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FICCI

Automation, Digitalisation and Technology Integration for the Indian Mining and Steel sector

August 2024

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Acknowledgement

FICCI would like to thank all the stakeholders involved with the development of the report. Special thanks to the Mentor, Chair, Co-Chair, and Members of the FICCI Steel Committee and FICCI Mining Committee for conceptualising this report **Automation, digitalisation and technology integration for the mining and steel sector** and guiding the team throughout its development with their input and suggestions.

FICCI would also like to thank Deloitte for preparation of the report in consultation with industry and other stakeholders in this sector. The Deloitte team conducted a qualitative survey alongside secondary research to come up with a rich output and holistic perspective, giving 360-degree coverage across the entire gamut of the Indian mining, steel and ICT industry.

In the report, an attempt has been made to comprehensively cover the trends and developments, opportunities, challenges, and recommendations pertaining to the emerging technologies in the mining and steel sector.

FICCI also conveys its appreciation for various organisations, associations, and individual experts in the sector for sharing their insights and contributing to the report. Their views have contributed immensely to finalising the report.

At the end, FICCI acknowledges the contribution made by all those associated with the report.

FICCI foreword

FICCI, in collaboration with Deloitte, is pleased to present the report **automation, digitalisation and technology integration for Indian mining and steel sector.** As the industry prepares to harness the potential of emerging technologies and innovations, it stands on the threshold of transformative growth and is presented with unprecedented opportunities that will drive the Indian steel industry through its Amrit Kaal journey.

The report highlights that integrating digital technologies and automation is the desired response to address the growing demand and dynamic market scenario of India's burgeoning steel industry. Technology integration with steel operations would help in optimizing production processes, improving productivity, reducing operational costs and increasing the competitiveness. The report also provides an in-depth analysis of the current trends, challenges and opportunities and offering valuable insights into how companies can leverage technologies to maintain a competitive edge. Towards this end, the report also focuses on the strategies that companies must adopt to remain ahead of the curve, re-iterating that companies which proactively implement such strategies will be better equipped to leverage technological advancements, drive innovation and achieve sustained success.

We are hopeful that industry and other stakeholders will find the recommendations in the report useful.

Jyoti Vij
Director General
FICCI

Deloitte foreword

The Indian mining and steel sector is at a critical juncture, poised between sustainability and growth. As a crucial driver in the nation's roadmap towards Viksit Bharat by 2047, the sector is committed to increasing domestic steel consumption and ensuring the production of input minerals and high-quality steel. The focus is to create a technologically advanced and globally competitive steel industry.

In addition to meeting domestic demand for steel, the industry must adopt the latest processes and digital technologies. The sector is on the cusp of a digital transformation, focusing on digital technologies to enhance synchronisation, enable faster decision-making, and seamlessly integrate people, processes and systems.

To achieve these ambitious digitalisation and technological goals, the industry must strengthen its technological core and competencies. Understanding this imperative, FICCI and Deloitte have collaborated to provide valuable insights into the sector’s future. The report results from this partnership. It delves into industry trends, addresses challenges and highlights technology related opportunities that will define the industry’s narrative in shaping its transformation journey.

We hope you find this report insightful and beneficial as you navigate the evolving landscape of the Indian mining and steel industry.

Rajib Maitra
Partner, Deloitte India

Executive summary

Indian mining and steel sector is at the forefront of driving the roadmap towards Viksit Bharat by 2047. With increasing demand, policy support, strategic alliances and increasing investment in innovation and technologies, India is currently the second-largest crude steel producer. However, India's per capita steel consumption of 93.4 kg[1] in FY23 against the global average of 219 kg[2] is highlighting the potential for augmenting domestic overall steel demand in the long run. Growing demand and a focus on operational excellence, product innovation, customer centricity and sustainability will drive the domestic mining and steel industry.

The persistent focus on sustainability, innovating new products and process improvement are redefining the global mining and steel industry and reshaping the industry's approach to adopting disruptive technologies with varying regional implementation strategies. Moreover, supply chain disruptions, market volatility and competitiveness are forcing the industry to look forward to innovation in process and digital technologies in green steel transition, energy management & sustainability, plant modernization, manufacturing automation and reliability, workplace of the future, resilient supply chain and customer excellence. Global economies are facilitating this transformation by providing investment funds to drive the adoption of cleaner technologies and tax credits to reduce emissions.

However, the underlying enabling digital technologies, such as AI/ML, IIoT and networks, automation, robotics, AR/VR, drones and cybersecurity remain consistent. They are being adopted in collaboration with process innovations that promote low-carbon input materials, carbon management solutions, improvement in conventional and non-conventional steelmaking and development of new products. Significant themes such as digital and physical transformation, a digitally enabled connected workforce, an integrated enterprise platform and ecosystem, and next-gen analytics are being used to unlock value-driven opportunities to optimise process variables, reduce downtime and ensure resource efficiency. Considering the level of adoption, The World Economic Forum has identified six[3] lighthouse iron and steel factories worldwide, which serve as a beacon for integrating and scaling transformative technologies across the value chain. The global investment in digital technologies is estimated to reach ~ US$6 billion by 2031, at ~11 percent CAGR.[4]

The global mining and steel industry, led by the First Mover Coalition, is further exploring the opportunity to achieve near-zero carbon emissions. Advancements in digital technologies, such as industrial metaverse, GenAI, spatial computing and blockchain, are exploring and supporting the potential of various breakthrough process technologies, such as clean hydrogen, hydrogen-based DRI process and electrolysis technologies for low-grade ore.

In line with global trends, major steel producers in India have already started expanding their capacities to meet the growing domestic demand and achieve the aspirational 300 MT[5] steel production capacity target by 2030 per the National Steel Policy, 2017. CBAM regulations, may significantly affect India's export potential for mining and steel products. Hence, there is an urgency to modernize infrastructure and adopt new technologies for monitoring and reducing carbon footprint.

Indian mining and steel players have adopted digital interventions such as process yield optimisation, digital twin for autonomous operations, intelligent surveillance, supply chain optimisation, energy efficiency optimisation and AR/VR-based safety training and established digital infrastructure to drive deeper insights and make decisions, create engaging interactions and generate more substantial business outcomes. While some leading organisations have made substantial strides in adopting and integrating advanced technologies, others are still in the initial stages of their digital transformation journey and exploring the opportunities of digital technologies. The government has also taken several initiatives, such as SAMARTH Udyog Bharat 4.0, led by the Ministry of Heavy Industry, to create experiential centres and develop an ecosystem for innovation.

[1] World Steel Association report on Apparent steel consumption per capita 2023

[2] World Steel Association reports

[3] https://initiatives.weforum.org/global-lighthouse-network/lighthouses

[4] Steel Industry in 2022: Most Promising Technologies to Keep an Eye on (abiresearch.com)

[5] https://economictimes.indiatimes.com/industry/indl-goods/svs/steel/india-steel-production-to-cross-300mt-by-2030-official/articleshow/112065042.cms?from=mdr

As the industry adopts the emerging technologies to generate more data insights, it also witnesses certain barriers such as high initial cost, skill gaps, data management issues, legacy systems, regulatory and environmental compliances and organisational resistance to change. Overcoming these challenges, the Indian mining and steel sector can unlock more potential across the value chain by strengthening foundational technologies and integrating digital technologies. The investment in process and digital technologies across the Indian steel value chain is projected to reach US$2.3-2.7 billion[6] by 2030 towards an efficient and sustainable steel industry.[7]

Addressing the prevalent challenges and tapping into existing opportunities, the mining and steel players need to focus on leadership and organisational alignment with technological roadmap, capability development of workforce, forging strategic partnerships, building a culture of innovation and collaboration, developing and modernising existing digital infrastructure in complying with the appliable environmental & regulatory norms. It is a gradual transformation journey that can only be successful if adequately channelled through human efforts. Emerging processing and digital technologies are providing an opportunity to reimagine what the sector's future can look like and provide strategic advantages towards unlocking new business horizons. This multimodal business model protects and optimises the core while simultaneously exploring new ways to drive business value and ensuring that organisations remain competitive and relevant.

[6] Deloitte Analysis

[7] Industry estimates, Deloitte analysis

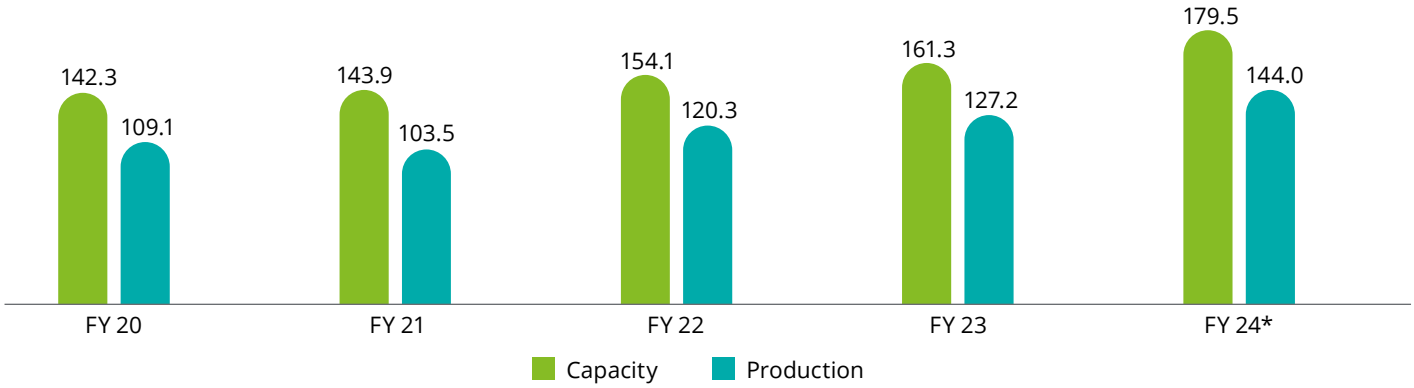
1. Introduction

India's economic growth primarily depends on the steel industry, making the country a global hub for steel production. India is the world's second-largest producer and has made deliberate strides towards industrial self-sufficiency, particularly in steel. With robust economic growth and government initiatives to support the sector, India is well-positioned to witness continued growth in the steel industry.

India seeks to reach 300[8] million tonnes of crude steel capacity by 2030 and 500[9] million tonnes by 2047. Consumption across sectors of the end-user ecosystem will drive this growth, which will also be promoted by government expenditure and increasing urbanisation.

