prices impacted earnings of iron ore miners. ArcelorMittal's EBITDA decreased to US$311m in 3Q22, down 41% q-o-q, largely due to low prices, partly offset by lower freight costs. Similarly, lower prices also reduced NMDC's turnover to US$400m in 3Q22, down 33% q-o-q.

Effects of regulatory changes on iron mineral industry

- The Indian Constitution vests in the Central Government the power to regulate mines and mineral development, to the extent that the Parliament considers the same to be 'expedient in the public interest'. In exercise of these powers, the Mines and Minerals (Development and Regulation) Act, 1957 was enacted.
- The Mines and Minerals (Development and Regulation) Act (MMDR), 1957 is the principal legislation that governs the mineral and mining sector in India. The Act is a central legislation in force for regulation of mining operations in India.
- It has been argued that post the liberalization of the Indian economy in the 1990s, the country's legal framework on mining has witnessed a shift paralleled across the developing world-that is, a re-orientation aimed at attracting greater private investment in the sector.

Mineral Laws (Amendment) Bill, 2020.

- Aims to open a new era in the Indian coal and mining sector, specially to promote 'ease of doing business. It will reduce dependency on import.

National Mineral Policy 2019

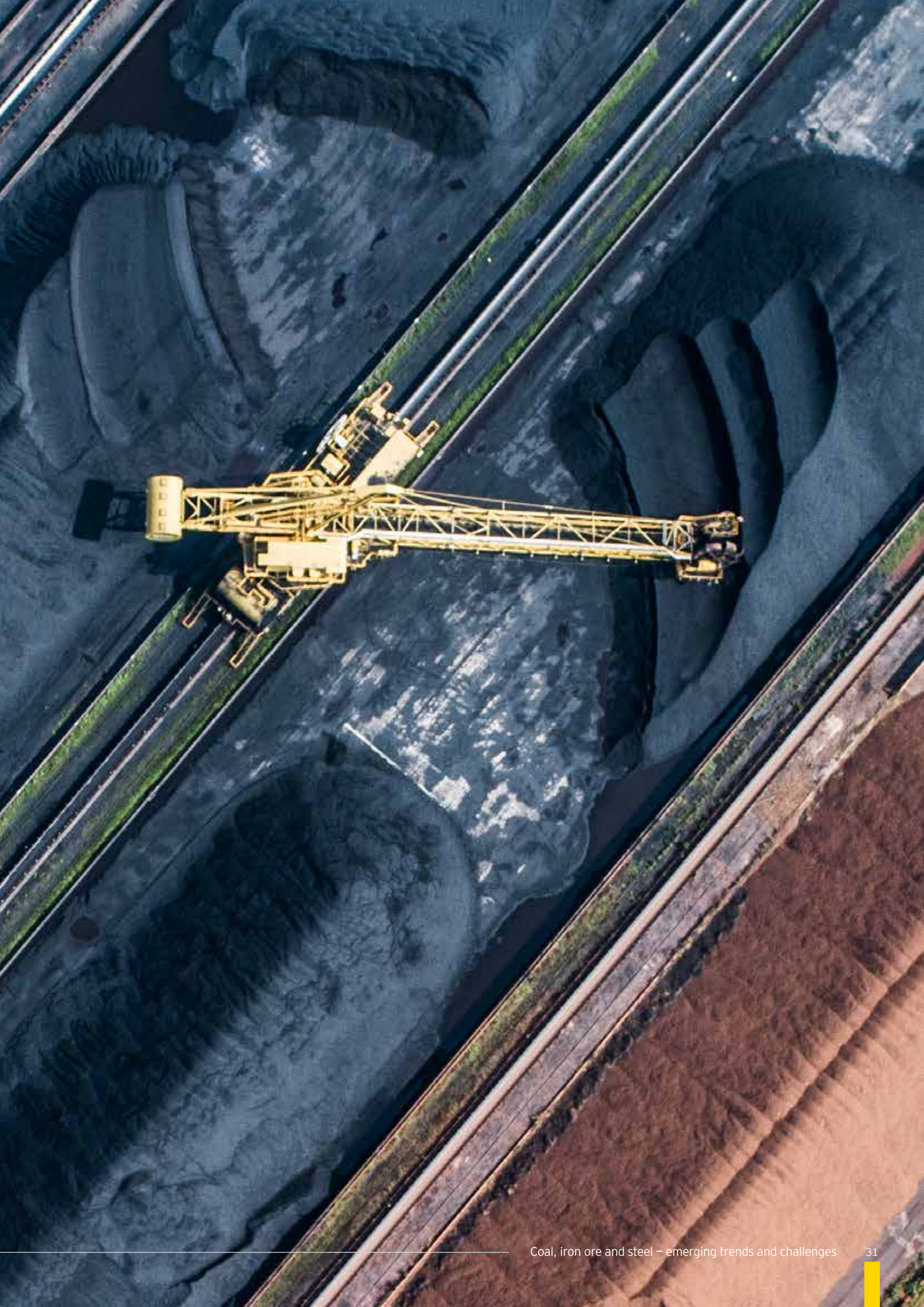
- To bring more transparency, better regulation and enforcement, balanced socio-economic growth along with sustainable mining practices.
- Proposed to grant 'industry' status to mining with an objective of boosting financing of private sector.

Relaxed FDI norms

- FDI up to 100% is permitted under the automatic route to explore and exploit all non-fuel and non-atomic minerals and process all metals as well as for metallurgy.
- FDI cap in the mining and exploration of metal and non-metal ores have been increased to 100% under the automatic route.

Industry Consultation on Utilization of Low and Lean Grade Iron Ore Resources in the Country (Circular dated 12 August 2022)

- Government of India Ministry of Mines is of the view to mandate eighty percent (80%) of the total mineral produced in a year by the holder of a mining lease, which is below fifty-eight percent (58%) Fe grade; to be upgraded through beneficiation to produce beneficiated ore of sixty-two percent (62%) Fe grade and above. Failing which will attract a penalty of the difference between the minimum quantity of mineral to be beneficiated in the said quarter and the quantity beneficiated.
- Industries bodies have responded to the above circular stating the policy to be capex intensive, while the commercial viability of such investments continue to be under question, especially when the metal / commodity cycle remains depressed. They also contend that fines are steep and harsh, while there is little benefit for those complying with the policy.



