JMK Research & Analytics

Green Power Procurement
IRON & STEEL
Sector in India

DEEP-DIVE INTO JSW STEEL
CASE STUDY

JULY 2024

JMK Research & Analytics is a specialist consultancy firm that provides research and advisory services to Indian and International clients across Renewables, Electric mobility, and the Battery storage markets.

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SED Fund is a philanthropic initiative to support the Sustainable Development Goals (SDGs) of clean air, access to energy, clean water, climate action and equity, by backing efforts of governments and civil society on clean energy transition, according to principles of sustainability, diversity and equity. The fund intends to amplify impact by consolidating philanthropic resources, strengthening country level institutions and civil society groups and supporting initiatives that will have the most impact in support of these goals.

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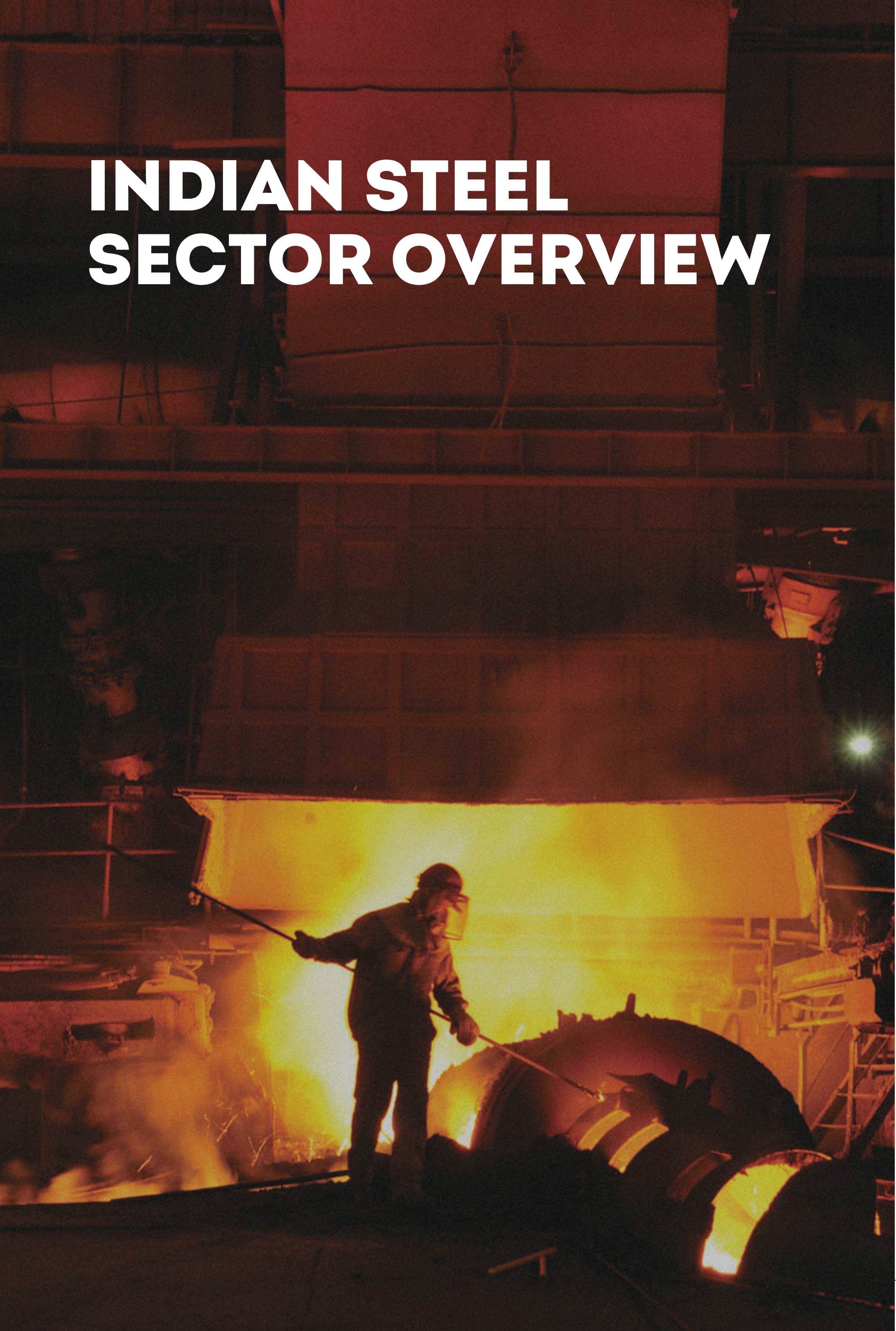
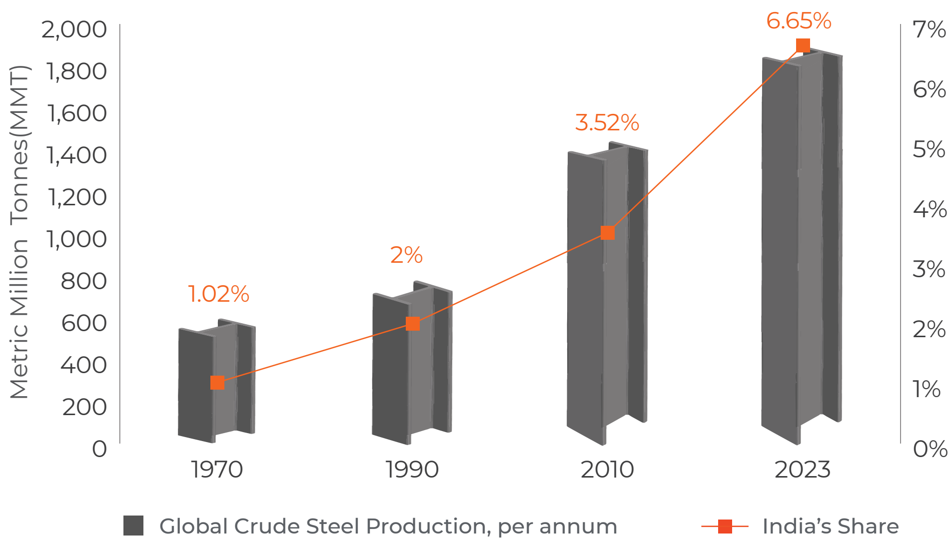


INDIAN STEEL SECTOR OVERVIEW

The steel sector is a significant contributor to the Indian economy and has been a fundamental pillar of industrial development. It led the path to the liberalization of the industrial sector and has seen substantial growth. Iron & Steel sector contributes around 2.5% to India's gross domestic product and employs more than 2.5 million people. The growth of Iron & Steel industry also leads to the expansion of related sectors like construction, transportation, machinery and manufacturing.

India began steel production in 1911 and gradually became the 6th largest steel producer in the 1970s. By 2019, it achieved the second rank. Currently, India holds the position of the world's second-largest steel producer, accounting for 6.65% of annual global steel production.[1]

Figure 1: Global Crude Steel Production, with India's share



Source: Ministry of Steel, IEA, TERI, JMK Research

[1] World Steel Association | World Steel in Figures 2023 | 2023

The table given below gives an overview of the Indian Iron & Steel sector.

Table 1: Indian Steel Sector Overview

Parameters	Description
Crude Steel Production (MMTPA, FY2024)	144.3
Finished Steel Production (MMTPA, FY2024)	138.5
Steel Consumption (MMTPA, FY2024)	135.9
India's Share in Global Steel Production (2023)	6.65%
Largest integrated manufacturing plant in India	Vijayanagar Steel Plant, JSW Steel – 12.5 MTPA
Electricity consumption in Iron & Steel sector (FY2023)	70 Terawatt hours (TWh)
Coal Consumption in Iron & Steel sector (FY2023)	79 MMTPA (~ 32% is used in captive power plants (CPP)
Scrap Consumption in Iron & Steel sector (2023)	29 MMTPA (11 MMTPA imported)
Annual CO_2 emissions in Iron & Steel sector (FY2023)	357 $MtCO_2$ (~17% from thermal CPP)
Contribution to India's GDP (2022)	2.5%
Employment (2022)	2.5 million(0.5 million direct + 2 million indirect)

Source: Ministry of Steel, IEA, TERI, JMK Research
*Note: **Crude Steel** is defined as the first product obtained after the solidification of molten steel.*
***Finished steel** is defined as the final product of semi-finished steel produced after hot/cold rolling and forging.*

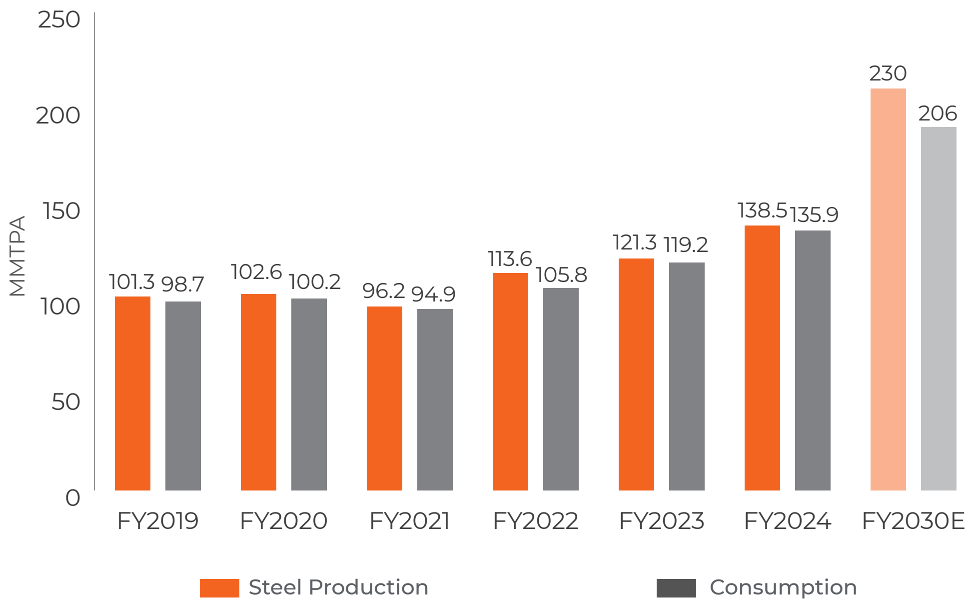
In FY2024, India exported and imported 7.46 and 8.3 million metric tonne (MMT) of finished steel, respectively. European countries like Italy, Belgium and Spain were the top 3 finished steel exporting destinations, accounting for 42.7% of the total exports. On the other hand, India imported close to 80% of finished steel from just three countries i.e. China, South Korea and Japan.