The global and Indian steel sectors have witnessed significant technological advancements, which have driven efficiency, productivity, and sustainability improvements across the entire value chain. The Indian steel industry has undergone significant changes over the last decade, with rapid steel capacity and consumption growth. Domestic steel consumption has grown robustly, driven by infrastructure and automotive demand and supported by government investments.

Figure 1: Crude steel production and capacity trends in India (in million tonnes)

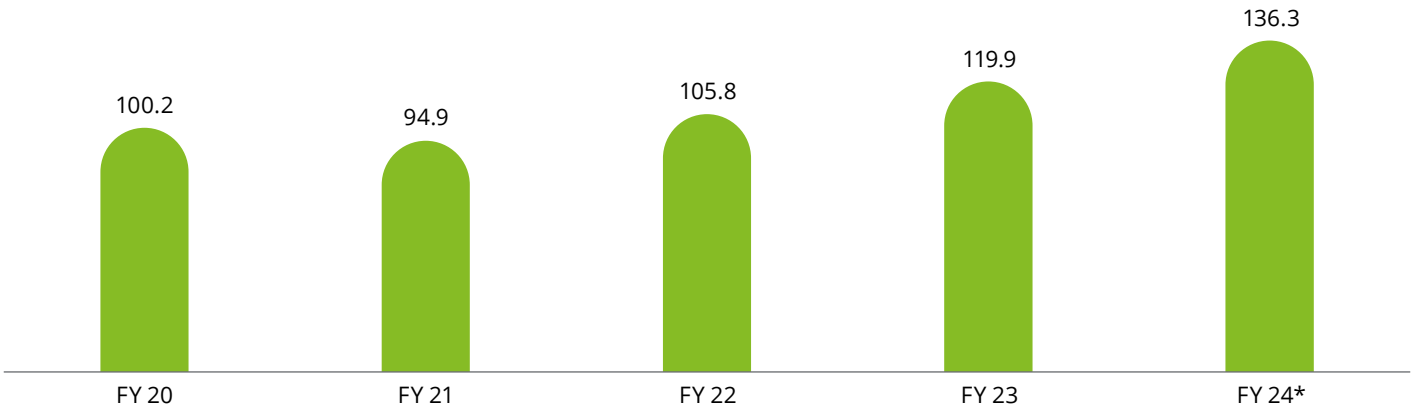


Source: Joint Plant Committee, Ministry of Steel
*Provisional

[8] https://pib.gov.in/PressReleasePage.aspx?PRID=1930585

[9] https://economictimes.indiatimes.com/industry/indl-goods/svs/steel/india-plans-to-raise-steel-production-capacity-three-fold-by-2047/articleshow/109173405.cms?from=mdr

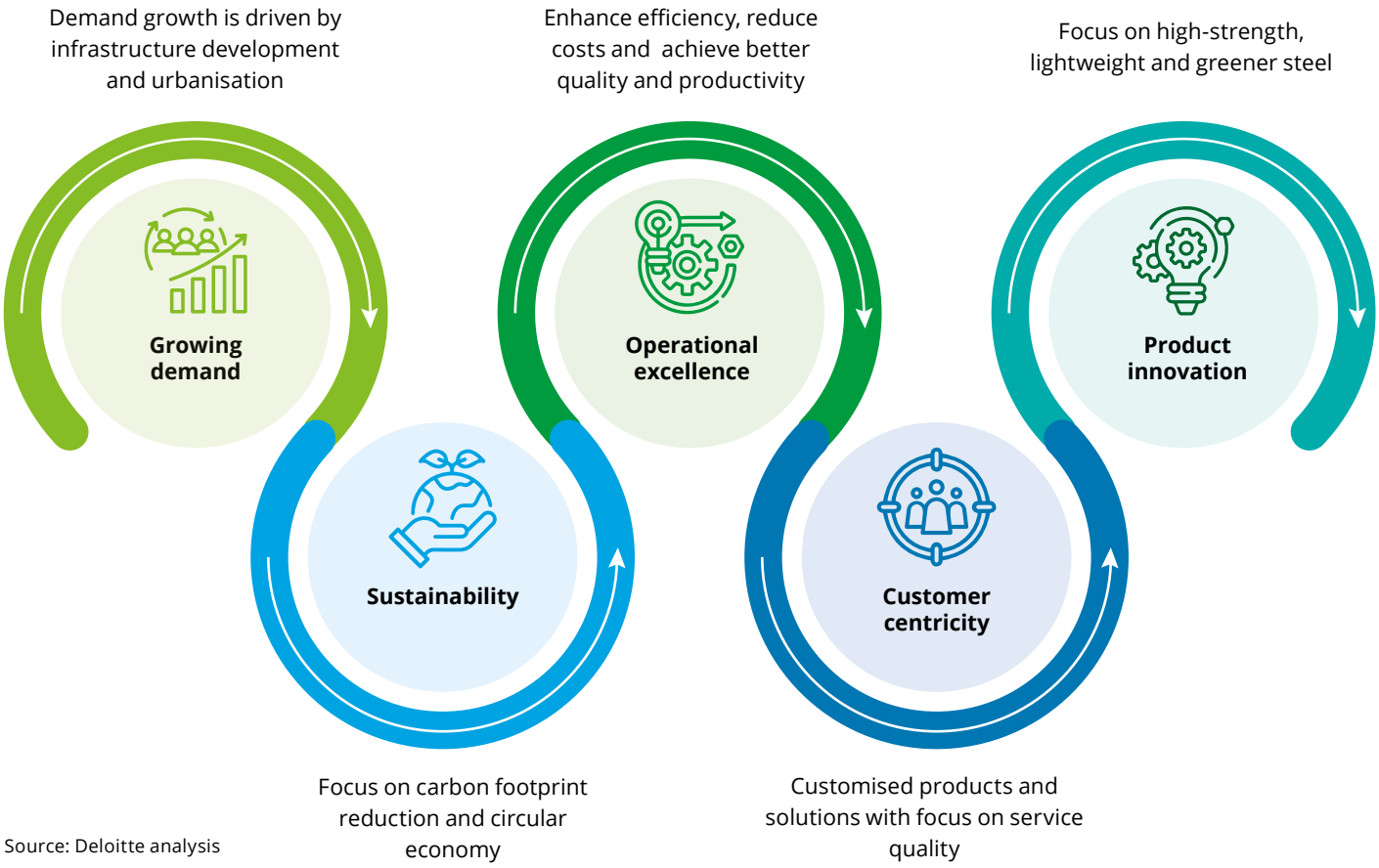
Figure 2: India's finished steel consumption trends (in million tonnes)



Source: Joint Plant Committee, Ministry of Steel
*Provisional

However, current sector trends make it imperative for steel players to focus on asset sweating and cost and operations control. In addition, the sector is experiencing enhanced focus on sustainability, product innovations and customer centricity.

Figure 3: Current trends in the Indian mining and steel sector



Source: Deloitte analysis

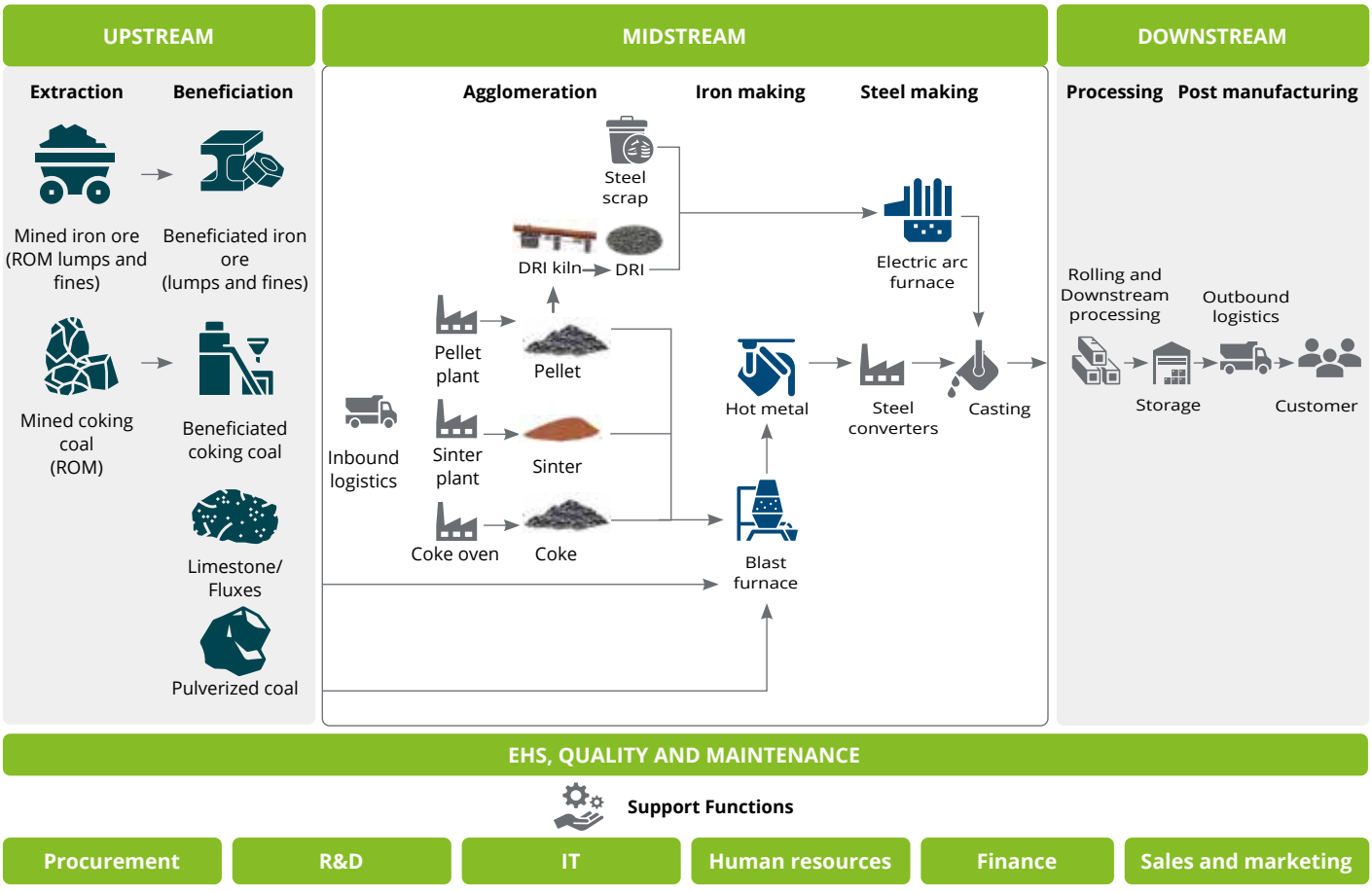
Technology advancements are poised to influence the dynamics of the steel industry significantly. As the sector faces evolving demands and challenges, using cutting-edge technologies will be pivotal in driving operational efficiency, ensuring sustainability and fostering innovation. The integration of digital tools and smart manufacturing practices will not only streamline processes but also enhance decision-making and customer engagement. By embracing these technological advancements, steel manufacturers can navigate industry shifts more effectively, optimise resource utilisation and position themselves for long-term success in a competitive global market.