3

How emerging technologies and trends are addressing these challenges

3.1 Coal

3.1
Coal

Coal is a non-clean energy resource with the highest carbon emission coefficient, but it plays a vital role in electricity generation worldwide. Given the importance of coal in the global energy framework, and the difficulty in phasing out its use, at least in the foreseeable future, there is an urgent need to create a detailed roadmap for the development of clean coal technologies (CCTs).

Clean Coal Technology (CCT) is defined as technologies designed to enhance both the efficiency and the environmental acceptability of coal extraction, preparation, and use. The country needs to upgrade its mining practices to produce coal efficiently and in a sustainable manner. India must not only produce the required quantity of coal efficiently but also ensure that the impact of mining is minimal on the environment and at the same time, quality of coal produced is suitable for achieving desired efficiency and effectiveness of downstream processes, such as coal beneficiation, coal combustion, coal gasification etc., to address our targets of achieving clean coal technologies.

Industry is rapidly transitioning from Industry 4.0 to the next step of Industry 5.0. The coal industry could use technology for monitoring both moving and fixed assets connected by sensors, operating in an Internet of Things environment for delivering real time data for decision making.

Coal industry should aim to improve the end-to-end logistics supply chain associated with evacuation of coal throughout the country. Technology adoption in thermal coal supply chain can solve logistics issues and increase productivity.

High methane emissions

- The coal industry contributes significantly to global methane emissions and reducing these is a challenge for the miners
- Methane emissions need to be regularly tracked on the ground and from the sky using drones and satellites
- Governments need to introduce strong policies to incentivize methane capture and mitigation projects

Mining of coal

- Reduction of coal dilution during mining
- Coal cutting technology-selective
- Advanced innovative blasting

Preparation of coal

- Coal beneficiation
- Coal Blending
- Coal liquification
- Underground coal gasification

Burning

- Combustion pathway
- Gasification pathway

Post burning

- Carbon capture and storage
- Combined cycles

Also, rapid advances in technological innovation, including automation, digitization, and electrification, fundamentally impacts the mining sector. A sampling of the new technologies currently reshaping the sector would include autonomous vehicles – haul trucks, loaders, and long-distance haul trains– remote operating centers; automated drilling and tunnel boring systems; GIS/GPS; drones; autonomous equipment monitoring; smart sensors; wearable technology; and machine learning.

Infrastructure constraints

- Coal miners in some regions face logistical challenges, such as fragile rail and road infrastructure
- Use of advanced technologies like big data and AI in the transportation of coal can result in improved logistics and help in improving safety levels

Safety in coal stockpiling

- Operator safety in coal stockpiles is a challenge faced by miners across the key coal producing regions
- Use of digitalization to record operator responses to emergency situations can help in avoiding high risk situations in coal mining

Digital innovation

- Digitization can help improve human efficiency and develop extensive real-time performance systems in the overall supply chain of the steel industry.
- Preventing downtime could lead to massive savings. Digital manufacturing (including real-time data analytics, self-monitoring, and remote-control equipment), applications based on artificial intelligence involving predictive and preventive analytics, can be used which will eventually help cutting the costs of variability in conventional manufacturing.

3.2 Iron ore

The mining sector is evolving in technologies. . There are a lot of new techniques used by miners in day to day operations – mining operations, logistics, etc.

According to the World Economic Forum (WEF), technological advances in mining have the potential to deliver more than $425b to the industry

Automation and robotics

- The actual use of automation concentrates on the processing steps, where automation systems have been used for decades. "Automation" or rather 'autonomy technologies' are actively used in the haulage process. Surface mines use automated trucks, where constant and long-lasting haulage roads and simple implementation of communication infrastructures, such as GPS or LTE, allow the successful implementation of automation systems.

IoT

- In mining, "IoT" is used in tracking the position and loading status of trucks, which helps coordinate mobile equipment. Also, there are systems to track people for emergency situations. "IoT" monitoring systems are also applied to monitor rock stability and movements in the underground mines.

Big data and real-time data

- The mining industry can significantly benefit from implementing "big data" and "real-time data" analysis. In fact, predictive maintenance systems for belt conveyors or dump trucks rely on "big data" and "real-time" infrastructure, which in turn allow a better forecast of mechanical breakdowns and status as well as tracking the equipment and operators.

Artificial intelligence and machine learning

- Machine learning (ML) is commonly perceived as a subcategory of AI and includes techniques that recognize patterns by learning from structured historical data. ML methods have already successfully been applied in the mining industry. For example, structured data from infrared spectroscopy or images from drones are processed by ML algorithms to determine the mineralogy of exposed lithologies in mining areas.

3D printing

- In mining, a possible field of application for "3D printing" is produce spare parts and custom-built components, which in turn can reduce the cost of storage, production, and delivery times. Similarly, it is possible to use geological data, pictures of drones or point clouds from laser scanners to create digital items and print those as 3D ore deposit or open pit models for illustrative purposes.

Diffusion of digital technologies in mining

- Many of the new technologies are yet to be adopted by the mining industry and individual mine sites as shown by the overall lack of adoption of digital technologies across the mining sector. Other industries are rated better in an OECD digital index study. Mining is rated low in the digital index, but industries such as "machinery and equipment" or "electrical equipment" manufacturing are rated high.
- It remains increasingly difficult for mining companies to decide which digital technologies are most relevant to their needs and individual mines.
- Large-scale mining operations appear to select and apply digital technologies suitable to their needs, whereas operations with lower production rates do not implement the currently available digital technologies to the same extent. These minor producers may require other digital transformation solutions tailored to their capabilities and needs and applicable to their scale of operations.

3.3 Steel

Rapid spend and absorption new tech on EAF based steel making through partnerships and focused R&D -for integrated steel players, considering a transition to scrap based EAF production, ease of and affordable scrap availability, end-product quality will be important determinants of the strategy and technological choice between the options as below:

- EAF with full scrap (Scrap-)EAF.
- Primary steel through DRI with natural gas as the primary reductant followed by EAF
- Primary steel through DRI with green hydrogen as the primary reductant, but feasibility remains a concern.