STEEL PRODUCTION TREND IN INDIA

Between FY2019 and FY2024, India's annual finished steel production increased from 101.3 million tonnes to 138.5 million tonnes, with a compound annual growth rate (CAGR) of 5.35%. This growth was accompanied by a simultaneous surge in steel consumption, which rose by around 38%.

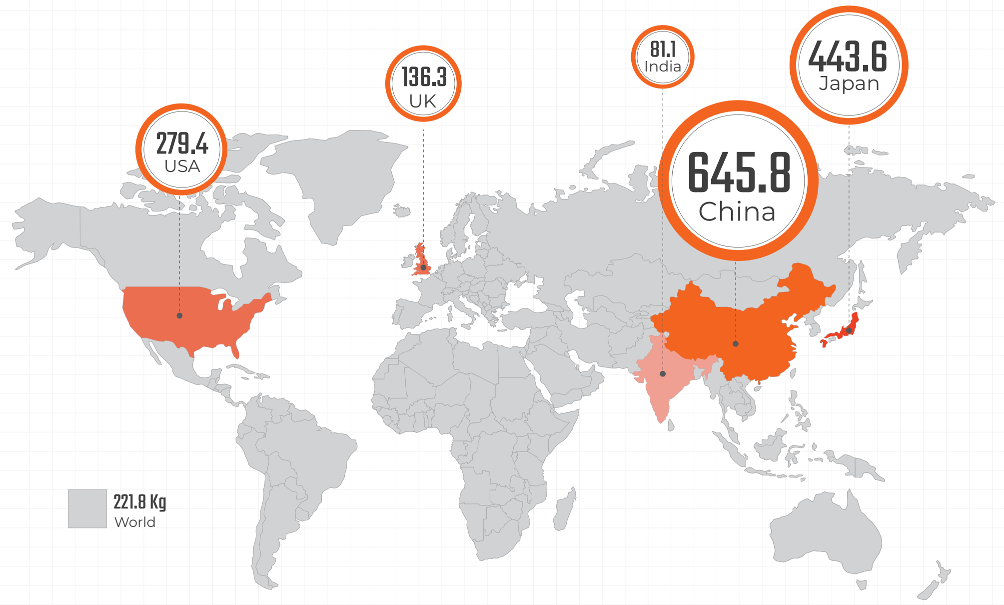
Ministry of Steel estimates suggest that by 2030-31, the annual finished steel production will experience a compound annual growth rate (CAGR) of 8.8%, reaching 230 million tonnes. At the same time, annual steel consumption is projected to increase to 206 million tonnes.

Figure 2: Steel Production and Consumption Trend



Source: Ministry of Steel (MOS), World Steel Association

Per capita steel consumption 2022 (kg)



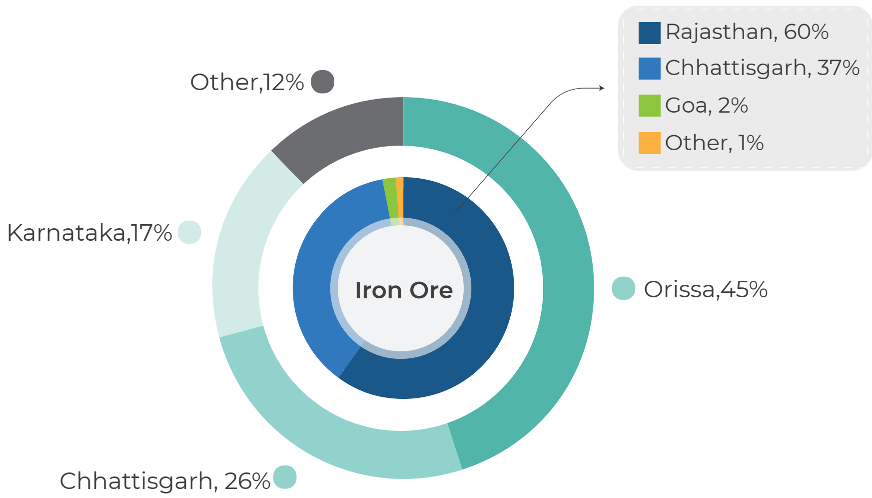
India's Target - 158 kg per capita consumption by 2030

In 2022, India's per capita steel consumption was 81 kg, significantly lower than the global average of 222 kg. As India's steel consumption continues to rise, closing the gap with global averages, the steel industry in India is poised for significant expansion and increased prominence on the global stage.

STATEWISE SHARE

In terms of state-wise share, the top three states for steel production in FY2024 were Odisha (26 MMTPA), Chhattisgarh (18 MMTPA), and Jharkhand (20 MMTPA). Additionally, Maharashtra produced 16 MMTPA, Karnataka produced 15 MMTPA, and West Bengal produced 11 MMTPA.[2]

Figure 3: State-wise share of iron ore reserves as of March 2023

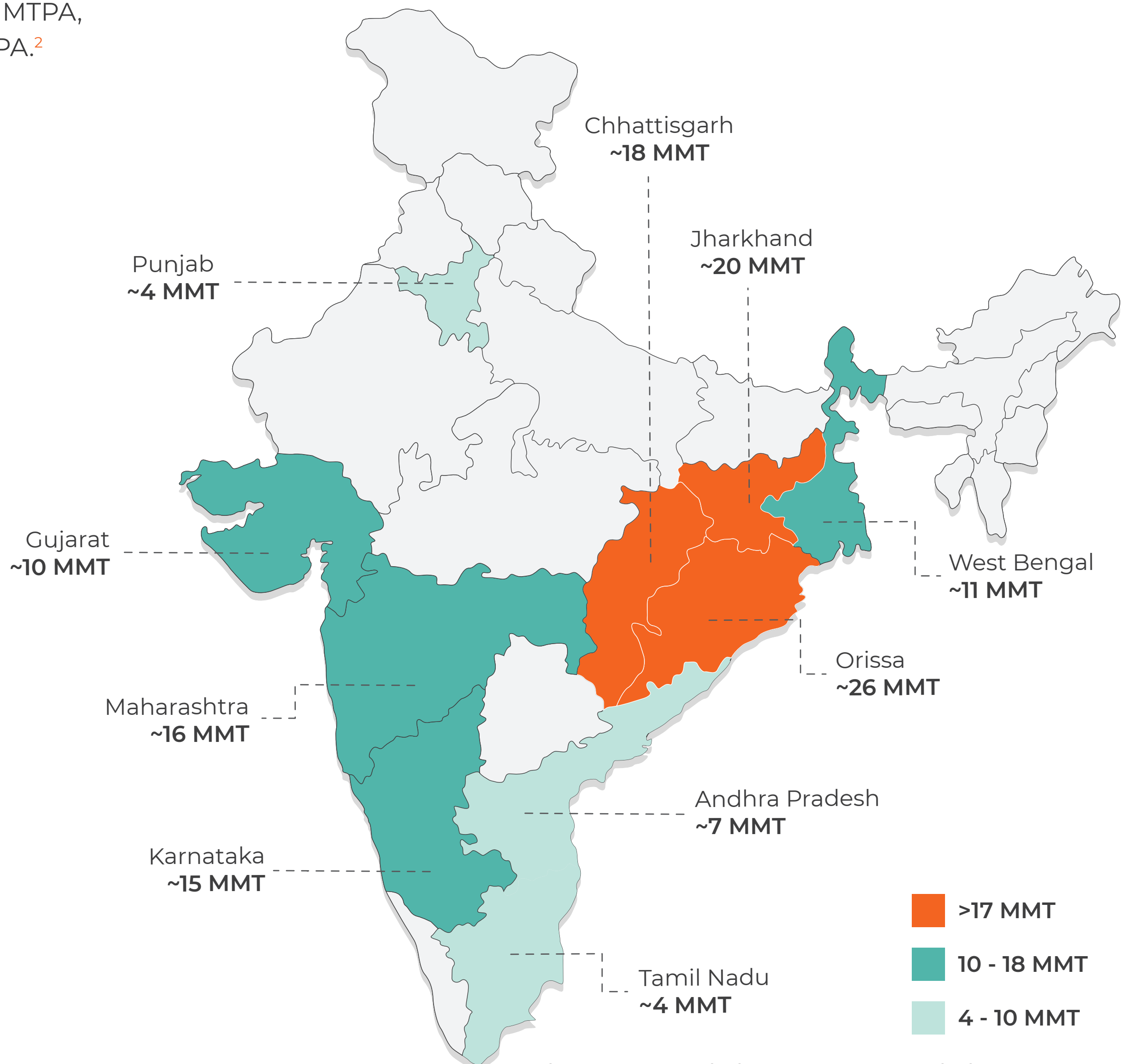


100%(Haematite) = 6209 MMT *100%(Magnetite) = 202 MMT*

The inner pie chart represents magnetite ore reserves while the outer pie represents haematite ore

Source: BigMint, JMK Research

Figure 4: Ten leading steel producing states, as of March 2024



Others = 12.6 MMT(Telangana, Uttar Pradesh, Haryana, etc)