The introduction of mechanisation and mass production processes, followed by the development of electric arc furnaces and continuous casting technologies, had significant implications for the steel industry. During the 21st century, the digital revolution introduced a new wave of transformation, characterised by integrating digital technologies, automation and data analytics into steel manufacturing processes. The industry is embracing digital transformation opportunities across the steel value chain.

Over the years, the mining and steel industry has evolved and adopted various technologies to address the growing demand and dynamic market scenario. The Indian mining and steel sector has consistently adopted the latest advancements to enhance throughput, uptime, quality, revenue, and EHS while reducing costs. By integrating cutting-edge technologies, the industry has improved operational efficiency and upheld high safety and environmental standards across the value chain, from mining to processing.

Similarly, on a global scale, there has been a strong focus on improving process efficiency, safety, and sustainability while optimizing costs. Integrating automation, digitalisation, and advanced technologies has allowed steel producers worldwide to set new industry benchmarks.

Figure 4: Typical steel value chain



Source: Deloitte analysis

2. Global perspectives on automation, digitalisation and technology integration

The focus on sustainability globally is driving the mining and steel sector to adopt advanced process and digital technologies, fundamentally reshaping the industry's approach. As major economies increasingly prioritise environmental responsibility, the sector is witnessing significant shifts in strategy. For instance, China is actively reducing its steel production to curb emissions, while Europe is mandating stringent CO2 reduction targets, compelling steelmakers to innovate and implement cleaner, more efficient technologies.[10] Decarbonisation and sustainability are thus driving technological adoption and redefining the steel industry's competitive landscape.

Global climate commitments are compelling economies to move towards a green transition, necessitating the adoption of disruptive technologies to achieve more sustainable and environmentally friendly steel production. This shift underscores a unified global movement towards sustainability, even as regional implementation strategies vary.

A high-level analysis of the top 50 global steel producers in FY23, covering more than 60 percent of crude steel production, shows significant technological adoption. The study identifies key enablers driving this transformation across different economies and organisations.

Table 1: Technology adoption of steel players for leading global economies and the key enablers

Countries	Technology adoption in mining and steel	Key enablers and implications
China	54 percent of global crude steel production in FY23.[11] The highest number of technological use cases was implemented in FY23 **(38 percent of global total)[12],** of which 30 percent were for process technology while the remaining 70 percent[13] were from digital technologies.	39 percent increase in **subsidies** for 33 listed steelmakers between 2008-2015.[14] **Economic stimulus** to drive end-use industries and enablers such as CNY 300 billion (US$44 billion) allocated for infrastructure quotas and bank investments in 2022.[15] **Key implementations:** One-button steel making, dynamic process control system and auto-positioning of coke ovens.
United States of America	4.2 percent of global crude steel production in FY23[16] Implemented 5 percent[17] of the global use cases in technology and digital in FY23 mostly focused on promoting sustainable process, including scrap usages and carbon management solution.	The Inflation Reduction Act which invests US$350 million grants and tax credits to reduce greenhouse gas emissions, can help steel producers **invest in cleaner technologies and processes.**[18] **Key implementations:** Recycling ferrous scrap, high grade steel making, integration of supply chain.
South Korea	3.5 percent of global crude steel production in FY23[19] Implemented 16 percent of the global use cases in technology and digital of which 38 percent corresponds to analytics.[20]	The government has established a ₩KRW150 billion investment fund to provide support and steelmakers are committed to achieving carbon neutrality by 2050.[21] **Key implementations:** Digital twins, failure prediction systems, smart safety solutions, and smart factories.

[10] https://www.cnbctv18.com/business/china-to-cut-steel-output-for-third-consecutive-year-16175451.htm
[11] https://worldsteel.org/media/press-releases/2024/december-2023-crude-steel-production-and-2023-global-totals/
[12] Deloitte analysis
[13] Deloitte analysis
[14] https://www.mitsui.com/mgssi/en/report/detail/__icsFiles/afieldfile/2021/02/19/2101c_matano_e.pdf
[15] https://gmk.center/en/news/government-stimulus-to-the-chinese-economy-could-revive-the-steel-market/
[16] https://worldsteel.org/data/top-producers/
[17] Deloitte analysis
[18] https://www.epa.gov/inflation-reduction-act/inflation-reduction-act-programs-fight-climate-change-reducing-embodied#:~:text=The%20Inflation%20Reduction%20Act%20invests,and%20other%20greenhouse%20gas%20emissions
[19] https://worldsteel.org/data/top-producers/
[20] Deloitte analysis
[21] https://en.yna.co.kr/view/AEN20230216005000320

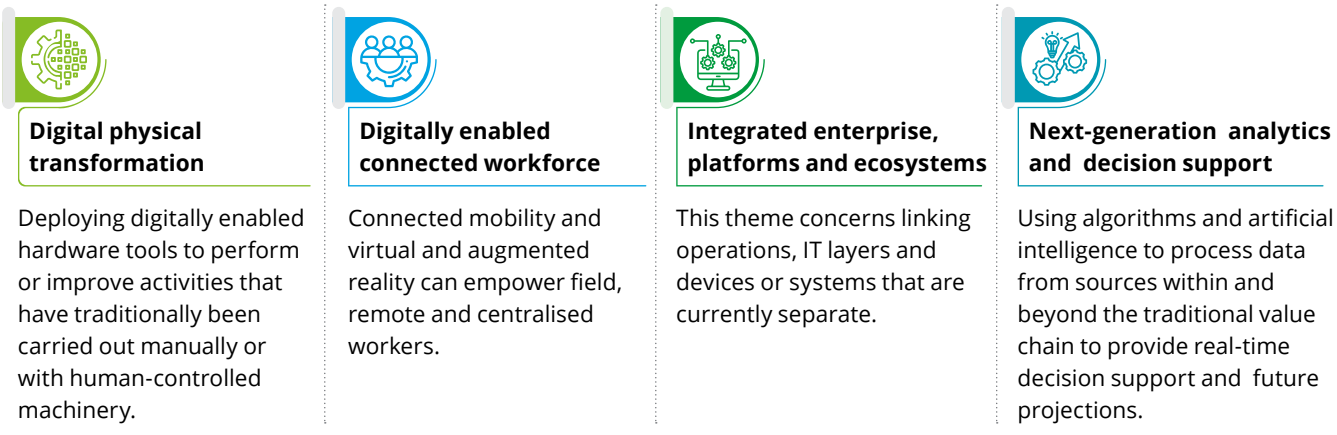
2.1 The rise in demand for disruptive digital technologies

Figure 5: Factors driving the demand for technology in the mining and steel sector

Source: Deloitte analysis

The mining and steel industry is undergoing a profound transformation as digital technologies are helping to enhance efficiency, sustainability, and product quality. Digital tools such as IIoT sensors, 5G networks, optimisation models, and energy management systems are revolutionising operations by optimising process variables, reducing downtime, and ensuring resource efficiency. Integrating real-time monitoring, and sophisticated data analytics, organisations are achieving higher levels of sustainability and operational efficiency. The industry is embracing digital transformation opportunities while addressing its challenges through four key themes that drive value and meet customer needs.

Figure 6: Themes that will help mining and steel industry players to unlock value-driven opportunities

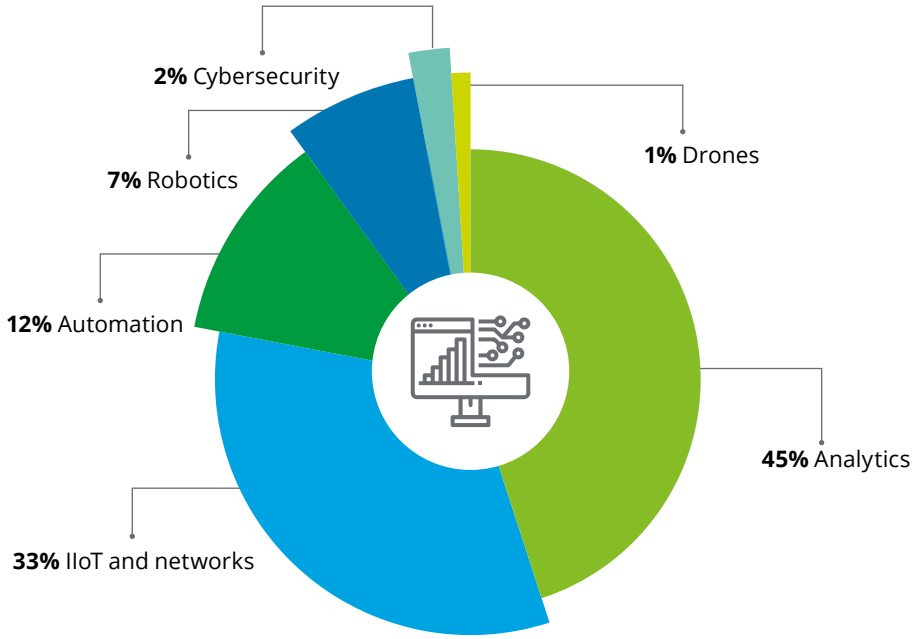


Source: Deloitte analysis

A review of use cases from the top 50 global steel production companies shows that many industry leaders are focusing on improving the efficiency of ironmaking and steelmaking processes through various initiatives. In FY23, iron and steelmaking accounted for 49 percent of the global implemented use cases among these companies, with enterprise-level solutions following at 19 percent.[22]

The digital use cases implemented across various value chain components encompass advanced analytics, robotics, IIoT sensors, platforms and networks, and cybersecurity. These technologies are integrated across multiple parts of the value chain to drive digital transformation, which leads to improved process efficiency and reduced operational costs.