Renewables for power usage and electric vehicles for steel logistics

- On its target to produce 300 MTPA of steel by 2030, from mines to the last-mile customer, around 900 MTPA tons of raw material would require logistics. Anticipating the needs of the future, the government has already started working on the infrastructural readiness of mega projects in logistics, like Sagarmala, Bharatmala and Dedicated Freight Corridor.
- Preparation for hydrogen intrusion in the industry is crucial toward decarbonization goals. With proper planning, usage of hydrogen-based DRI and EAF globally and in India will help make green hydrogen the most affordable fuel, bringing it down to $2 per kg. India can potentially set an even more aggressive target of achieving under $1 per kg within a decade. In the medium to long term Primary steel through DRI with green hydrogen as the primary reductant followed by EAF (H2-DRI/ EAF) can be a very cost and green friendly way of steel manufacturing.

Digital disruption

- Digitization can help in improving human efficiency and developing extensive real-time performance systems in the overall supply chain of the steel industry.
- Preventing downtime could lead to massive savings, digital manufacturing (including real-time data analytics, self-monitoring, and remote-control equipment), applications based on artificial intelligence involving predictive and preventive analytics can be used which will eventually help in cutting the costs of variability in conventional manufacturing.

Hypermart and online selling of steel

- 100% FDI and e-commerce 3.0 makes the entry of Hypermart model (value chain integration) and online selling inevitable.
- Online platforms seamlessly connect the different stakeholders involved in the steel force chain. Online platform offers multiple brands and different grades of steel, sourced from merchandisers and manufacturers across the country.