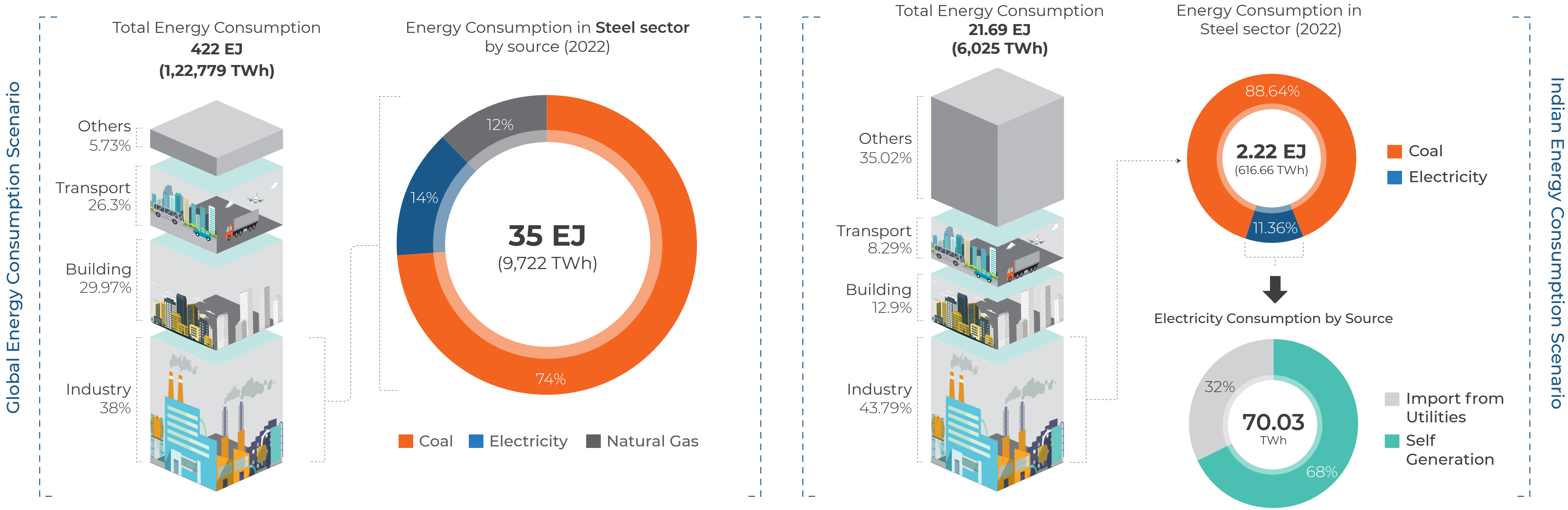
[2]BigMint | Insights | April 2024

ENERGY AND ELECTRICITY CONSUMPTION

In 2022, global Industrial sector accounted for 38% of total energy consumption. Globally, the Iron & Steel sector consumed approximately 35 EJ (9,722 TWh) of energy in 2022. The industry heavily relied on coal, which supplied 74% of its annual energy needs, with electricity accounting for 14% of the total energy requirement.[3]

In India, the Iron & Steel sector consumed 2.22 EJ (616.66 TWh) of energy in 2022, making up around 23% of the total annual industrial energy consumption.[4] Only about 11.36% of this energy came from electricity.

Figure 5: **Energy Consumption in Iron & Steel sector (Global vs India)**



Source: IEA, CEA, JMK Research

In the Iron & Steel sector in India, a significant portion (68%) of electricity consumption comes from captive power plants (CPP). These plants can be either coal-based or waste heat recovery plants.

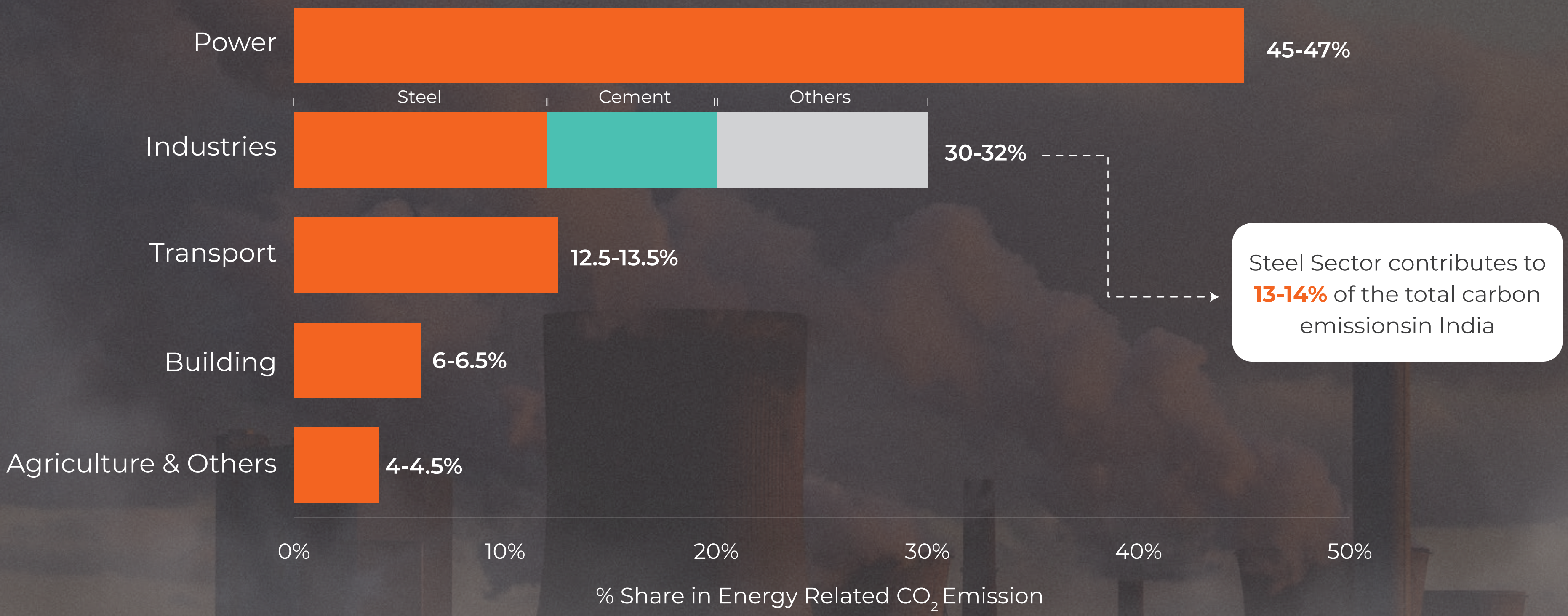
The main reasons for the heavy reliance on CPPs are the availability of cheaper electricity (Rs. 5-8/unit for coal-based CPP compared to Rs. 7-10/unit from the grid), consistent local power supply, and the ability to generate on-site steam, which can be used in steel plants to operate auxiliary components such as mechanical drives, heat exchangers, steam jet cooling systems etc.

[3] IEA | Tracking Clean Energy Progress 2023 | July 2023   [4] Niti Ayog | India Climate and Energy Dashboard | 2022

EMISSION INTENSITY

Industries account for 30-32% of the total annual carbon (CO_2) emissions in India. Among industries, the Iron & Steel sector is the largest emitter, contributing around 357 MT of carbon emissions in FY2023. This represents about 13-14% of India's CO_2 emissions and approximately 10% of Greenhouse Gas Emissions (GHG).

Figure 6: Sector-wise CO_2 emissions in India

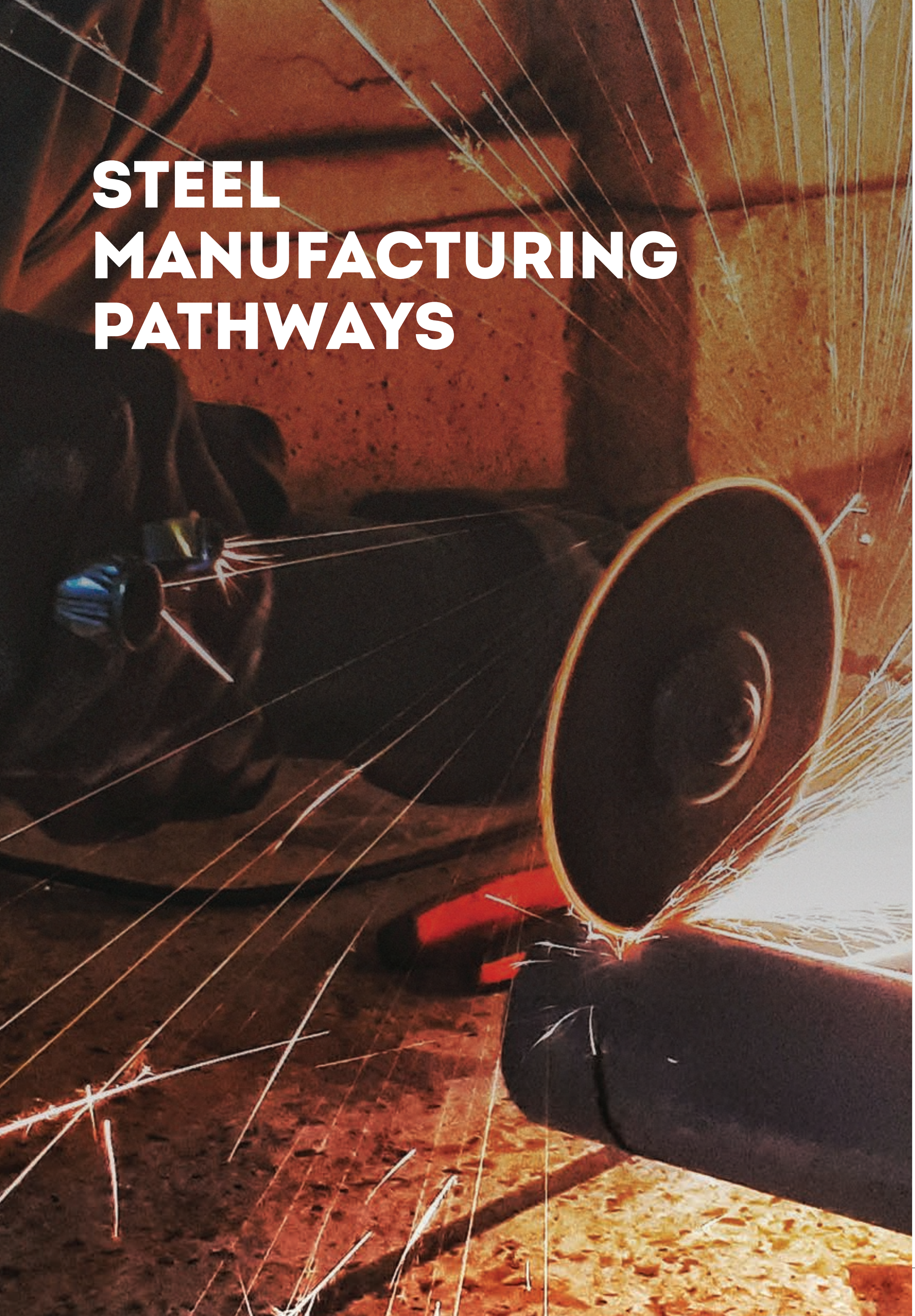


Source: IEA, JMK Research

Emission Intensity: Emission intensity refers to the amount of carbon dioxide emitted during the production of one ton of steel. In India, as of 2022, the emission intensity stands at 2.55 tCO_2/tcs, compared to the global average of 1.85 tCO_2/tcs.[5] The lower emission intensity elsewhere is due to higher efficiency and the use of better quality raw materials in the manufacturing process.