Figure 7: Interventions across major digital technologies implemented by global steel players



Source: Deloitte analysis

[22] Deloitte analysis

Globally, mining and steel producers strategically implement various transformative technologies to address industry challenges and enhance value across the entire steel value chain.

Digital infrastructure and connectivity, digital operational technologies, data management and analytics, and enterprise resource planning (ERP) are critical components driving transformation in mining and steel industry. Digital infrastructure and connectivity, including networks like 5G and cloud data platforms, ensures seamless communication, data storage, and robust connectivity essential for advanced industrial operations. Digital operational technologies, such as sensors, robotics, and drones, enhance automation, precision, and efficiency in daily operations, from resource extraction to asset management. Data management and analytics, encompassing data analytics and visualisation, provides critical insights into performance, enabling informed decision-making and predictive maintenance. Enterprise resource planning (ERP) and integration systems, including SCM, CRM, and MES, amongst others, unify business processes, streamline operations, and enhance overall productivity. Together, these elements create a cohesive digital ecosystem that optimises operations, improves safety, and drives innovation, making them integral to the advancement and competitiveness of the mining and steel sector.

Digital core and foundational elements

Digital network

Digital network enables fast, reliable connectivity that enhances automation and real-time communication integrated across different sensing technologies. The seamless data communication can make possible by the deployment of high-speed wireless 5G network infrastructure with proper redundancy, facilitating rapid data exchange.

A leading South Korean steel maker exploring the use of private 5G networks to improve intelligent network control, facilitating more accurate and responsive automation in steel production.

Industrial Internet of Things (IIoT)

The Internet of Things (IoT) connects physical devices to collect and share data over the internet. In the mining and steel industry, IoT enables real-time monitoring, continuous data analysis, and predictive maintenance, enhancing operational efficiency and reducing downtime. Benefits include process optimisation, inventory tracking, energy management, safety monitoring, and quality control.

A leading Japanese steel manufacturer has installed Cyber-Physical Systems (CPS) to integrate digital and physical components to monitor and control beneficiation processes in real-time leading to enhanced productivity and uptime.

Transition to cloud data platform

Centralising data with robust data management practices and architecture, organisations can significantly enhance their ability to access, analyse, and leverage information across the value chain for continuous improvement. Transition to cloud platform is helping organisations in avoiding high investments, achieving higher scalability and flexibility, and ensuring advanced security with effective disaster recovery solutions.

A leading Indian steel player invested in cloud technologies for operational data storage and computation which facilitated the creation of integrated remote-operations control centres. The implementation of AI algorithms on the centralized data led to a savings of around US$ 1.4 billion by 2023.[23]

Enterprise resource planning (ERP)

ERP is a comprehensive planning tool used across mining and steel industry for managing operations like procurement, inventory, production, and financial planning. It enhances departmental coordination, driving growth and profitability.

A leading Indian steel player's ERP implementation led to new business models, enhanced customer reach, and real-time order tracking. The solution reduced order processing time by 85 percent, eliminated lead time for delivery confirmation, and halved the order creation time, streamlining operations and improving efficiency.[24]

[23] AI chips in to save $2 billion foleading steel player - The Hindu BusinessLine

[24] https://www.sap.com/documents/2024/01/00d38c3a-a57e-0010-bca6-c68f7e60039b.html

Robotics

Robotics, which involves automated machines designed to perform high-precision tasks, is used across major use cases such as automated material handling, precision welding, improved quality inspection, enhanced quality inspection, predictive maintenance, and workflow automation.

A leading South Korean company has been advancing its smart factory initiatives by automating production processes by integrate advanced robotics and automated control systems.

Drones

Drones are transforming the mining and steel industries with real-time monitoring and inspection. They capture high-resolution data that can be processed for efficient, safe and productive mine and steelmaking operations.

A European steel major is utilizing drones at one of its units located in France for inspecting hazardous elevated areas, surveying and monitoring stockpiles, performing thermal monitoring of chimney temperatures and overseeing green cover as part of its environmental monitoring programs.

Data visualisation and analytics

Business intelligence tools

The deployment of business intelligence tools in mining and steel plants streamlines operations by providing real-time insights into production metrics and equipment performance through descriptive analytics. These solutions enable precise monitoring and analysis, enabling plant managers quickly identify bottlenecks, optimize resource utilisation, and improve product quality.

A leading Indian iron manufacturer deployed BI tools on operational database to create real time visualization dashboards across different management levels, enabling faster decision making.

Digital twins

Digital twins are virtual models replicating physical objects or processes using real-time data and advanced algorithms to optimise and manage production. In the mining and steel industry, they offer detailed visualisation, customisation and improved process tracking across various stages of the production process. Benefits include comprehensive visualisation, improved process tracking, enhanced data analysis, real-time monitoring and adjustment. Digital twins transform production management and decision-making with extensive insights and precise control.

A South Korean steel manufacturer has integrated digital twin technology in its steel mills. This technology supports autonomous operations with 3D simulation, visualisation and control, optimising facility performance, enhancing quality and facilitating predictive maintenance.

Analytics and Artificial Intelligence (AI)

Analytics and AI are redefining the mining industry across the value chain. In exploration and extraction, AI enhances precision by identifying mineral deposits which aids in optimizing operations for extraction. Through these advancements, AI is not only making mining operations more efficient and sustainable but also providing a competitive advantage.[25]

- A leading Australian mining player, with the use of machine learning and advanced analytics led to new mineral discoveries across Australia and United States.
- Chilean miners were able to save significant amount of energy by identifying anomalies from energy data and taking corrective actions.
- AI-integrated wearables enhanced worker safety by monitoring health metrics in real-time, like the smart hard hats at Chilean mines that prevents accidents by analysing driver fatigue.

Analytics and AI are also transforming the **steel industry across the value chain.**

- Global steel producers have implemented AI-driven models for Ferro Alloy and Blast Furnace optimization and are deploying solutions to refine BOF processes with detailed calculations and insights.
- A leading European steelmaker has implemented diagnostic systems using advanced analytics to ensure the high availability of their wire rod mills, enhancing reliability and minimizing downtime.
- AI imaging techniques are being used to predict quality and monitor safety, further expanding process automation and innovation.

Geo-positional tracking using GPS

GPS enables real-time tracking of inbound and outbound logistics along with route optimisation, leading to optimising turnaround time, reducing delays, and enhancing delivery accuracy. The solution improves inventory management and allows for quicker responses to disruptions, ensuring efficient logistics movement across the supply chain.

A leading Chinese steel maker have deployed GPS based vehicle tracking system to improve efficiency and ensure timely delivery of materials and products.

Cybersecurity

Cybersecurity plays a critical role in safeguarding the entire digital ecosystem from potential cyber risks. Safeguarding networks like 5G is essential to maintain secure, reliable connectivity across all operations. Effective cybersecurity measures thus ensure operational continuity, secure intellectual property and maintain trust in a connected manufacturing environment.

A leading South Korean steel player has implemented an integrated security control centre that operates 24/7 to prevent and respond to cyber threats. The centre monitors and detects attacks in real time, analyses hacking trends and conducts regular system inspections and penetration tests to enhance security and resilience.

[25] Company websites for leading mining player

Globally, organisations across industries have recognised the need to foster a more widespread and inclusive adoption of these advanced technologies. The World Economic Forum's Centre for Advanced Manufacturing and Supply Chains has created the Global Lighthouse Network to accelerate the integration of cutting-edge technologies across the industry, aiming to drive innovation and efficiency in manufacturing. Additionally, it has established six lighthouse iron and steel factories worldwide, showcasing best practices in technological adoption and scalability.[26]

The mining and steel industries are at the cusp of exponential digital transformation. Investments in digitalisation of steel industry are expected to reach ~ US$6 billion by 2031, growing at an 11 percent CAGR. Steelmakers are increasingly investing in devices and applications to enhance equipment performance and operational insights, with projections nearing US$1 billion. Data analytics, a key driver for optimising processes and reducing environmental impact, will attract the highest investment, expected to reach US$2.9 billion. Additionally, the rising adoption of connected devices is pushing cybersecurity to the forefront, with security services poised to grow the fastest, reaching US$192 million. This ever-increasing digitalisation points to a future where steelmaking is more efficient, sustainable, and secure.[27]

2.2 Sensing the key technologies of the future

The mining and steel industries are expected to adopt the following key digital technologies in near future.

GenAI

Unlike traditional AI, which typically analyses or classifies data, GenAI produces original data similar to the examples it was trained on. It is gaining popularity because of its ability to create new content such as text, images, audio and more by learning patterns from existing data. The industry is exploring GenAI to leverage various models such as LLMs, StyleGANs, GPTs, etc. for generating accurate insights from complex queries. It is also used to conduct "what-if" scenario analyses, generate optimised operational parameters, improve process visibility and more.

Application areas: Predictive analytics and optimisation, quality control and improvement, and supply chain and demand forecasting.

A leading US steel maker has collaborated with Google Cloud GenAI technology to optimise maintenance strategy across its iron ore mines.

Blockchain

Blockchain technology is emerging as a powerful tool in the iron and steel industry, offering enhanced transparency, traceability, and security across the supply chain. By providing a decentralized and immutable ledger, blockchain enables companies to track the provenance of materials, verify transactions, and ensure compliance with industry standards, thereby improving operational efficiency and fostering stakeholder trust.

Application areas: Supply chain management, quality assurance, contract management and sustainability reporting.

A Netherlands-based company has collaborated with steel manufacturers and developed a digital platform that enhances transparency and security in the steel supply chain using blockchain and cloud computing. Decentralising data and requiring approval for actions has ensured trust in material certifications and audits. The platform has also saved time by eliminating data silos and automatically verifying compliance with international standards.

[26] https://initiatives.weforum.org/global-lighthouse-network/lighthouses

[27] https://www.abiresearch.com/blogs/2022/06/28/steel-industry-in-2022-most-promising-technologies-to-keep-an-eye-on/

Computer vision

Computer vision involves processing and analysing images / videos for quality control by inspecting products for defects and ensuring they meet the set standards. It also enhances process monitoring by providing real-time visual data, which helps detect anomalies and improve overall manufacturing precision.