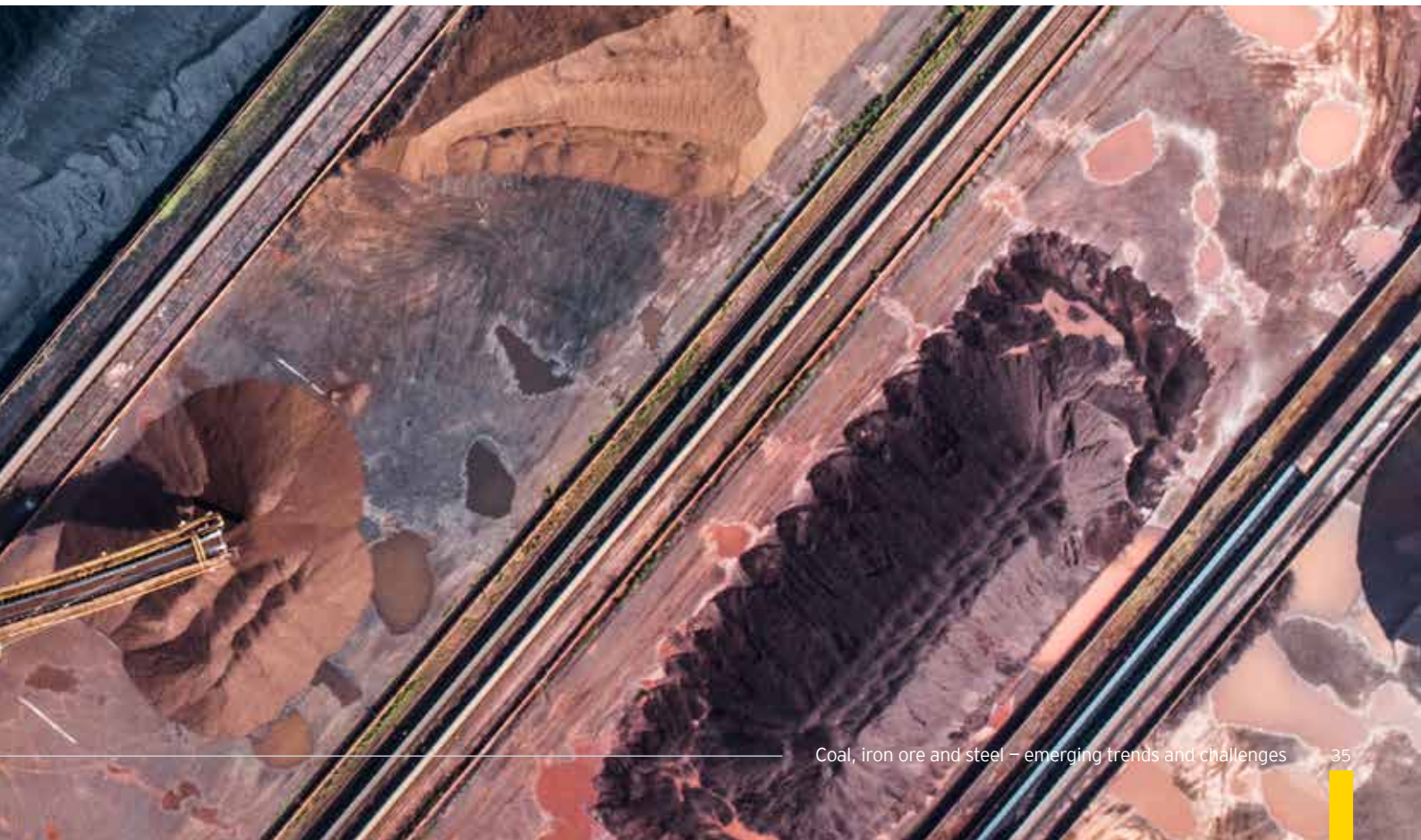


Table 6: Digitization interventions

Digitalization in mining for raw materials value chain	Typical business challenges	Potential interventions to address
Exploration, land and clearances	▶ Manual or file-based data upload ▶ Limitations in capture for the field data ▶ Manual interventions and variances in updating of the Geological parameter of the blocks ▶ Different data set with varied agencies and in different coordinate systems ▶ Cumbersome to collect and manage large amounts of place-based (geospatial) data ▶ Sometimes data is collected or purchased multiple times ▶ Data is not always organized and managed efficiently to support decision making in a timely and cost-effective manner	▶ Leverage advanced sensing technologies and analytics to characterise mineralogy, geochemistry, rock hardness, properties, structures and economic value under cover ▶ On-line and trusted geospatial data, services, and applications ▶ A "one-stop-shop" to deliver trusted, nationally consistent data and services. ▶ Authoritative data to support informed decision making ▶ Problem solving applications (services) that are built once and used many times ▶ A shared cloud-computing infrastructure to host data and applications
Mine planning	▶ SURPAC + MInex used for planning but not integrated ▶ Siloed Auto CAD system / design platform not integrated with SURPAC ▶ Delays and information coordination issues in planning	▶ Integrated system for planning / scheduling, ▶ Single version of truth Effective short term mine planning - new measurements, communication, integration technologies.
Mine operations	▶ Lack of visibility into contractor performances, deviations, RCA ▶ Manual Communication of plan and schedule to the contractor ▶ Low understanding of process complexity - impacts on KPIs / deviations ▶ Decentralised and reactive decision making / execution ▶ Absence of optimization in removal<->haulage cycle ▶ Lack of real-time fleet monitoring ▶ Manual tracking of lead for OB / Coal and Excel based analysis of related KPIs ▶ Limited visibility into planning, construction and maintenance of catchment area, sumps, culverts and water garlands. ▶ Limited visibility into OEE and operational performance of movable assets ▶ Absence of dataset / benchmarks and lack of an SOP for compliance with such benchmarks. ▶ Lack of analytical capabilities to make data driven decisions on productivity and asset utilization.	▶ Drone based aerial inspection ▶ Real time geo location of the moving assets ▶ Real-time haulage cycle optimization on HEMM deployment ▶ Actionable insights through visualisation, optimisation and predictive analytics with role-based dashboards ▶ Digital twin with real time mimics and analytics

Digitalization in mining for raw materials value chain	Typical business challenges	Potential interventions to address
Ore processing	▶ Weight sensors present to capture the weight automatically ▶ Asset availability of conveyor belts is a concern ▶ No Performance analysis of screeners/ crushers/ washeries ▶ Inline CBM on real-time condition of the screeners and crushers available ▶ Lack of prediction of clogging / failure of screens / crushers ▶ Lack of optimization of the water effluent treatment ▶ Manual preparation of daily production reports ▶ Worker safety during conveyor inspection	**Enhanced monitoring** ▶ Condition based asset monitoring with predictive analytics ▶ Mobile field logs to record circuit inspection. ▶ Real time data Analytics ▶ Automated DPR and MIS reports **Efficiency and productivity management** ▶ Digital Twin for real time mimic of the process ▶ VFD for rotating machinery for energy conservation and precise speed control ▶ Push to talk system along the conveyor circuit ▶ ISA defined standard automation architecture and specifications being Industry 4 ready
Digital logistics	▶ Manual spreadsheet-based planning and scheduling of rail rake dispatch ▶ Manual monitoring and reporting of loading activity. ▶ Limited visibility of TAT at various sub processes leads to delayed dispatch. ▶ Manual reporting of wagon filling status which leads to erroneous data ▶ Handwritten goods note is generated for the coal loaded on the rake. ▶ Scheduled contract based outsourced maintenance of rail tracks which is done manually once in a month which leads to frequent failures. ▶ Difficulty in retrieving the GPS information leads to delayed decision making ▶ No mechanism to detect pilferages. ▶ Railway line sabotage and incident prone	**Visibility, planning and scheduling** ▶ Integrated planning and scheduling tool – reduced rake TAT ▶ Real time visibility of the rakes to improve communication and alerts in case of delays. ▶ Automated generation of rake wise receipt of loaded quantity. **Rail track monitoring and surveillance** ▶ Rail inspection trolleys for CBM ▶ Thermal / optical camera with in-camera analytics ▶ GeoSAT system regular feeds for rail line scan ▶ Central security control room for quick response on feeds of alerts and alarms ▶ This inspection data can be leveraged to predict track failures **Efficiency improvement and optimization** ▶ Integration of control tower, weighbridge, rapid loading, DCS and SAP for automated invoices ▶ Optimization of maintenance schedules based on constant analysis of maintenance activities. ▶ Centralized integrated data platform for logistics reporting ▶ Using drone and image analytics, pilferages can be detected and mitigated

3.4 The innovation

Over the years, various Indian steel and power major companies were facing financial pressures along with operational challenges. The companies were disconnected with the new-age tech and Information Technology (IT) platforms that could prevent a 360-degree visibility into existing processes and with desired granularity. Steel players have been able to leverage the AI/ML assisted solution to address these challenges and transform their operations to enhance output at lower cost while maintaining consistent quality. Addressing these internal and external challenges, the steel players have leveraged digital to turnaround their business operations through:

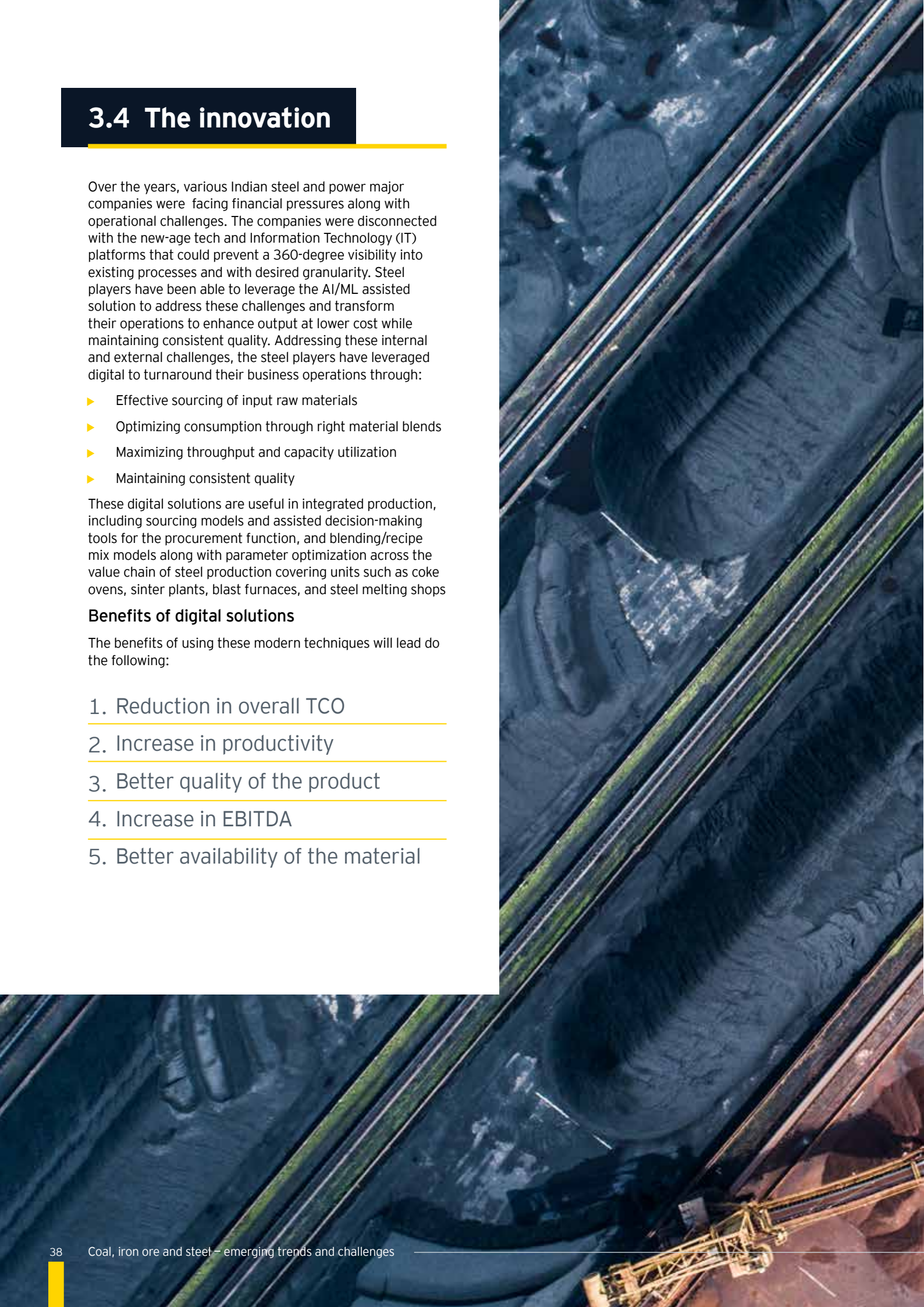
- Effective sourcing of input raw materials
- Optimizing consumption through right material blends
- Maximizing throughput and capacity utilization
- Maintaining consistent quality

These digital solutions are useful in integrated production, including sourcing models and assisted decision-making tools for the procurement function, and blending/recipe mix models along with parameter optimization across the value chain of steel production covering units such as coke ovens, sinter plants, blast furnaces, and steel melting shops

Benefits of digital solutions

The benefits of using these modern techniques will lead do the following:

1. Reduction in overall TCO
2. Increase in productivity
3. Better quality of the product
4. Increase in EBITDA
5. Better availability of the material



Different types of digital solution applications are:

1 Source mix optimization

A solution which considers myriad of potential sources for fuel and raw material with different quality profiles to achieve the optimal source-mix at least possible cost. Its features are:

i. Considers extensive quality parameters of the material and associated impact on the process cost

ii. Extensive repository of global and domestic mines and corresponding quality and cost components

2 For coke ovens

This is an advanced analytical tool aimed at designing the mix of coal blend in the coke oven to optimize coking coal consumption, to decrease the cost of gross coke, and decrease the hot metal loss due to ash and sulphur under dynamic plant conditions while ensuring optimal operating parameters and productivity. Its features are:

i. Considered extensive quality parameters of input coking coals such as Ash %, M40, M10, Vitrinite, CSI, etc., and utilized deep neural network models to suggest the least cost blend

ii. Proprietary coke blending model with feature of CSR prediction with >99.5 % accuracy

iii. Repository of global mines and miner sheets to design the least cost blend

3 For sinter plant

The solution helps identify optimal input mix for the sinter plant to ensure least cost sinter production while considering inputs' inventory and maintaining requisite hot metal quality and productivity. Its features are:

i. Recommendations for least cost production of sinter while ensuring requisite quality of hot metal

ii. Optimization model for cost while considering plant, process and quality constraints

4 For blast furnace

This is an analytical tool aimed at designing the mix of raw materials in the blast furnace to optimize raw material consumption, to decrease hot metal cost. Its features are:

i. Utilized advanced analytics techniques to suggest the least cost mix of burden to be fed into the blast furnace

ii. Ensures desired productivity of blast furnace and requisite quality of hot metal

iii. Delivers control over quality and productivity and provides cost savings from optimized material consumption.

5 Ferro-alloy consumption optimization

The solution is a cost optimal ferro-alloy mix taking into consideration dynamic heat conditions and delivered benefit through lean chemistry achievement and optimized usage of cheaper options. Its features are:

i. Utilized advanced programming techniques

ii. Provide the least cost ferro-alloy mix for the heat with dynamic heat considerations

iii. Benefits from lean chemistry achievement and optimized utilization of cheaper ferro-alloy