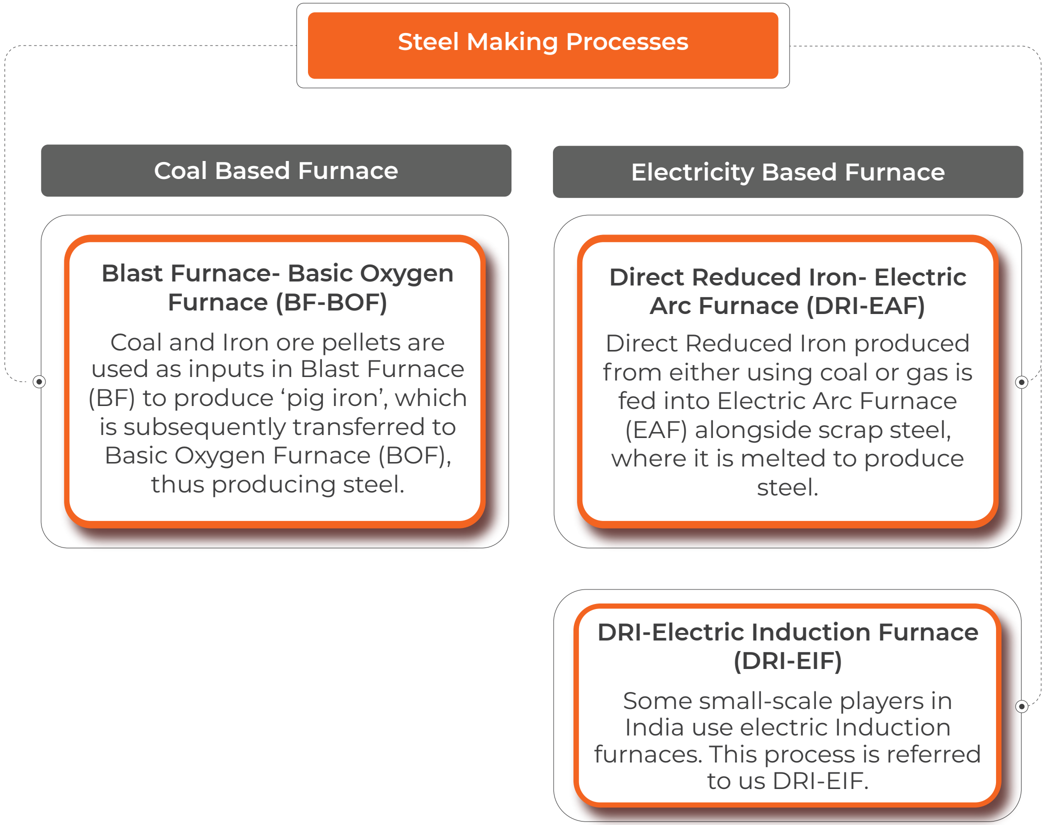
[5] PIB | **Year-end Review-2022 Ministry of Steel** | 2022

STEEL MANUFACTURING PATHWAYS



Based on the energy source of the furnace, there are two main routes for steel production. The first is the Blast Furnace - Basic Oxygen Furnace (BF-BOF), which uses coal as the main energy source. The second is the Direct Reduced Iron – Electric Arc Furnace (DRI-EAF), which operates using electricity.

Figure 7: Classification of Steel Manufacturing Processes

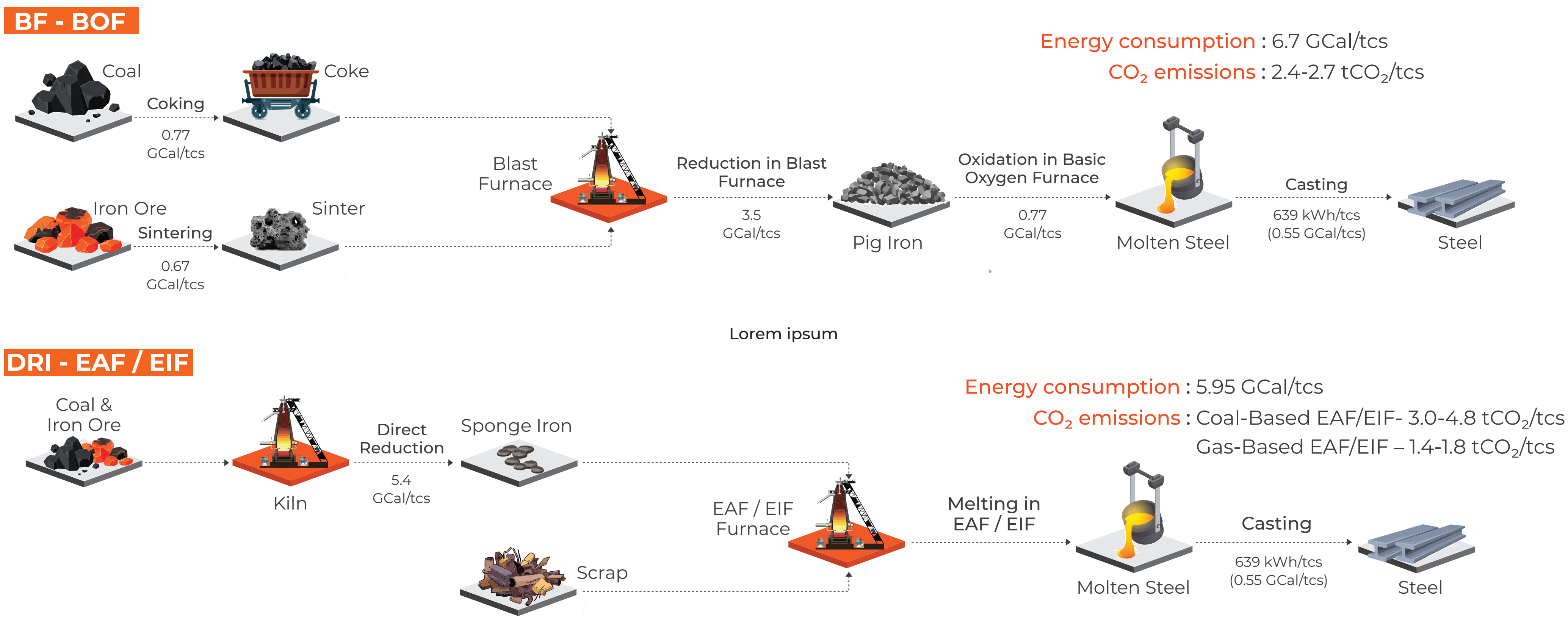


Source: JMK Research

ENERGY AND EMISSION INTENSITY COMPARISON OF STEEL MANUFACTURING PATHWAYS (INDIA PERSPECTIVE)

When comparing energy consumption, the BF-BOF route has a higher specific energy consumption of 6.7 GCal/tcs compared to the DRI-EAF/EIF route at 5.95 GCal/tcs.[6] In both routes, coal-based processes, i.e., Blast Furnace in BF-BOF and DRI in DRI EAF/EIF, account for the largest share of specific energy consumption, consuming around 50% and 90% within their respective routes.

Figure 8: Energy consumption in the steel manufacturing process, with emissions



Source: JMK Research, Industry reports
*Note: **tcs** - Tonne of crude steel*

[6] Ministry of Power (MOP) & Bureau of Energy Efficiency (BEE) | Energy Efficiency in the Iron and Steel Sector | December 2021

When we compare carbon emissions, we see significant variation between production routes depending on the type of fuel used. The coal-based BF-BOF route has an average CO_2 emission intensity of 2.4-2.7 tCO_2/tcs, while the gas-based DRI-EAF/EIF emissions are significantly lower at 1.4-1.8 tCO_2/tcs. **Despite the lower emissions of the gas-based route, India exclusively uses the coal-based DRI-EAF/EIF due to limited natural gas resources and abundant coal availability.**

A shortage of natural gas and its high prices has led to the gas-based DRI-EAF steel manufacturing units in India being on the brink of shutdown.[7] Another challenge is the unpredictable prices of natural gas in forward delivery contracts. According to the Japan-Korea Marker, a benchmark for asian liquified natural gas (LNG) spot prices, the LNG spot price fluctutated from a low of US$2/MMBtu (during Covid-19 lockdown in early 2020) to a high of US$84.7/MMBtu (during Russian-Ukraine conflict in March 2022). Currently, the prices have largely stabilized around US$10-12/MMBtu and are likely to reduce further in 2024.[8]

To tackle these challenges, Indian manufacturers are moving towards substituting or blending natural gas with other gases such as coke oven gas or corex gas.