Application areas: Quality control through defect identification, real-time process monitoring, identifying signs of premature breakdown and enhanced worker safety by monitoring hazardous areas.

A US-based company has developed an AI-empowered computer vision sensor fusion system to prevent collisions and avoid the prevalence of cobbling in the rolling mill of steel plants.

Advanced computing

Advanced computing can drive efficiency and innovation in the global mining and steel sector by creating sophisticated optimisation models. Companies can streamline operations, enhance production processes and reduce waste by utilising cutting-edge computational power and sophisticated optimisation algorithms. These technologies enable precise simulations, real-time monitoring and predictive analytics, improving resource allocation and reducing downtime.

Application areas: Process optimisation, predictive maintenance and quality control while reducing waste and improving resource management.

A leading Japanese steelmaker has implemented advanced simulation models to estimate the potential reduction of CO_2 emissions in a blast furnace process using carbon recycling technology. Higher levels of computing will enable the deployment of sophisticated optimisation models.

Industrial metaverse

The industrial metaverse is a virtual space where physical and digital realities converge, offering a platform for virtual collaboration, simulation, and optimisation of manufacturing processes. Engineers and operators can interact with digital twins of their production lines, testing scenarios and adjusting without disrupting operations, leading to better decision-making and accelerated innovation.

Application areas: Virtual prototyping, enhancing capabilities of digital twins, augmented work instructions, collaborative digital spaces across operation, maintenance and new product and prototype development.

A leading South Korean steel company has implemented a digital twin-based cost analysis system. Metaverse can enhance its capabilities through advanced simulation, real-time virtual visualisation of steelworks and fostering collaborative decision-making across teams. Additionally, virtual prototyping offers a solution by enabling rapid design iterations and reducing reliance on physical prototypes by integrating AR, CAD and AI algorithms with metaverse.

Spatial computing

Spatial computing merges physical and digital worlds using augmented reality (AR) and virtual reality (VR). It allows for enhanced visualisation of manufacturing processes, improved design accuracy, streamlined maintenance, and better employee training.

Application areas: Immersive training simulations, visualisation of production processes, augmenting capabilities of augmented reality-based maintenance and inspection process.

Digital twin applications by leading global steel producers can be evolved into spatial twins using spatial computing, offering greater capabilities. Spatial twins provide a more immersive 3D representation of steel plants, allowing for enhanced real-time visualisation, simulation and interaction with the physical environment.

3. Indian perspectives on automation, digitalisation and technology integration

The Indian steel sector has emerged as a significant driver of the country's economic growth, playing a pivotal role in industries such as construction, infrastructure, automobile, engineering, and defence. The steel sector contributes ~2 percent to India's GDP and employs 6 lakh people directly and 20 lakh indirectly.[28] India's steel sector has posted a CAGR of 4.9 percent from 2014 to 2023.[29] The country is the world's second largest steel producer. The new steel policy enshrines the government's long-term vision for the steel sector. It also seeks to enhance domestic steel consumption, ensure high quality production and create a technologically advanced and globally competitive steel industry.[30]

[28] https://www.investindia.gov.in/
[29] India: production volume of crude steel 2023 | Statista
[30] National Steel Policy, 2017

3.1 How are organisations pivoting towards technology, automation and digitalisation?

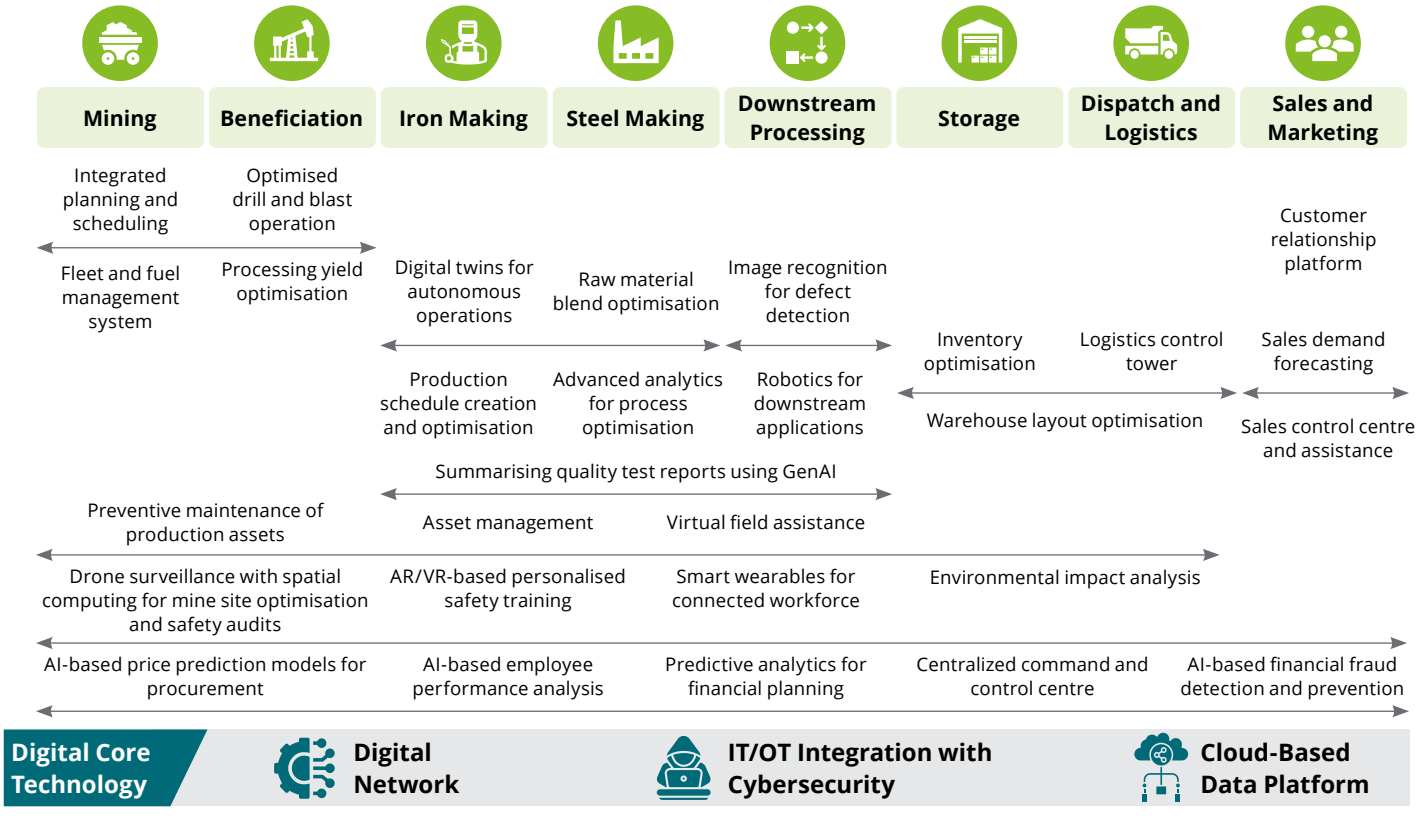
Indian steel sector is projected to grow significantly aligning with the country's expected economic growth during the Amrit Kaal till 2047. The per capita steel consumption is anticipated to reach ~160 kg by 2030 and ~220 kg by 2047[31]

Leading steel producers in India have already initiated expansions of their steel plants. The process routes adopted for expansions do have significant carbon footprints vis-à-vis scrap based steel production. Thus, it is expected that the carbon intensive production routes would particularly impact the steel exports going forward due to introduction of regulations such as CBAM.

The EU has announced the **Carbon Border Adjustment Mechanism (CBAM)** to put a price on emissions during the production of carbon-intensive goods such as steel, cement and fertilisers entering its territory by imposing a tax based on the quantum of emissions. Through the CBAM, the EU seeks to encourage cleaner industrial production in non-EU countries and provide a level-playing field for European producers that must pay for permits to use carbon.[32] India currently exports steel products worth **US$ 4,307 million**[33] and sponge and pig iron worth **US$13 million.**[34] While European steel importers need to report the total quantity of imported steel, actual embedded emissions, indirect emissions, and the carbon price for these emissions, the Indian steel industry must monitor and reduce its carbon emissions to meet CBAM regulations.

Digital tools can help to enhance compliance with environmental regulations through better energy efficiency and emission monitoring. Furthermore, digital technologies offer the flexibility and scalability necessary to adapt to market changes, drive innovation, and improve worker safety . Integrating digital technologies across the value chain can thus unlock transformative capabilities.

Figure 8: Possible digital use cases across the steel value chain

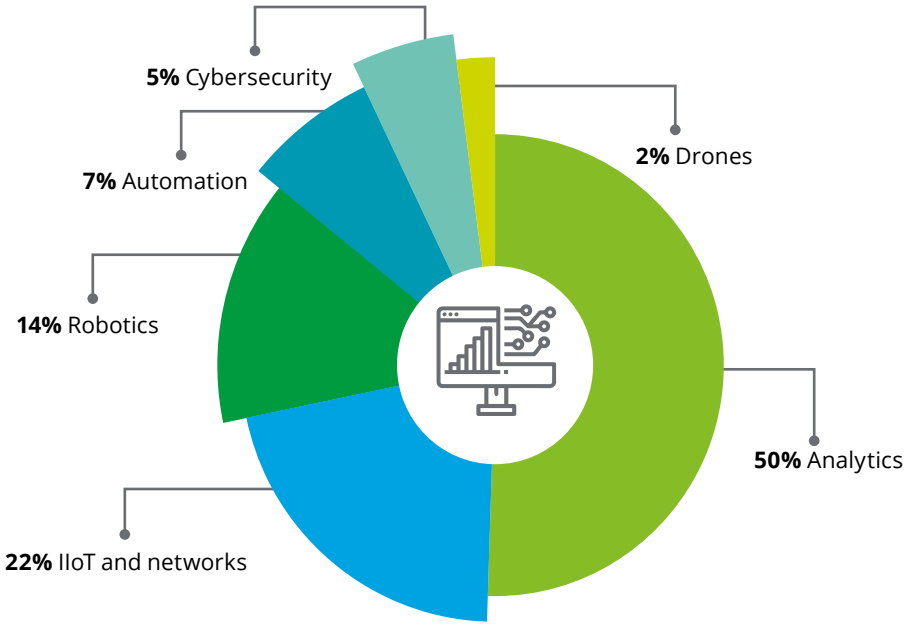


Source: Deloitte Analysis

[31] https://www.blueweaveconsulting.com/report/india-steel-market#:~:text=The%20per%20capita%20steel%20consumption,to%20220%20kg%20by%202047.
[32] https://economictimes.indiatimes.com/industry/indl-goods/svs/metals-mining/explainer-impact-of-cbam-on-indian-steel-industry/articleshow/105812012.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst
[33] EU CBAM Article, MoC, News reports
[34] EU CBAM Article, MoC, News reports

A review of use cases from the top 50 global steel production companies shows that Indian steel players[35] implemented 21 percent of the total use cases. Initiatives across steelmaking and ironmaking contributed around 35 percent of implementation, followed by deploying solutions at the enterprise level. Additionally, the number of use cases implemented corresponding to analytics had the highest number, followed by IIoT and networks.