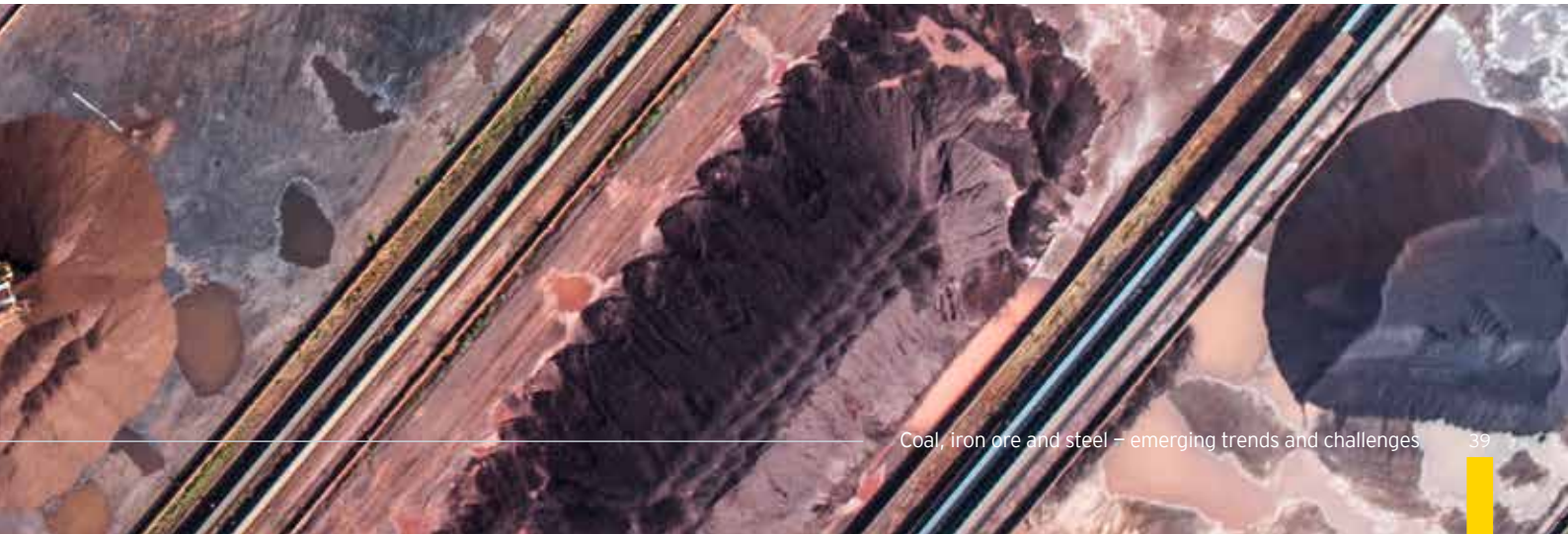
6 Power plant control tower

The tool is an integrated solution offering for the power plant operations comprising of planning for thermal coal procurement, inventory norming, and thermal coal blending for least cost power generation while maintaining requisite operating parameters for desired power output. Its features are:

i. An integrated solution offering along the entire power generation value chain

ii. Tools for planning for procurement, inventory norming and thermal coal blending for least cost power generation

iii. Consideration of coal properties such as ash, FC, GCV and joint parameters, such as PLF



4

Summary and way forward

While there are a number of initial steps that have been undertaken by major Indian steel players for R&D, policy intervention by government and industry-user collaboration, there is a persistent need to not only have sustained R&D investment by Indian steel companies but also engage and develop a deeper level of collaboration across different stakeholders within the steel ecosystem.

On the other hand, thermal coal demand is projected to fall, as many countries focus on developing cleaner energy sources, slowing demand for coal used to generate electricity. Meanwhile, despite rising growth from some emerging economies, growth from Chinese operators is forecast to continue to slow, diminishing demand for coking coal.

With India's power demand expected to double in the coming decade, coal power generation may not yet have reached its peak. Historically, coal plants have accounted for 70 to 80%of the country's total power generation. This share is estimated to remain above 50% even in 2030. Further, India's current installed coal capacity of 209 GW will expand, with around 57 GW of new capacity in the pipeline. Coal is a reliable energy source, especially when compared with the seasonal and diurnal variability of renewables.

One of the key initiatives, in this regard, is the promotion of coal gasification, liquefaction, and hydrogen production as alternate uses of coal. These technologies allow for the conversion of coal into gaseous or liquid forms, which can be used as feedstock for various chemical and industrial processes.

The demand for these technologies is expected to increase in the coming years as the government continues to focus on reducing emissions from the power sector. However, the supply of coal needs to be increased to meet this demand, which may require the expansion of existing coal mines or the development of new ones.

Similarly, there is a significant scope for new mining capacities in iron ore and considerable opportunities for future discoveries of sub-surface deposits. Beneficiation capacity expansion for low / sub grade iron ore remains key in achieving full potential of the sector. Infrastructure projects continue to provide lucrative business opportunities for steel iron and steel make up a core component for the real estate sector. Demand for these metals will continue given strong growth expectations for the residential and commercial building industry.

Additionally, the new government policies aim to facilitate the merger and acquisition of mining companies, entice private sector involvement in exploration, and permit the transfer of mineral corridors created specifically for metals and mining leases. In the future, both increased domestic demand and exports are projected to play significant roles in driving the industry's expansion and its contribution to GDP growth in a post-COVID-19 environment.

Vision of India 2047

The vision of 2047 for India is to emerge as global leader and become the third largest GDP of the world. The aim of the ministry on green steel is to raise steel production capacity through scrap to 300 million tons (60%) and reduce carbon footprint by 50% from 2.6 T CO2/T to 1.3 T CO2/T of crude steel

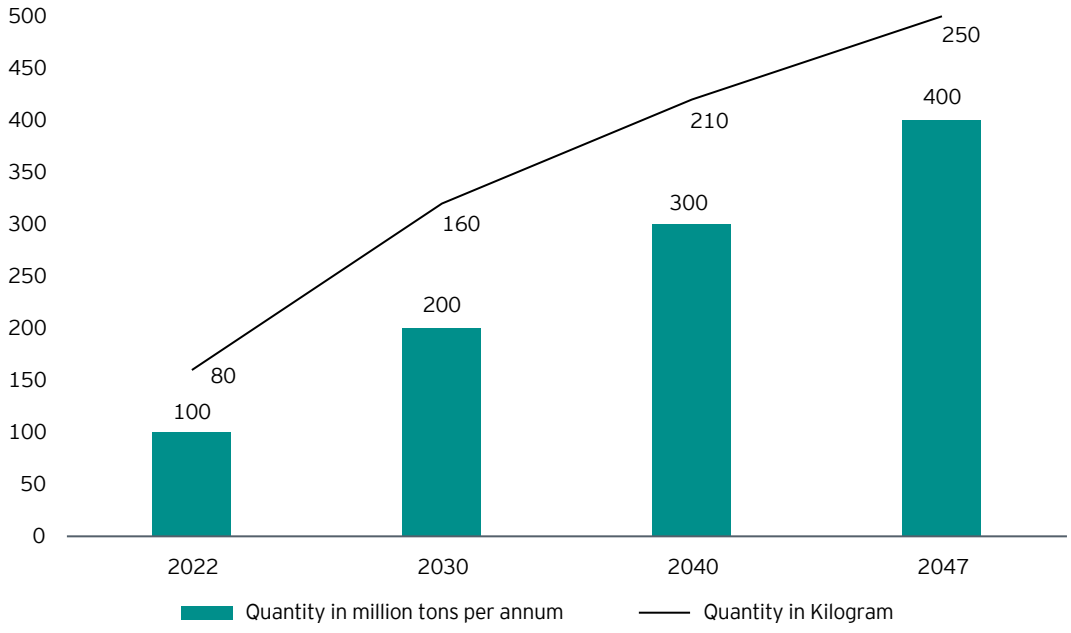
There are several combinations through which they plan to achieve targets. Some examples are:

- producing 60% steel through scrap.
- reduction of coking coal dependence.
- maximized usage of pellets and 100% gas-based DRI production.
- Other factors include increased use of Green H2 and carbon capture, usage and storage (CCUS) and 100% renewable energy use.