However, the actual carbon emissions of the DRI-EIF route could be around 4 tCO_2/tcs or even higher, given the involvement of many MSME players. Their data tends to be unreliable due to the fragmented and unorganized nature of the MSME industry.

MARKET SHARE OF STEEL MANUFACTURING PROCESSES

Globally, the coal-based BF-BOF method dominates steel production, accounting for around 71.6% of total output, while the EAF/EIF routes contribute the remaining 28.4%.

Countries like China and Japan rely on the BF-BOF method because the alternative route, DRI-EAF, is unfeasible due to the absence of a robust steel recycling system. India and the United States of Amercia (USA) predominantly utilize electricity-driven routes to produce steel. DRI processes account for 55% and 69% of the entire steel production in India and the USA.

[7] JSW Steel| JSW Steel (Salav) Limited| 2015 [8] Economic Times| LNG Importers rush to buy spot cargoes as price hits 3 year low| March 2024

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WAYS TO DECARBONIZE THE IRON AND STEEL SECTOR

It is crucial to decarbonize the steel sector due to its heavy dependence on fossil fuels for energy, which significantly contributes to greenhouse gas emissions. Various decarbonization solutions are emerging to address this challenge.

There are four key levers to decarbonize the iron and steel sector: improving energy efficiency throughout steel production processes, incorporating and maximizing the use of renewable electricity, utilizing green hydrogen in the manufacturing process, and implementing Carbon Capture, Utilization, and Storage (CCUS) to reduce emissions from carbon-intensive steel production methods.

The following matrix presents a comparative evaluation of the decarbonization levers for the iron and steel industry based on their technical and economic feasibility.

Figure 9: Key Decarbonization levers for the Steel sector in India

		Technical Feasibility		Economic Feasibility		
	Description	Maturity	Scalability	Capital Cost	Payback Period	Carbon Abatement Potential
Scrap Steel	Reduces the need of using conventional steel production routes resulting in reduced carbon emissions	Evolving	Medium	Low	Low	Low
Energy Efficiency Technologies	Increasing the adoption of energy efficient technologies thought the production process	Proven	High	Low	Medium	Low
Renewable Energy	Transitioning from coal-based captive power plants to a mix of renewables (solar,wind) and waste heat recovery units	Proven	High	Medium	Low	Medium
Green Hydrogen	Transitioning from coal as a reducing agent in BF and DRI to using green hydrogen	Evolving	Medium	High	High	Medium
Carbon Capture, Utilization & Storage	Capturing carbon from steel production routes like BF-BOF and reusing/storing them for later	Nascent	Low	High	High	High

Source: JMK Research

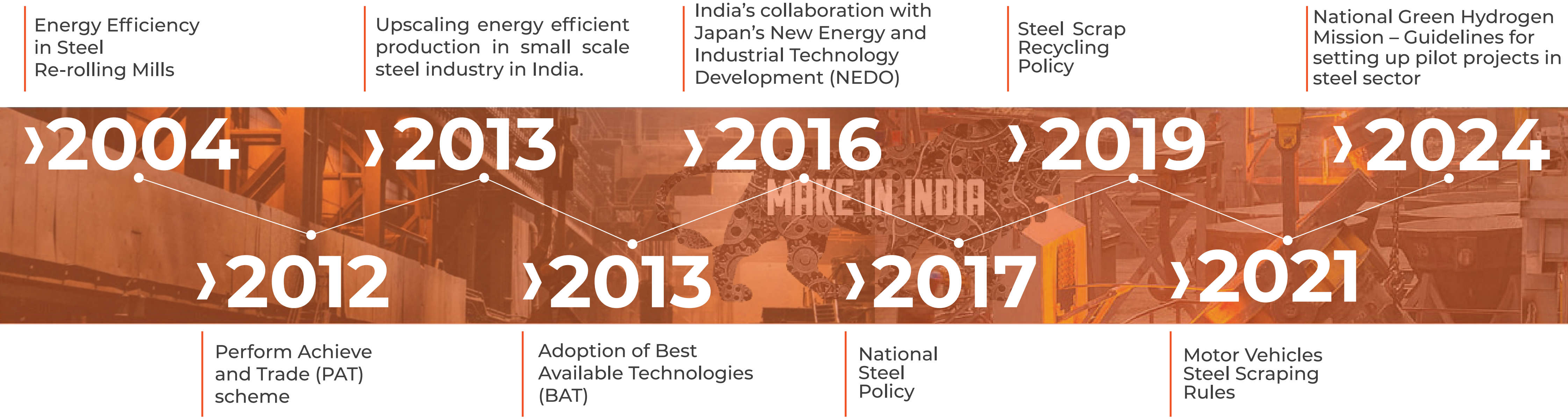
CCUS and green hydrogen are considered the best options for reducing emissions. **CCUS has the potential to reduce up to 55% of emissions, while green hydrogen could decrease emissions by around 14% from the base level.** However, due to the current high costs associated with these technologies, they are not economically feasible at the moment.

On the other hand, there are more practical and achievable decarbonization strategies, such as improving energy efficiency through waste heat recovery systems (WHRS), increasing the use of renewable electricity, and utilizing scrap steel. However, challenges like heavy reliance on coal-based on-site captive plants, and limited availability of scrap steel in India, hinder the effectiveness of these approaches.

Although the potential impact of each individual decarbonization strategy may be modest, their combined effect can be significant. Additionally, these improvements often result in cost savings through reduced energy consumption, making a strong economic case along with the environmental benefits.

KEY GOVERNMENT INITIATIVES

Figure 10: Timeline of government decarbonization initiatives in the steel sector



Source: Ministry of Steel, JMK Research

Over the last decade, the central government has taken numerous initiatives to decarbonize the steel industry. These initiatives include:

1. **Energy Efficiency in Steel Re-rolling mills:** The Ministry of Steel collaborated with the United Nations Development Programme (UNDP) to launch a project funded by the Global Environment Facility (GEF) and the Indian Government, with a total funding of US$ 14.03 million. This project aimed to introduce low carbon technologies in 34 steel re-rolling mills to reduce energy consumption by approximately 36% (787 TJ/year) and lower emissions by 25-50% (88,400 tCO_2/year).[9]

2. **Perform, Achieve and Trade (PAT):** In 2012, the Ministry of Steel, in collaboration with the Bureau of Energy Efficiency, introduced the PAT Scheme. This initiative aimed to enhance energy efficiency in the steel industry with seven cycles scheduled from 2012 to 2024 under the National Mission for Enhanced Energy Efficiency. The goal was to incentivize energy consumption reduction. As a result of this program, the steel sector successfully achieved energy savings of 5.5 million tonnes of oil equivalent (MTOE) and a corresponding reduction of 20 million tonnes of CO_2 emissions from 2012 to 2020.[10]

[9] UNDP | Energy-efficient technologies driving India's secondary steel production | 2017
[10] PIB | Indian Steel Industry Reduces its Energy Consumption and Carbon Emissions Substantially with Adoption of Best Available Technologies in Modernisation & Expansions Projects | February 2022

3. **Upscaling Energy Efficient Production in Small Scale Steel Industry in India (June 2013-June 2016):** The Ministry of Steel launched phase 2 of the energy efficiency project in SMEs (321 steel mills inclusive of 5 induction furnaces) in collaboration with the United Nations Development Programme (UNDP) and Australian Agency for International Development (AusAID). The project has facilitated a reduction in specific energy consumption by ~24 % (431 MJ/tcs), with a CO_2 reduction of 400,000 tCO_2/year.[11]

4. **Best Available Technology (BAT):** In 2013, the Indian steel industry adopted the BAT scheme to improve energy efficiency and mitigate GHG emissions. This led to a significant reduction in CO_2 emissions from around 3.1tCO_2/tcs in 2005 to around 2.6tCO_2/tcs in 2020.

5. **India's collaboration with Japan's NEDO:** In 2016, India and Japan's NEDO signed a memorandum of understanding (MoU). The project model was implemented in four steel plants, namely SAIL, Tata Steelworks, and RINL, to improve energy consumption with an investment of US$60.7 million. These projects resulted in a reduction of more than 3.85 PJ in energy consumption and 0.35 MMTPA of CO_2.[12]

6. **National Steel Policy:** Issued in May 2017, it set an ambitious target to achieve a crude steel production capacity of 300 MMT by FY2031. It also aims to cut emissions to 2.2 – 2.4 tCO_2/tcs for the BF-BOF route and 2.6 – 2.7 tCO_2/tcs for the DRI-EAF route by 2030. Since the policy issuance, production capacity has just grown from 122 MMT to 160.3 MMT in approximately 8 years, well short of its required trajectory to hit the 300 MMT target by FY2031. The government launched the production liked incentive (PLI) scheme in 2021, aiming to increase manufacturing capacity by 25 MMT.[13] However, despite these efforts, according to industry estimates, the Indian steel industry is likely to only reach 230-240 MMT of production capacity by FY2031.

7. **Steel Scrap Recycling Policy:** In 2019, the government introduced a Steel Scrap Recycling Policy to enhance the availability of domestically generated scrap and reduce coal consumption in steelmaking. In 2023, India had a scrap steel consumption of 29 MT, out of which 11 MT was imported and the rest was sourced domestically. Scrap steel consumption is anticipated to reach 70-80 MT by 2030, resulting in energy savings of 16-17% and a reduction in GHG emissions by 58%.[14]

8. **Motors Vehicles scrap policy:** In September 2021, the government issued the Motor Vehicles (Registration and Functions of Vehicles Scrapping Facility) Rule 2021 to increase scrap availability in the steel sector. Around 9.1 MT of scrap steel would be generated from motor vehicles by 2025.[15]

9. **National Green Hydrogen Mission:** In February 2024, the Ministry of New and Renewable Energy (MNRE) announced the guidelines for the implementation of pilot projects for the use of green hydrogen in the steel sector with a budget allowance of INR 455 crores until FY2029-30. The guidelines also mandate that upcoming steel plants should be capable of operating with green hydrogen. It also envisages that considering high green hydrogen costs, steel plants could begin by blending a small percentage of green hydrogen (~10%) and gradually increasing it over time.[16]

The Ministry of Steel (MoS) aims to achieve Net Zero for the steel sector in India by 2070. To accomplish this, the Ministry has established 13 task forces, involving various stakeholders, to outline the roadmap for green steel.