Figure 9: Interventions across major digital technologies implemented by Indian steel players



Source: Deloitte Analysis

The steel industry's digital adoption, marked by two lighthouse factories, part of the World Economic Forum's Global Lighthouse Network, showcases its leadership in integrating advanced technologies. These facilities set benchmarks in integrating and scaling technological transformation to develop connected steel plants encompassing smart raw material zones and smart steel and mill zones towards resource optimisation, waste minimisation and emissions reduction.

Domestic mining and steel players are increasingly using emerging technologies to drive significant digital advancements . Along with adopting the emerging technologies, Indian companies has started investing in digital core technologies to establish network infrastructure, sensorisation of assets, IT/OT integration in compliance with cybersecurity and cloud data platform for seamless data collection from shopfloor to data management in a centralised repository with higher governance and security. Listed below are some of the related digital initiatives being adopted by Indian mining and steel organisations across the value chain.

[35] Headquarters in India

Upstream: Mining and beneficiation

Illustrative use cases	Underlying technologies	Impacted areas	Industry example
Intelligent mine planning for geological resource modelling, preparation of mine schedules and automated grade control system	Applications	Enhanced confidence in resource estimation, production plan	A leading Indian steel player has implemented end to end planning solutions for mining operations
Fleet & fuel management and predictive asset health for real-time tracking of mining equipment positional data and critical health parameters with predictive analytics	Sensors, business intelligence tools, analytical model	Improved fleet utilisation and operational safety, improved asset reliability, reduced maintenance cost	A leading Indian steel player has achieved significant improvement in fleet utilisation, reduction in non-productive time and decrease in maintenance cost by fleet management system
Autonomous drill rigs with hole navigation system for remote drilling **and blast fragmentation analyser** for assessing blast fragmentation	Automation, image analytics, AI algorithms	Enhanced drill and blast efficiency and operational safety	A leading Indian steel player has deployed remote controlled drill rigs in iron ore mines and post-blast image analytics
Processing yield optimisation with predictive insights for quality prediction, optimisation of process parameters, specific energy, and consumables	IIoT and networks, AI based algorithms	Improved yield, optimised consumption of energy and consumables	A leading Indian steel player has deployed control systems in the beneficiation plant to monitor and optimise the separation of valuable minerals from ores
Integrated operation centre (IOC) for increasing efficiency and safety in mining through real-time monitoring, remote control and collaboration	Networks, business intelligence tools	Enhanced safety, productivity and faster decision making	A leading Indian steel player developed an integrated operation centre for monitoring of remote operations in iron ore mines

Midstream: Ironmaking, steel making and casting

Illustrative use cases	Underlying technologies	Impacted areas	Industry example
Raw materials mix optimisation through predictive analytical model to continuously refine and optimise raw material mix and maintain consistent product quality	Sensors, network, ML models	Reduced waste and overall operational expenses, improved quality consistency	A leading Indian steel player has leveraged ML models to predict sinter quality and optimise addition of fluxes in the blast furnace leading to reduction in coke consumption
Blast furnace optimisation through Level 2 process automation by monitoring internal conditions with models such as gas flow patterns and hearth condition monitoring. Along with digital twin technology, it allows for risk-free simulation and optimisation of production scenario	IIoT sensors, predictive models	Process stability, improved visibility on furnace health parameters, reduction of unplanned downtime, improved energy efficiency	A leading Indian steel player has deployed Level 2 process automation to diagnose the internal conditions of the blast furnace towards ensuring higher efficiency and consistency in output
Advanced analytics-based models for machine, process and raw material optimisation	Optimisation models, business intelligence tools	Reduced downtime, cost control and raw material efficiency	A leading Indian steel player has leveraged advanced analytics to prevent slab bulging, optimise caster pull and ferro alloys utilisation
Analysis of critical asset health data and **AI-powered predictive analytics** for identifying potential failures before they occur to improve asset availability	Predictive models	Improved equipment availability and reliability, reduced overall maintenance cost	A leading Indian steel player has implemented an AI-driven system for predicting the lifespan of critical equipment from iron and steelmaking processes for reducing unplanned breakdowns
Virtual field assistance for troubleshooting of maintenance related activities	AR, networks, application	Faster troubleshooting	A leading Indian steel player has introduced AR based remote assistance in BF maintenance activities
Manufacturing Execution System (MES) for real-time tracking of equipment performance, optimising scheduling and inventory	Sensors, digital network, PLC, automation, business intelligence tools	Enhanced operational efficiency, collaboration, optimised, faster decision-making	Leading Indian steel players have implemented MES to capture and monitor parameters across the production process
Digital Twin for autonomous process control, simulation and scenario testing, and using insights to optimise operations	IIoT sensors, AI, ML	Optimised operations and improved equipment reliability	A leading Indian steel player has developed a digital twin for its sintering operations to reduce stack emissions in the sinter-making process
Energy efficiency optimisation through AI algorithms to monitor and optimise load distribution, detect anomalies early	IIoT, business intelligence, AI	Reduced specific energy consumption	Leading Indian steel players have deployed energy management systems to track and optimise specific energy consumption
Application of drones for capturing high resolution images and processing it with AI models for analysing parameters corresponding to raw materials	Drones, AI models	Faster decision making, accurate assessment of stock, safety	A leading steel player has collaborated with startups to conduct drone surveys in open-case mines for surveillance, yard monitoring, and volumetric assessment

Rolling and downstream processing

Illustrative use cases	Underlying technologies	Impacted areas	Industry example
Application of **reinforcement-based AI models** for optimising operational parameters	Sensor and networks, AI models	Enhanced productivity, higher throughput	A leading Indian steel player has enhanced its pickling line productivity through AI-based models
Application of collaborative robots to automate repetitive, hazardous, manual tasks	Robotics, network, automation	Improved productivity, safety, product quality	A leading Indian steel player has deployed robots for loading sleeves and coating steel plates
Centralised command and control centre for data visualisation and analytics of key metrics	Business intelligence tools, data lake	Faster decision making with real time descriptive analytics	A leading Indian steel player has created management dashboards for integrated planning and execution monitoring of its cold rolling activities
High-precision camera-based image analytics for defect detection and classification of defects in products	Network, computer vision, AI algorithm	Improved quality control, customer satisfaction, reduced wastage	A leading Indian steel player has deployed video analytics-based quality monitoring system in rolling mills
Application of AI models to detect anomalies by analysing operational and machine parameters	Sensors, networks, and AI models	Reduced unplanned downtime, higher machine availability	A leading Indian steel player has deployed an AI model-based coil conveyor chain breakage detection to reduce hot mill downtime

Support functions: Sales and marketing, logistics, procurement, EHS

Illustrative use cases	Underlying technologies	Impact areas	Industry example
Smart surveillance through AI-powered image analytics on drone/CCTV captured data to detect and alert PPE compliance, proximity detection, site specific hazards detection	Drone, image analytics	Improved safety, governance, and productivity	A leading Indian steel player has developed a proprietary solution using AI to detect patterns and trends that impact occupational risk in production areas
Personalised environment, health, and safety (EHS) training programmes enabled by connected workforce, by providing immersive experience through augmented and virtual reality technology and the use of smart wearables	Augmented reality, virtual reality	Improved safety awareness, and productivity	A leading Indian steel player has developed VR-based immersive solutions to train employees on SOPs related to working in heights and in confined places

Illustrative use cases	Underlying technologies	Impact areas	Industry example
Carbon emission monitoring for adhering to sustainability norms and reporting for CBAM/BRSR requirements	IIoT, analytics, business intelligence tools	Environmental compliance	A leading Indian steel player has implemented digital tool for capturing and reporting carbon emissions
Supply chain optimisation to manage complex and fragmented supply chain and optimise raw material sourcing ,inventory, resource, and equipment	Business intelligence tools, optimisation model	Improved schedule compliance and inventory management	A leading Indian steel player has implemented supply chain management tool to optimise production schedule and supply chain processes
Logistics control tower for dispatch planning, inbound & outbound vehicle movement tracking with route optimisation and alerts in case of deviation from plan	Sensors, network, analytical and simulation models	Improved truck turnaround time (TAT), better logistics management and reduced cost	A leading Indian steel player has implemented digital logistics management system across mines and simulation technique for barge optimisation
Price prediction model for procurement by analysing trends alongside current market conditions, economic indicators, and geo-political factors to redefine procurement strategies	AI, business intelligence tools	Optimised raw material procurement cost	A leading Indian iron and steel player has implemented price prediction model for forecasting imported raw material prices
Sales control centre and assistance for monitoring and managing sales activities, leads and orders, customer grievance and feedback with customer analytics	Business intelligence tools, analytical models	Improved customer service, increased sales, and profitability	A leading Indian steel player has implemented customer relationship management tool to manage sales and marketing activities

This digital evolution is also reaching the smaller steel producers, supported by the Ministry of Steel's policies and initiatives. Institutions such as the National Institute of Secondary Steel Technology and Biju Patnaik National Steel Institute are crucial in capability building, aligned with India's goal of achieving net-zero emissions by 2070. Government efforts, including the India AI mission, robotics ecosystem development, and centres of excellence for IIoT, blockchain, and AR/VR, will drive future digital technology adoption. Initiatives such as SAMARTH Udyog Bharat 4.0, led by the Ministry of Heavy Industry, are pivotal in creating experiential centres and developing an ecosystem to integrate new technologies.

AI and Industry 4.0 technologies are set to revolutionise logistics, simulate green steel manufacturing, and boost overall efficiency, making steel production safer and more sustainable. Big data analytics will support waste reduction, promote a circular economy, and track carbon emissions, advancing the industry's shift towards efficient and eco-friendly practices.