Demand-side: It also aims to increase the country's total consumption from 106 mt to 400 mt by 2047. Even expansion of per capita consumption from 77 kg to 245 kg and rural consumption is aimed for, from the current 21.3 kg to 80 kg in another 25 years.

Figure 13: Future trends

India's per capita steel consumption may increase to 245 kgs by 2047



Indian government is focusing on building an energy infrastructure to fulfill its energy goal. India would require a roadmap which is visionary, pays close attention to challenges, and a model which brings finance and tech together resulting in a successful.

India needs a turn around in the thought process, i.e., it needs to focus on supply and infrastructure building to create the political demand for an Energy Vision 2047.

Energy and finance

- Major investment will be pumped from domestic and international private sources.
- Financial de-risking is needed for proven clean energy technologies
- Blended public-private finance will be required for research and development investments in horizon technologies, such as green hydrogen and carbon capture utilization and storage.

Future of energy

- Energy futures are likely to be more decentralized, digitalized, and decarbonized.
- 80% of the renewables workers in 2030 could be from rooftop solar.
- India will need to find a new convergence of digital tech and energy tech.
- Technology and market signals can change demand patterns favoring super-efficient appliances, sustainable urban mobility, and cleaner industrial fuels.

Government action plan

The collaboration across the stakeholders, with the government taking the lead, needs to operate across three levels:

Policy level interventions

- At a policy level, focus on integration of science and research labs, universities, government level agencies and industry level partnerships through a policy framework to promote advanced R&D activities to enable innovation is critical.
- Though initial steps have been taken in different forms, there is a need to align technology, research, and innovation with an integrated policy that will allow the stakeholders to identify areas of greatest impact.

Establishment of nodal agency

- With the inputs from different stakeholders, the policy framework needs to address dimensions of technological upgradation, product innovation, skill development and productivity across a broad spectrum of the steel industry and support sustainable development in India.
- Policy framework would also require a formal governance structure to ensure active engagement of all the stakeholders across the steel ecosystem and supported by a structural review to achieve the desired objectives.

Helping others to join alloy-club

- The government is pushing hard for an Atmanirbhar Bharat or Make in India. This is a tremendous advantage to help high-grade steel development in India.
- It becomes important for Indian companies to explore this option (more critical for mid-size and MSME companies) as the learning curve for technology and product innovation needs to be very steep as upfront R&D costs are significantly high

Improving FTA with different countries

- Establishing bilateral relationships with G20 presidency
- The steel industry should make best use of the India-Australia Economic Cooperation & Trade Agreement (ECTA) and look at capturing new opportunities in Australia.

Private players' action plan

In an effort to capture the projected coal, iron ore and steel demand in India, the players in India will have to calibrate their choice of capital spend with the right technologies and right quantities. The debt burden of the industries is a concern. Any future economic shocks to the industries will make them more liable for being sick and dependent on external support for keeping it alive. Choices of capital spend may need to be calibrated to the current state of oversupply to ensure the prices of steel remain stable and see less volatility in the future. The sector should actively seek to modernize and adapt to the global developments in management thought on mastering the future for robustness and sustainability.

The diversity of the Indian market presents both a challenge and an opportunity for the Indian manufacturers. Rural markets are still under-penetrated for steel as a category. However, the unavailability of high-quality steel from Indian manufacturers necessitates the import of such steel grades for specialty steel buyers. The visibility of sales and inventory data of the last mile steel distribution networks makes the services to the retail market cost and service inefficient. Focus on adoption of relevant information technologies with appropriate linkages to physical distribution chains to service the complex market dynamics can yield significant business returns for players who demonstrate insight and act to actualize such initiatives.

Smart factory

Data can help steelmakers quantify, monitor, record and assess processes to enhance performance and ensure reporting requirements are met.

These digital solutions can be leveraged across the steel making value chain and drive operational efficiencies by enhancing decision making across major aspects that impact material utilization in the steel manufacturing:

Sourcing-related: Right quantities and quality of the different material integrated with consumption optimization

Consumption related: Optimal blending / recipe mix decisions to maximize yield and reduce consumption while maintaining desired outputs

Parameter related: Leverage relationships between parameters and material characteristics to fix parameters to achieve optimal cost for desired productivity

Productivity related: Maximize productivity in a cost efficient manner

The following are an illustration of the typical business and operational benefits that may be realized by deploying digital solutions across the steel value chain:

- Optimizing raw material mix
- Increasing throughput and yield
- Optimizing energy consumption
- Predictive maintenance to reduce costs
- Enhanced quality and rejections reduction

The experiences of leading steel manufacturers in the Indian steel industry indicate that typical benefits of 3% to 4 % reduction in production costs driven through consumption and parameter optimization and 2% to 3 % improvement in productivity may be realized through the deployment of digital solutions.

Digital value chain for steel

- Digital solutions can be designed for different production units of steel making, namely sinter plants, coke ovens, captive power plants, blast furnace and the steel melting shop.
- The stages of digital adoption in these production units are typically in multiple stages – descriptive (enhance visibility), diagnostic (issues identification and root causes), predictive (simulations for sensitivity analysis), prescriptive (optimal state recommendations).
- Digital solutions can optimize the logistics for inbound and outbound materials flows to maximize material throughput in a multimodal transport world and ensure the least fuel burned per ton of material moved.