The short-term focus, to be achieved by the fiscal year 2030, is to reduce carbon emissions through energy and resource efficiency, as well as to promote renewable energy in the Iron & Steel sector. Subsequently, between 2030 and 2047, the focus will shift to enhancing Green Hydrogen and Carbon Capture, Utilization, and Storage (CCUS) capabilities.

[11] UNDP | Using Energy Efficiency to Re-Imagine Steel Production in India | 2017

[12] NEDO | Projects in India | 2022

[13] Ministry of Steel | National Steel Policy | 2017

[14] Ministry of Steel | National Steel Recycling Policy | 2019

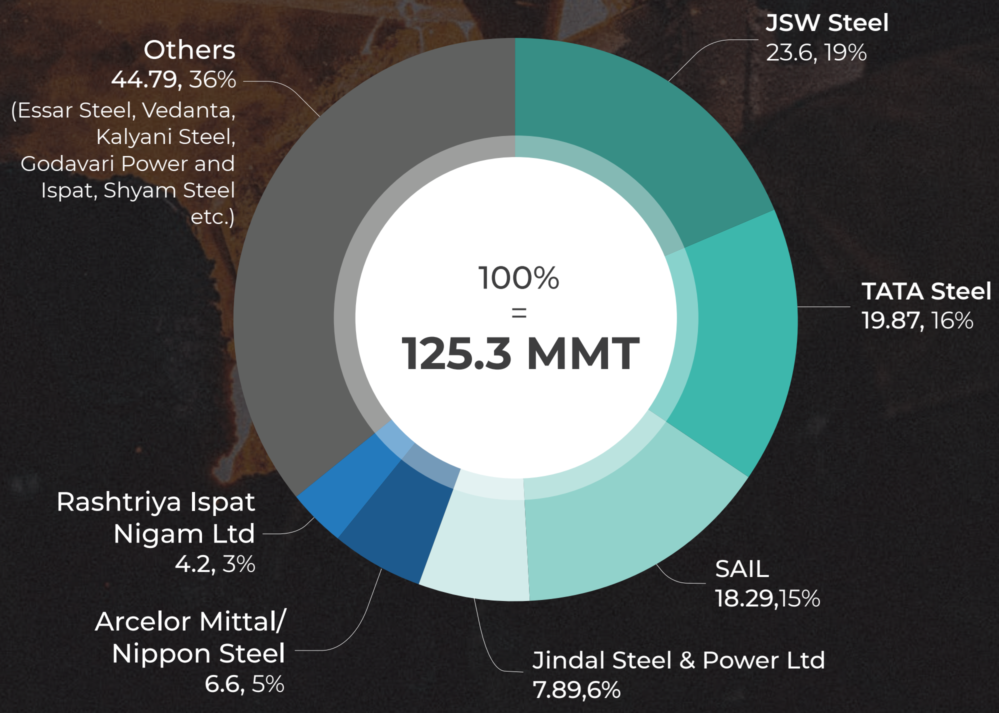
[15] Ficci | Accelerating India's Circular Economy Shift: A half a trillion USD opportunity | 2018

[16] MNRE | Scheme Guidelines for implementation of Pilot projects for use of Green Hydrogen in Steel Sector under the National Green Hydrogen Mission (NGHM)| 2024

LEADING PLAYERS IN THE STEEL SECTOR

The Indian steel sector is mainly dominated by large private and public sector companies. In FY2023, six leading companies - JSW Steel Limited, Tata Steel Limited, Steel Authority of India Limited (SAIL), Jindal Steel & Power Limited (JSPL), Arcelor Mittal/Nippon Steel India (AM/NS), and Rashtriya Ispat Nigam Limited (RINL) - accounted for 64% of the total crude steel production in India. The rest 36% of the market share consists of players such as Essar Steel, Vedanta, Kalyani Steel, Godawari Power and Ispat, Shyam Steel etc.

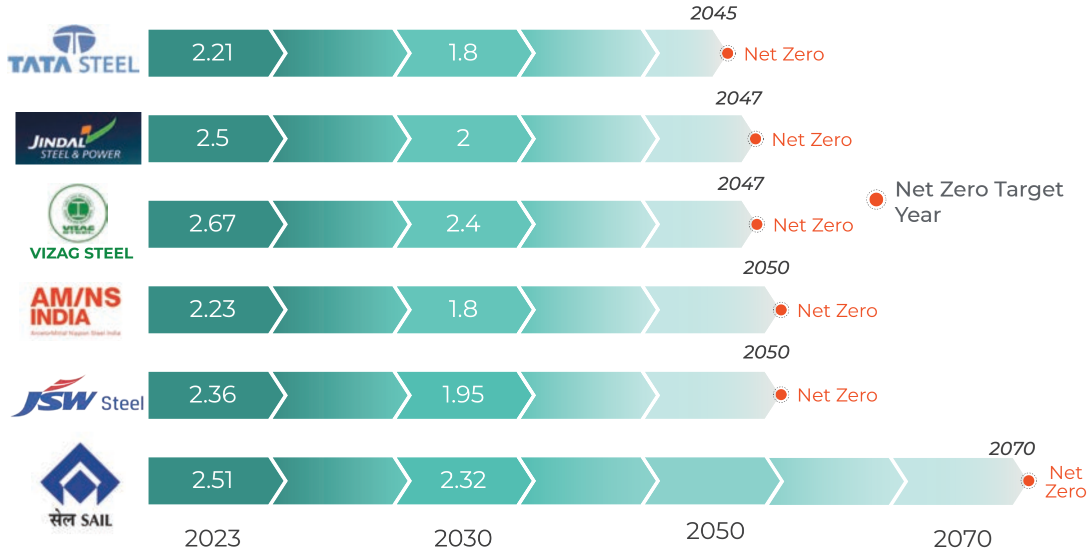
Figure 11: Steel production share by major players in FY2023



Source: JMK Research, Company annual reports

Manufacturers in the steel sector have made deliberate efforts to shift investments from traditional fossil fuel-based assets to decarbonize their operations. Greening steel manufacturing is crucial as Europe accounts for over 42% of its India's steel exports. Europe has adopted a Carbon Border Adjustment Mechanism (CBAM), which takes effect from January 2026 requires non-EU steel producers to report and offset emissions associated with their products.

Figure 12: Emission intensity (tCO_2/tcs) timeline of leading Indian steel players



Source: JMK Research, Company annual reports

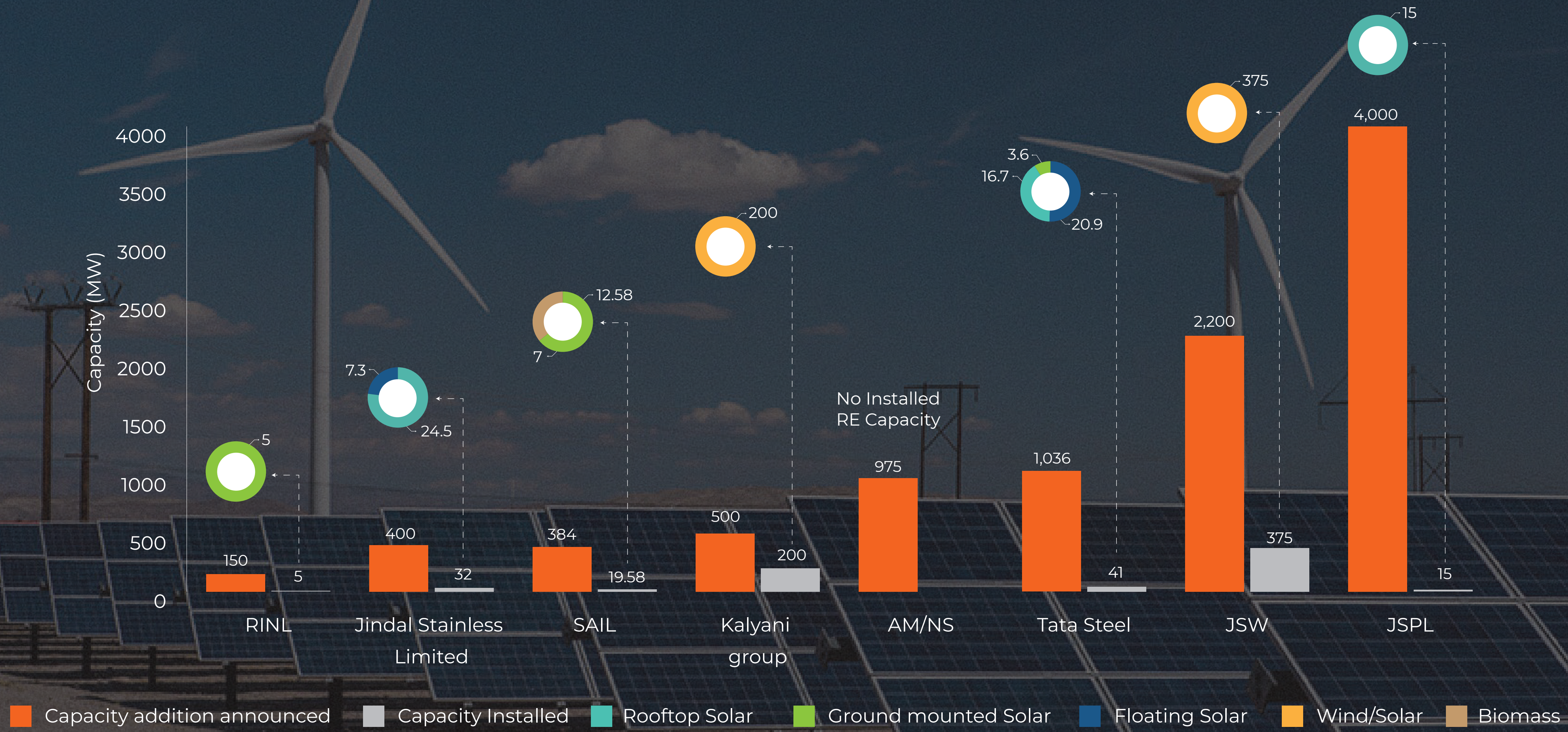
All major integrated steel companies in India have established specific emission reduction targets. By 2030, these leading companies aim to decrease their CO_2 emissions per tonne of crude steel by 7% to 23%. Furthermore, they are all committed to achieving net zero emissions by 2070. Tata Steel, Jindal Steel[17] and Vizag Steel[18] have all announced their plans to achieve net zero emissions before 2050.