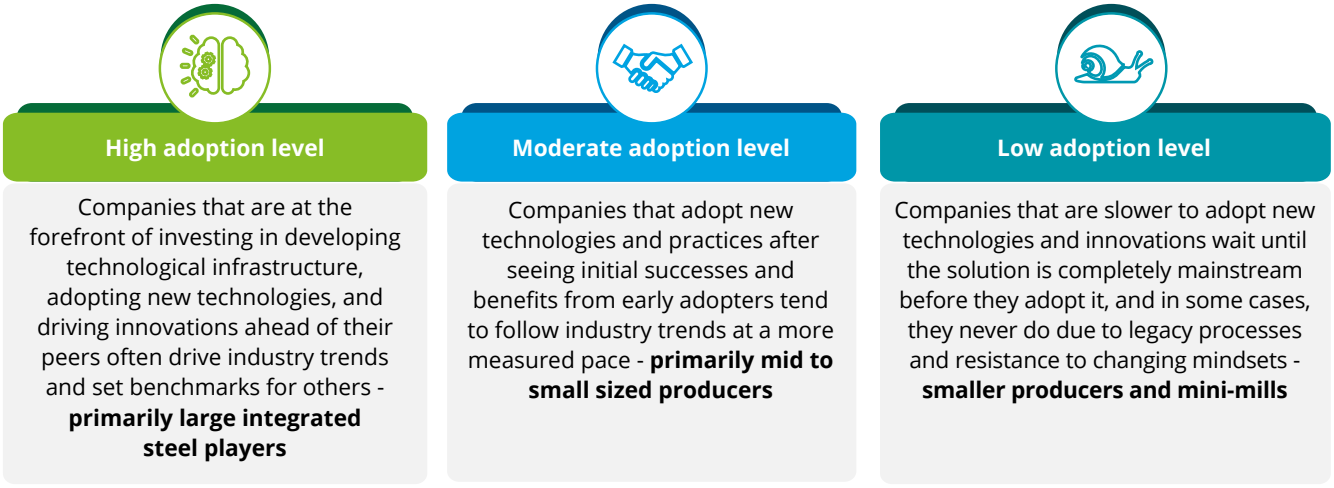
India aims to achieve 500 million tonnes[36] of crude steel capacity by 2047; hence, integrating digital technologies will enhance efficiency, increase safety and ensure sustainability.

[36] https://economictimes.indiatimes.com/industry/indl-goods/svs/steel/india-plans-to-raise-steel-production-capacity-three-fold-by-2047/articleshow/109173405.cms?from=mdr

3.2 Level of technology preparedness among organisations

Global competitiveness, sustainability, decarbonisation, and continuously changing market dynamics have forced the Indian mining and steel industry to embark on a digital transformation journey. The level of technology preparedness among Indian mining and steel organisations varies significantly across the players. While some leading companies have made substantial strides in adopting and integrating advanced technologies, whereas others are still in the early stages of their digital transformation journey and exploring the opportunities of digital technologies. However, most organisations often fail to integrate these technologies within their departments due to a lack of technological infrastructure readiness in the existing systems, processes, and practices with high degree of manpower resistance.

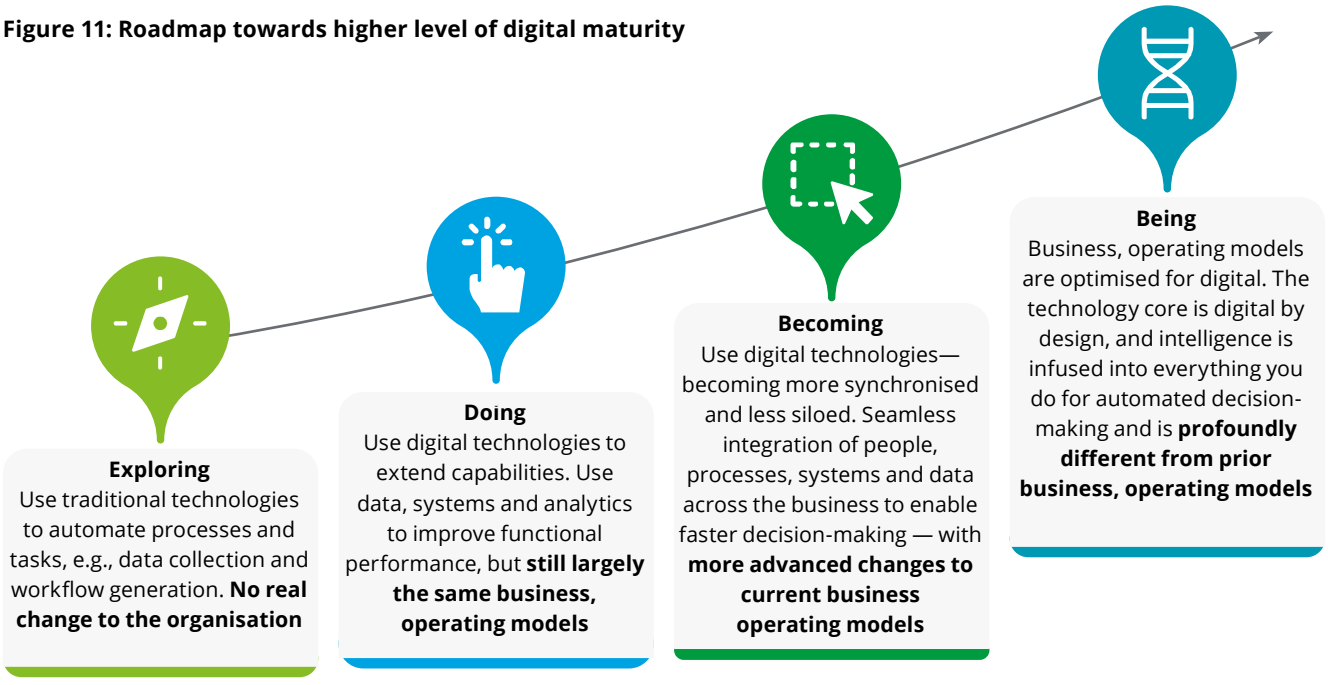
Figure 10: Category of technology adoption level in Indian mining and steel industry



Source: Deloitte Analysis

Many organisations swirl in an endless loop of "Exploring" to "Doing" digital things – an illusion of "Being Digital" rather than making necessary changes to their business, operating and customer models. "Exploring" or "Doing" digital is just a stop, not a destination; with right technology ecosystem in place, the Indian mining and steel sector can strive towards "Being Digital".

Figure 11: Roadmap towards higher level of digital maturity



Source: Deloitte Analysis

The path of digital transformation from "Exploring Digital" to "Being Digital" is fraught with challenges, particularly in the realms of people, process and data. Some of the key challenges while adopting digital technologies across the value chain include:

Siloed ways of working

Organisational silos and implementation of point solutions over enterprise-level platforms are indicating potential hinderances to driving a culture of digital which is further impacting the scalability and interoperability of the solution.

Resistance to change

Organisational culture and lack of digital awareness can hinder technology adoption. Employees and management may be reluctant to embrace new technologies due to fear of the unknown, potential job displacement, or perceived complexity, which can slow the implementation process.

High upfront investment needed for digital infrastructure

The implementation of IoT, AI, ML and other advanced technologies, along with establishing advanced data collection infrastructure, requires substantial initial investment in hardware, software, and skilled personnel. This can be a significant barrier, especially for smaller companies.

Data management and data integration

- The vast amounts of data from IoT sensors and digital systems require robust data management and analytics, while integrating new technologies with legacy systems presents challenges in compatibility and customisation, complicating implementation and increasing costs.
- The lack of integrated systems across the production process makes it challenging to track data efficiently, causing delays, inefficiencies, and missed opportunities for improvement.

Data quality and consistency

Poor data quality and governance can severely limit the effectiveness of digital applications, leading to inaccurate predictions, suboptimal decisions, and potential operational setbacks.

Right talent availability

There is a shortage of skilled workers proficient in modern technologies. Training existing employees and attracting and retaining talent with the necessary expertise is a critical challenge.

A strategic approach is necessary to increase digital adoption and become "Being Digital" as an organization. This approach must be comprehensive, phased, and supported by leadership to ensure effective technology scaling and integration. Initial steps include securing strong commitment from top leadership, with a clearly defined vision for digital transformation aligned with organizational goals. Executives must actively champion this vision, demonstrating commitment through involvement and resource allocation. A robust management strategy will address resistance, communicate benefits, and foster a culture of innovation.

Digital transformation requires, along with the implementation of new technologies, a fundamental shift in organisational culture and its capability development. With industries embracing digital tools like AI, IIoT, automation etc, fostering a culture that supports innovation, continuous learning, and cross-functional collaboration is crucial. Capability development ensures that the workforce is equipped with the necessary skills to leverage these technologies effectively. Leading steel players have addressed these challenges through a comprehensive planning of culture and capability development initiatives such as capability bootcamps, communities of practice, digital mindset activation workshops, etc.

3.3 Potential 2030 market for disruptive technologies

Over the past decade, major integrated steel players have spearheaded technological transformation by developing data repositories through cyber-physical systems and networks. These leaders have invested in cloud storage and AI algorithms to leverage various use cases, while process technologies focused on energy management and operational efficiency, resulting in EBITDA improvements.

The growth in the next decade will shift as past pioneers inspire new entrants to adopt proven technologies, and established players scale and innovate further. Future advancements in process technologies will be driven by monitoring of emissions reduction and carbon management demands, shaped by global regulations and India's net-zero commitments. Concurrently, investments in digital technologies will drive the need for advanced data management solutions, breaking data silos and enhancing quality. With advancements in IT infrastructure, sophisticated cybersecurity measures will become essential. The rising demand for professional services will aid in strategy formulation and achieving business goals. Overall, investment in process and digital technologies across the steel value chain in India is projected to increase from US$ 1 - 1.2 billion in 2024 to US$ 2.3 - 2.7 billion by 2030, excluding ERP upgrades. This investment will advance technological capabilities and drive significant progress toward a more efficient and sustainable mining and steel industry.[37]

[37] Deloitte analysis

4. Way forward and recommendations

The Indian steel industry is the second largest in the world and has grown by 75 percent since 2008.[38] To continue this stellar demand growth and promote higher steel production, the industry needs to focus on the following aspects to become technologically advanced in-line with global peers. Below are some recommendations and initiatives (segregated into short-term and medium-to-long-term) that could accelerate the steel sector's growth trajectory.