Inter-dependencies of material aspects across process and impact on downstream process considered in digital solutions

Sourcing/ Procurement	Coke making	Sinter plant and BF	BF Operating parameters	BF Operating parameters
Mines / Suppliers	Coke oven	Sinter plant, BF	Blast furnace	EAF, LRF and casting
Aspects considered for TCO				
Source Mix Optimization ▸ Optimized TCO cost ▸ Consistent quality ▸ Enhanced availability ▸ Source of material ▸ Inventory levels ▸ Material quality	**Coal Blending Optimization** ▸ Optimized coke cost ▸ Consistent Quality ▸ Increased productivity ▸ Coking coal Blend – prime hard, semi hard , Soft % ▸ Quality – TM, VM, FC, Vitrinite, CSN, etc. ▸ Coking speed, temperature	**Burden Mix Optimization** ▸ Optimized TCO cost ▸ Consistent quality ▸ Optimized Sinter and HM ▸ Sinter mix – Iron ore, coke, flux fines % ▸ IBM Mix (Lump, sinter, pellet), fuel & flux ▸ Quality – Fe %, Al2O3, CaO, SiO2 etc	**BF Parameter Optimization** ▸ Optimized operating parameter ▸ Increased productivity ▸ O2, Steam, hot blast, cold blast, RAFT, heat load etc ▸ Coke rate, PCI rate, Slag rate	**Burden Mix Optimization** ▸ Lean chemistry ▸ Optimized usage of FA ▸ Optimized killing cost ▸ Ferro-alloy types and addition ▸ Opening chemistry ▸ Killing Aspects – C vs. Si / Al
Outputs				
▸ Landed Cost ▸ TCO Cost ▸ Availability at plant ▸ Impacts downstream process costs	▸ Coke productivity and cost ▸ Coke Quality – CSR, CRI, TM, VM, ▸ Impacts BF process and HM productivity	▸ Sinter and HM productivity and cost ▸ Sinter quality ▸ HM cost, Si, temp and chemistry ▸ Impacts BF process and HM productivity	▸ HM productivity and cost ▸ HM temperature and Si ▸ HM Chemistry ▸ Impacts HM productivity and quality, SMS cost and steel productivity	▸ Lean chemistry and FA cost ▸ Optimized killing ▸ Impacts FG quality and market prices

Smart services

- Real-time dynamic routing and allocation of gases used in heating stoves, power plants, sinter, pellet, coke oven plants and rolling mills can help minimize flare burning in Integrated Steel Plants (ISP)

Green steel

- It refers to a steelmaking process that lowers greenhouse gas emissions, cuts cost, and improves the quality of steel. This can be done through the usage of gas in place of coal, recycling steel, etc.
- To move toward 'Green Steel', the Petroleum and Natural Gas Ministry has launched the Pradhan Mantri Urja Ganga project in the Eastern India, which can provide gas to all the Steel plants, located in the area.

Investing in state-of-the art infrastructure

- High grade tools and machinery and supply networks

Investment in the R&D Sector

- To find sustainable resources for production process
- Improving internal processes related to saving costs, and efficiency.
- Process improvements such as beneficiation and palletization of iron ore
- Deep dive in the steel structure design in college curriculum is needed

Innovation in digitization

- Using e-commerce and promote digital culture as India enter in age of Industry 5.0
- Advanced tools for the optimization of the production chain and specific technologies for low-carbon and sustainable production
- The rapid evolution of the technologies in the steel sector requires the continuous update of the skills of the industrial workforce.

Digital solutions can transform the value chain, improving the production line in an integrated manner, which will help in providing intangible and tangible business benefits. These solutions can help with cost savings and end-to-end process visibility and control, along with process and parameter optimization.

The data-driven analytical approach to provide solution supported by robust teaming and governance enabled development to address the relevant challenges, transform operations and deliver results is need of the hour.

Hence, in order to realize the best efficiencies in the as-is state of production of steel, local and global optimization of all processes is imperative. Indian steel making has room for benefits from process optimization through the application of advanced analytics and digital solutions as the industry lags in the adoption of optimizing tools and digital solutions. Digital solutions can be leveraged across the steel making value chain and drive operational efficiencies by enhancing decision making across major aspects that impact material utilization in the steel manufacturing.

Private sector

Initiative/way forward activity	Impact
Implementation of smart factory	▶ Optimizing raw material mix ▶ Increasing throughput and yield ▶ Optimizing energy -consumption ▶ Predictive maintenance to reduce costs ▶ Enhanced quality and rejections reduction
Digital value chain for steel	▶ Optimization of the logistics for inbound ▶ Maximize material throughput in a multimodal transport world ▶ Least fuel burnt per ton of the material moved.
Increased usage of green steel	▶ Provides sustainable portfolio ▶ Lowers carbon footprint ▶ Helps with ESG compliance
Innovation using digitization	▶ Optimization of the production chain ▶ Sustainable production ▶ Tech advancement, resulting in efficiency ▶ Better service to customers

Public sector

Initiative/way forward activity	Impact
Policy level interventions	▶ Promotion of advanced R&D activities ▶ Alignment of tech, research, innovation with policy ▶ more opportunities for researchers and technocrats
Establishment of nodal agency	▶ Enhanced coordination across multiple agencies ▶ Identification of greatest impact and synergies across the ecosystem. ▶ Formal governance structure ▶ Active engagement of all the stakeholders across the steel ecosystem and support
Improving FTA with different countries	▶ Strengthening of the certificate of origin rule to stop circumvention ▶ Making maximum usage of Make in India and increasing exports ▶ High impact on trade deficit

Abbreviations:

1. Coal Preparation Plant - CPP
2. Coal India Limited -CIL
3. Singareni Collieries Company Limited - SCCl
4. Direct Reduced Iron - DRI
5. Run of Mine - ROM
6. In-pit Crushing and Conveying System – IPCC
7. Million Tons - MT
8. Production Linked Incentive - PLI
9. Million Tons Per Annum - MTPA
10. Clean Coal Technology - CCT
11. World Economic Forum - WEF
12. Long Term Evolution – LTE
13. Machine Learning - ML
14. Internet of Things - IoT
15. Electric Arc Furnace - EAF
16. Economic Cooperation & Trade Agreement - ECTA
17. Total Cost of Ownership - TCO
18. Conference of the Parties – COP
19. Environmental, Social and Governance - ESG

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