[17] Jindal Steel & Power | Sustainability At JSP

[18] PIB | RINL Bags National Energy Leader Award For The Fourth Time Consecutively| 2022

As of December 2023, Indian steel players have installed a total of only 850 MW of renewable energy capacity. However, according to their annual reports and press articles, this capacity is expected to increase to >8.5 GW by 2026. Due to the increasing focus on the quality of renewable energy by consumers, most of the new capacity that will come online in the next few years will be from wind solar hybrid (WSH) projects. WSH projects are expected to provide a significantly improved power output compared to traditional standalone solar or wind projects.

Figure 13: Renewable capacity of key players, currently installed and planned by 2026



Source: JMK Research, Company annual reports, Industry news articles

SHIFTING PARADIGM IN RE PROCUREMENT BY STEEL INDUSTRY

Dominance of coal-based captive power

Heavy reliance of steel industry on coal based captive power plants. Grid and renewable energy are used as secondary power sources. Key reasons for this include:

Reliable power supply

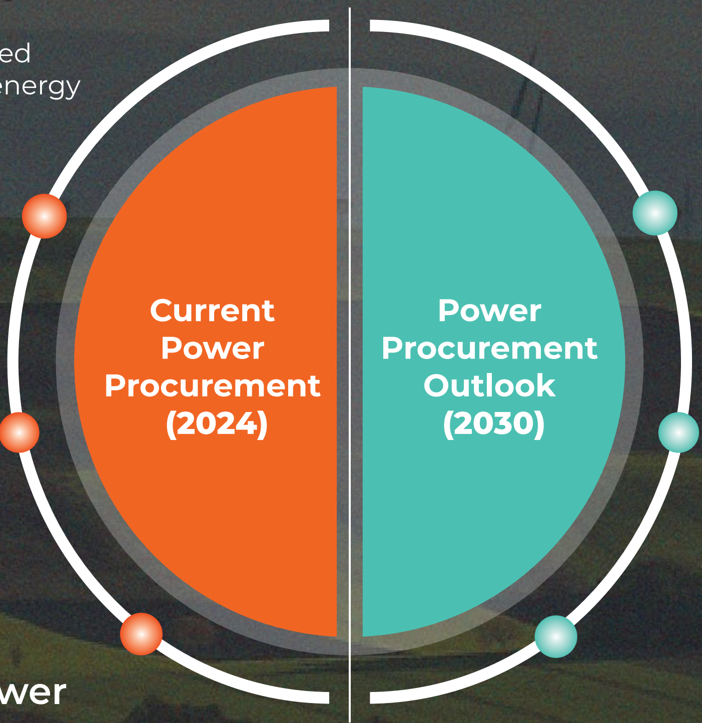
Consistent and stable energy supply crucial for continuous operations which prevents revenue losses.

Cheaper supply than grid

Thermal CPP per unit power cost is 25-30% lesser than the grid.

Ability to meet substantial power demand

Steel sector's consumption scale is too large to be entirely satisfied by intermittent RE sources until the energy storage (ESS) market develops.



Increased adoption of RE

In the ensuing decade, the RE adoption will substantially increase.

Major RE expansion announcements

More than 4.6 GW Renewable Capacity has been announced to be set up by the large steel players by the end of FY2025.

Carbon Border Adjustment Mechanism

CBAM under EUETS will promote the production of green steel using green hydrogen, which will enable the accelerated adoption of renewable energy.

ESS growth can ensure reliable power supply

ESS augmentation with renewables can be a game changer for the steel sector by ensuring a continuous power supply. However, setting up ESS is currently challenging due to technological barriers and high costs.

To support this transition to renewables, transmission infrastructure and last mile connectivity of steel consumers should be enhanced. This will require an investment of up to ₹ 21,400 Crore ($ 2.56 Billion) over the next 6 years.

Investing in renewable energy sources has the potential to significantly reduce electricity costs for steel manufacturing companies. Traditional sources like CPP (priced at Rs. 5-8 per unit) and the grid (priced at Rs. 7-10 per unit) are significantly more expensive than completely owned on-site solar projects, which have per unit costs of about Rs. 1.5/unit. Additionally, when considering open access charges for offsite projects, electricity costs typically range from Rs. 2/unit to Rs. 3.5/unit.

In addition to renewable energy sources, steel manufacturers are exploring innovative technologies such as green hydrogen and CCUS. The table alongside provides insights into how major players are embracing these new methods to decarbonize steel production.

Table 2: Green Steel initiatives planned by key players

Company Name	Investments planned	Green Hydrogen/Green Steel Initiatives
KALYANI	Invested Rs. 400 crores (US$ 47.8 million) in solar and wind projects to switch its Pune electric arc furnace to 100% renewables	The group has launched India's first green steel brand as "Kalyani FeRRESTA" with a capacity of 250,000 tonnes. The brand will have two types of products: FeRRESTA (near zero emission intensity of <0.19/tcs) and FeRRESTA Plus which offers zero emission intensity green steel.
AM/NS INDIA	AM/NS invested around US$0.7 billion in solar and wind sites spanning 3,500 acres	AM/NS signed a MoU with the Maharashtra government to set up a green steel plant within the state with a capacity of 6 MTPA
JSW Steel	Investment of Rs. 10,000 crores (US$ 1.19 billion) in various renewable energy initiatives and use of the best available technologies (BAT)	Partnered with JSW Energy to set up a green hydrogen plant using 25 MW of renewable energy in Vijayanagar, and is expected to be operational by FY2025. It will produce 3,800 tonne per annum of green hydrogen.
VIZAG STEEL Pride of Steel	Invested Rs. 36 crores (US$ 4.3 million) for installation of 5 MW solar power plant.	-
JSL JINDAL STAINLESS	• Invested Rs. 120 crores (US$ 14.3 million) for rooftop solar plants in Jaipur & Hisar • Jindal Stainless Steel (JSL) will invest Rs. 700 crores (US$ 83.7 million) over the next three years in sustainability projects, including renewable energy	JSL, in collaboration with Hygenco, has inaugurated a green hydrogen facility of 78 tonnes per annum capacity which aims to reduce 54,000 tCO_2 carbon emissions over next years

Source: Company annual reports and news articles, JMK Research

CASE STUDY
JSW STEEL LTD

Company Overview

JSW Steel is the cornerstone of the JSW Group, boasting an impressive global steel production capacity of 29.7 MMTPA. Over the last three decades, it has grown from a single manufacturing unit to India's leading integrated steel company, with a manufacturing capacity of 27.7 MMTPA. JSW plans to increase the manufacturing capacity to 50 MMTPA by FY2030.

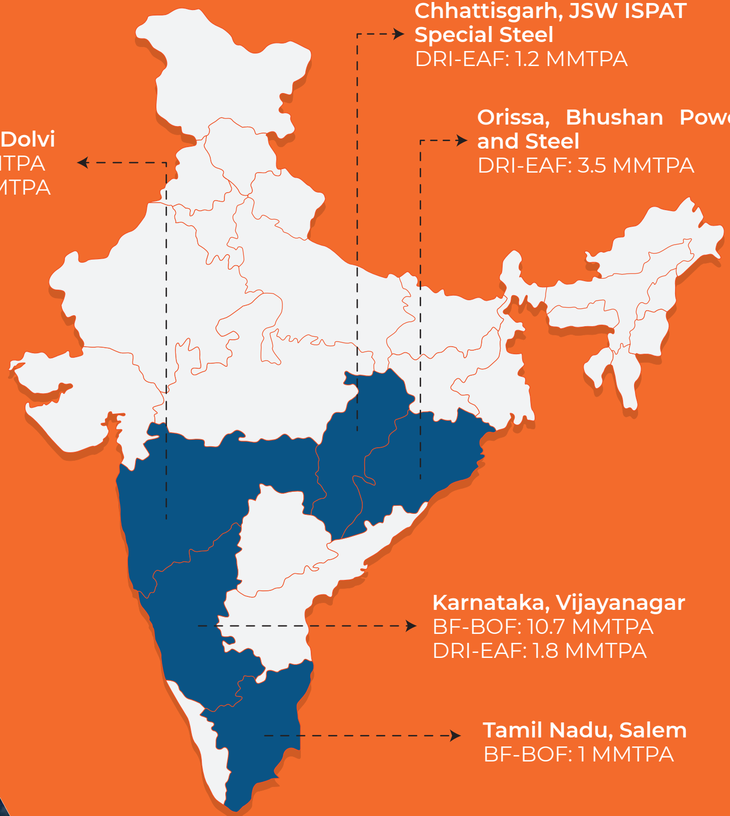
Table 3: JSW Steel Company Overview

Parameter	Details
Name	JSW Steel
Year of establishment	1994
Number of steel manufacturing units	16 domestic and 3 international
Steel Sales (FY2024)	24.78 MMT
Domestic Crude Steel Capacity (FY2024)	28.2 MMTPA
Actual Crude steel Production (FY2024)	26.43 MMT
Installed Capacity of Captive Power plants	1770 MW
Number of Employees	12,856
Total Revenue (FY2024)	Rs. 1,75,006 crores (US$ 20.9 billion)
Market Capitalization	Rs. 2,17,511 crores (US$ 25.9 billion)
Scope 1 & 2 emission intensity (FY2023)	2.36 tCO_2/tcs

Source: JSW Steel Annual Report

JSW Steel's biggest and oldest facility in India is the Vijayanagar plant in Karnataka. It has an annual steel manufacturing capacity of 12.5 million metric tons. This plant is also the largest single-location steel-producing unit in India.