1. Leadership and organisational alignment

Short-term

- **Create a digital vision and roadmap:** Develop a clear digital vision with a phase-wise implementation roadmap that aligns with the overall business strategy and secures active drive from top management.
- **Identify and prioritise key use cases:** Assess their impact and create an integrated action plan for implementing these initiatives.
- **Establish a digital governance structure:** Establish a dedicated digital leadership team with representatives from key departments to oversee technology adoption and integration. Allocate adequate resources – financial, human, and technological – to support digital initiatives.
- **Effective change management (communication, training, and support):** Develop a structured change management strategy with communication plans, training, and support systems. Engage employees at all levels by providing tools and training for adapting to new technologies. Establish feedback mechanisms to address concerns and gather input from employees.

[38] https://www.ibef.org/industry/steel#:~:text=Production%20has%20increased%20by%2075,MT%20and%20121.29%20MT%2C%20respectively.

2. Readiness for adoption of technologies

Short-term

- **Deployment of IIoT:** Deploy IIoT devices and sensors within the manufacturing facility to provide real-time data, ensure robust connectivity and data transmission between IoT devices and central systems, and implement the right applications for deriving insights.
- **Establish a robust data architecture:** Develop a centralized data warehouse to integrate data from various sources and ensure data encryption and security.
- **Invest in cybersecurity:** Implement robust security measures, such as advanced threat detection, encryption, and access controls, to protect sensitive data and systems from cyber threats and breaches.
- **Invest in smart manufacturing:** Integrate advanced automation and robotics to streamline production processes, implement MES for real-time tracking of production processes, create digital twins of critical equipment and methods for simulation and scenario testing, and use insights from digital twins to optimise operations.

Medium-to-long-term

- **Assessment of the types of technologies** required to improve their processes and achieve business objectives, while also ensuring compatibility with their existing systems and manufacturing processes.
- **Evaluation of the budget needed** for the entire project lifecycle, from prototype development to full-scale deployment, including change management initiatives.
- **Adoption of digital twins for enhanced simulation and process optimization:** Create digital twins of critical equipment and complex processes in virtual environment to simulate different scenarios and outcomes. Use insights from digital twins to optimize operations by identifying potential issues and inefficiencies and testing and validating changes in the virtual environment.
- **Adoption of AI, GenAI and ML across operations:** Generate predictive insights and resolution methodologies for troubleshooting shopfloor operational issues.
- **Blockchain Technology is used for better traceability** of raw materials and finished products and smart contracts are used to automate transactions and improve employee experience.

3. Innovation and Collaboration:

Short-term

- **Establish idea incubators:** Establish internal and open idea incubators and innovation hubs to develop ideas related to emerging technologies.
- **Collaborate with academic institutions:** For research on AI applications specific to steel manufacturing, such as predictive analytics for maintenance, quality control, and process optimization.
- **Invest in R&D:** Increase the allocated budget corresponding for developing prototypes and scalable solutions for future technologies.

Medium-to-long-term

- **Create a digital centre of excellence:** Organisations should set up DCoEs to serve as innovation hubs for knowledge sharing and technology integration. Conduct pilot projects, hackathons, and innovation challenges to explore AI applications in real-world scenarios, resulting in in rapid prototyping, iterative testing and hands-on learning opportunities.
- **Collaborations and alliances with modern technology providers:** Develop domestic and global technological collaborations between organisations, OEMs and technology providers, leading to the adoption and implementation of best practices and knowledge sharing.
- **Incubators and accelerators:** Set up or collaborate with incubators and accelerators that support startups and small businesses working on AI solutions for the mining and steel industry. Provide mentorship, funding, and resources to nurture innovative ideas from conception to implementation. It will foster entrepreneurship, encourage new entrants, and bring fresh ideas into the industry.

4. Upskilling the workforce for technology adoption and integration

Short-term

- **Assess and address skill gaps:** Conduct a skills assessment to identify gaps related to new technologies. Develop targeted training programmes to bridge these gaps and enhance employees' proficiency with emerging tools.

- **Create a talent strategy:** Organisations must clearly define roles and outline steps to bridge the AI workforce demand-supply gaps, including collaboration with academia.
- **Develop technology training programmes:** Create comprehensive skill development programmes, in collaboration with the eco-system tailored to the specific technologies being adopted. Include hands-on training, simulations and real-world scenarios to ensure practical understanding.
- **Knowledge sharing:** Implement systems for knowledge sharing and disseminating best practices within the organization. Encourage employees to share what they have learned and experienced with their peers.

Medium-to-long-term

- **Offer continuous learning opportunities:** Provide ongoing education and resources to update employees on the latest technological advancements. Encourage participation in workshops, webinars, and certification programmes.
- **Provide career development opportunities:** Offer clear career paths and development opportunities in technology-related fields. Encourage employees to pursue certifications, advanced training, and other professional growth initiatives.

5. Regulatory support for driving technology adoption

Short-term

- **Define a national technology and AI vision for the Steel sector,** including short, medium and long-term targets.
- **Develop schemes to engage the technology and AI ecosystem** including industry, startups, and academia. These efforts will launch lighthouse projects, build partnerships for quality data and tech development, and offer incentives for research and innovation.
- **Establish international partnerships** for scaling innovative digital solutions using emerging technologies.
- **Facilitate industry collaboration** with other economies to establish partnership models and strategic tie-ups to transfer of technology and knowledge seamlessly.

Medium-to-long-term

- **Launch the national program for technology and AI** in steelmaking and create a central apex body to drive the dissemination of global best practices in the Indian steel industry.
- **Develop and enforce AI policies and standards,** focusing on data privacy and ethical AI usage.
- **Enhanced public-private partnerships:** Collaborate with public research institutions for R&D initiatives, pursue government grants and subsidies and drive joint projects for technical infrastructure improvement.
- **Development of technology ecosystems:** Investments in technology infrastructure and innovation hubs create environments that attract investment and promote technology adoption.
- **Regulatory frameworks:** Regulatory bodies set guidelines for data protection, cybersecurity, and technology use to ensure safe and compliant technology adoption.

6. Adoption of future digital technologies

Short-term

- **Identify potential use cases for future digital technologies** such as industrial metaverse, computer vision, GenAI, advanced computing, etc. across steel value chain.
- **Conduct PoC/pilot/prototyping for prioritised use cases** to access the technical feasibility of the project and define benefit realisation framework.
- **Assess current technology stack and identify pre-requisites** as data collection and integration capabilities and security for enterprise level implementation.

Medium-to-long-term

- **Full scale deployment at enterprise level** for unlocking transformative capabilities in line with business objectives.
- **Assess the value driven opportunities corresponding to combination of future technologies** such as application of GenAI with computer vision, development of spatial twin in combination with spatial computing and digital twin may help in extracting more useful insights beyond traditional capabilities.

5. Conclusion

The next few decades hold the promise of being a period of significant growth for the Indian mining and steel industry. With the country's ambitious infrastructural projects and urbanisation drive, the steel demand will increase in the coming years. Moreover, with a pressing thrust on sustainability and decarbonisation and achieving operational excellence, it becomes evident for the organisations to adopt emerging processing and digital technologies across the value chain.

Organisations may ensure that people, processes and machinery adapt and adopt the latest technologies such as AI/ML, blockchain, cloud computing, GPS, robotics, IIoT, AR/VR and GenAI, and unlock the sector's potential of integrating digital technologies with the existing manufacturing processes.

Navigating the complexities of emerging technologies and maintaining a competitive edge, organisations may adopt a comprehensive strategy that balances sector-specific and technology-driven approaches towards integrating modern technologies and driving innovation. By fostering collaboration within the industry and with government and technology partners, investing in workforce capability building, and establishing a solid foundation for digital transformation, organisations can effectively integrate advanced technologies into their operations and the industry can meet the growing demand and emerge as a beacon of opportunity and progress in the global steel arena. This transformation journey will pave the way for a brighter, more resilient future for the domestic mining and steel industry and the country as a whole.

Glossary

Abbreviation	Description
%	Percent
~	Approximately
3D	Three-dimensional
AI	Artificial Intelligence
AR	Augmented Reality
BF	Blast Furnace
BOF	Basic Oxygen Furnaces
BRSR	Business Responsibility and Sustainability Report
CAGR	Compound Annual Growth Rate
CBAM	Carbon Border Adjustment Mechanism
CCUS	Carbon Capture, Utilisation, and Storage
CPS	Cyber-Physical Systems
CRM	Customer Relationship Management
CV	Computer Vision
DCoE	Digital Centre of Excellence
DRI	Direct Reduced Iron
EAF	Electric Arc Furnaces
EBITDA	Earnings Before Interest, Taxes, Depreciation, and Amortization
EHS	Environment, Health and Safety
EMS	Energy Management Systems
ERP	Enterprise Resource Planning
ESG	Environmental, Social and Governance
EU	European Union
GAN	Generative Adversarial Network
GDP	Gross domestic product
GenAI	Generative AI
GPS	Global Positioning System
GPT	Generative Pre-trained Transformer
HPGR	High-Pressure Grinding Rolls
HR	Human Resource
IIoT	Industrial Internet of Things
LLM	Large Language Models
MES	Manufacturing Execution System
ML	Machine Learning
MT	Million Tonne
MWD	Measure While Drill
NIP	National Infrastructure Pipeline
OEM	Original Equipment Manufacturer
R&D	Research and development
SCM	Supply Chain Management
VR	Virtual Reality

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Note

About FICCI

Established in 1927, Federation of Indian Chambers of Commerce and Industry (FICCI) is the largest and oldest apex business organisation in India. Mahatma Gandhi addressed FICCI's fourth AGM in 1931. Our 96th AGM was held in December 2023. With our rich legacy, FICCI would play an even greater role as India emergence as the third-largest economy.

FICCI works with its key stakeholders to foster active engagement and dialogue with decision-makers and to support steps that are good for commerce and industry.

As a member-led and member-driven organisation, FICCI represents over 2,50,000 companies across all segments of the economy, including public, private, and multinationals. The diverse membership base of FICCI across all Indian states includes both direct and indirect members through its 300 affiliated regional and state-level industry associations. FICCI has a large international presence via partner agreements with 250 national business associations in over 100 countries.

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