Figure 14: Location and capacity of JSW Steel's Manufacturing units

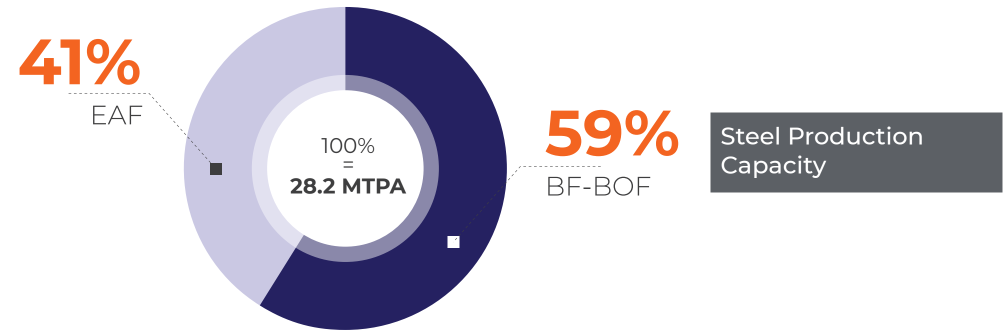


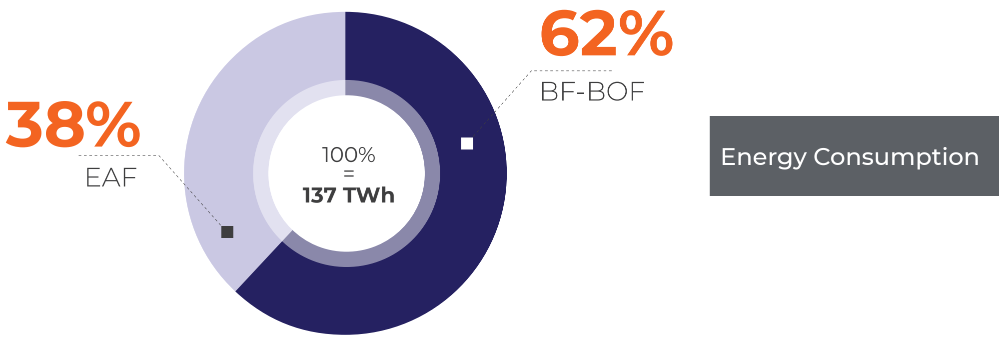
Source: JSW Steel Annual Report 2023

MANUFACTURING PROCESS OVERVIEW AND ENERGY CONSUMPTION

The company primarily produces steel through the BF-BOF route, accounting for 59% (16.7 MTPA) of its total capacity, with the remaining 41% (11.5 MTPA) coming from the electricity-based DRI-EAF route.

Figure 15: Manufacturing pathways share in capacity and energy consumption





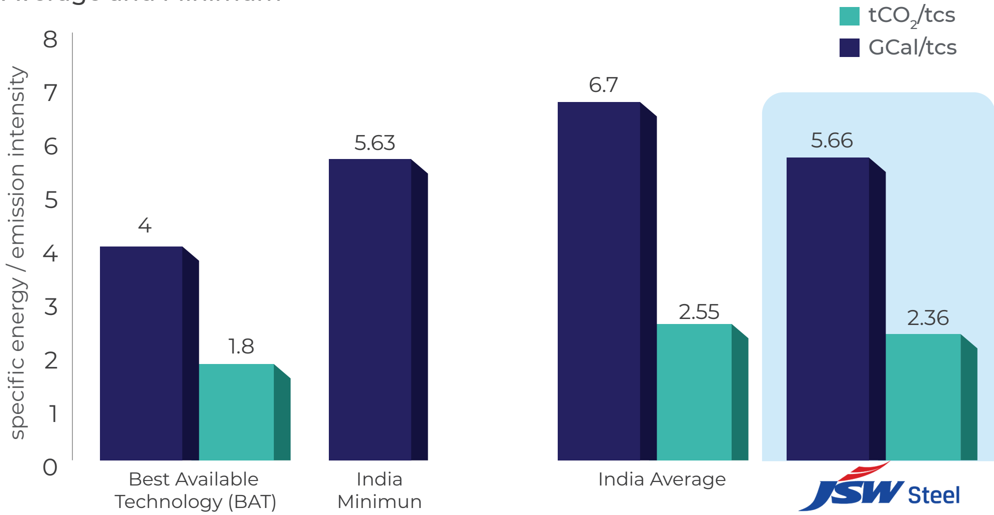
Source: Global Energy Monitor, JSW Steel Annual Report 2023, JMK Research
Note: Energy consumption numbers are estimated

JSW Steel's energy consumption corresponds to the distribution share of its respective steel production pathways. In 2023, the company consumed 494.38 petajoules (137.3 TWh). Notably, 62% of the total energy consumption comes from the BF-BOF route, while the remaining 38% originates from the EAF route.

JSW's specific energy consumption of 5.66 GCal/tcs (6.57 MWh/tcs) in 2023 is 15.5% below the national average in India, almost equivalent to the minimum energy consumption benchmark. This figure decreased by 6.3% compared to the preceding financial year.

However, further reduction in energy consumption can be achieved if the company adopts the Best Available Technologies (BAT) for steel production, such as Oven pressure control technology, Coke Dry Quenching (CDQ), Top Pressure Recovery Turbine (TRT), etc. across all its manufacturing units.

Figure 16: JSW's Specific Energy Consumption and emission intensity vs. National Average and Minimum



Source: JSW Annual Report, JMK Research

SUSTAINABILITY TARGETS AND INITIATIVES

JSW Steel, one of India's leading steel manufacturers, is committed to addressing climate change by aligning its strategies with India's objective of achieving net zero emissions by 2070. The company has set a target to reduce its carbon emissions by 42% by FY2030 (base year: FY2005), with a long-term decarbonization goal of reaching net zero by 2050.

Figure 17: JSW Steel decarbonization timeline

Until
2030

Emission Reduction

- Increasing usage of Renewable Energy
- Exploring CCUS pilot projects
- Adoption of Best Available Technology (BAT)
- Material qualityBeneficiation
- Increased use of scrap steel
- Process Efficiency through SEED

2030-
2050

Strategic Levers for Net Zero

- Large Scale Implementation of CCUS
- Commercial use of Green Hydrogen for Steel Making
- Carbon Offset & Sequestration
- Scrap-based EAF
- Nature-based solutions
- Alternate steel-making
- technologies

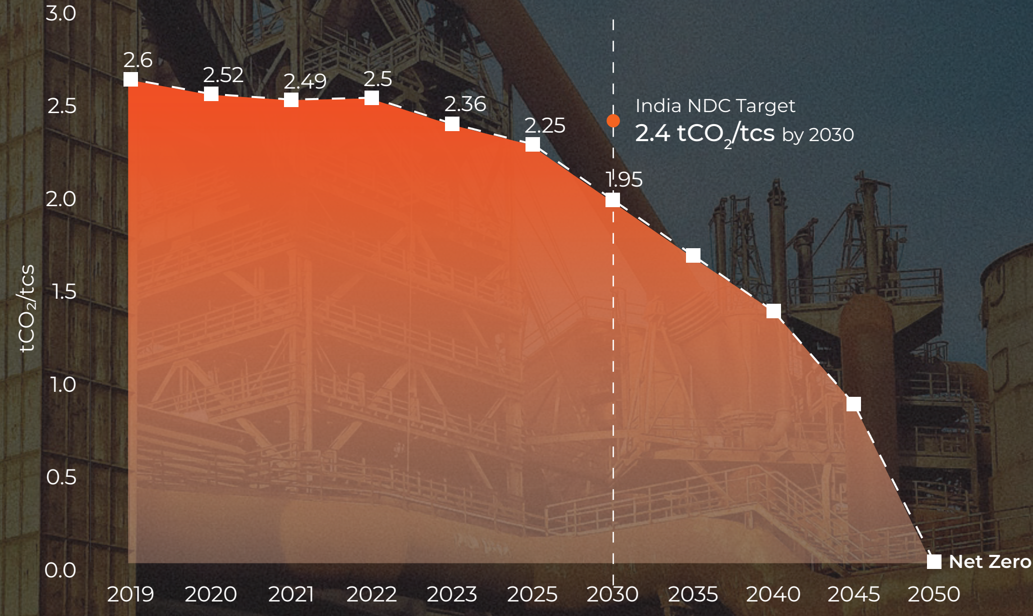
Net Zero Target 2050

Source: JSW Annual Report, JMK Research

After reducing its emission intensity to 1.95 tCO_2/tcs by 2030 through the SEED (Sustainable Energy Environment and Decarbonization) initiative, which is a company-wide decarbonization effort, JSW will focus in the next two decades on offsetting carbon to attain net zero by 2050. The measures to do that include direct electrolysis of iron ore, development of green cover to act as carbon sink and continued scaling up of green hydrogen and CCUS capabilities.

According to the targets outlined by the Government's Nationally Determined Contribution (NDC), the emission intensity of the iron and steel sector in India must be reduced to 2.4 tCO_2/tcs by 2030. JSW Steel has already surpassed this target with an emission intensity of 2.36 tCO_2/tcs in 2023. By 2030, JSW Steel estimates that its carbon emission intensity will be reduced to 1.95 tCO_2/tcs.

Figure 18: JSW Steel carbon emission intensity trajectory



Source: JSW Steel Climate Action Report 2024

RENEWABLE ENERGY INSTALLATIONS BY JSW STEEL

In 2022, JSW Steel entered into a long-term Power Purchase Agreement (PPA) with its energy subsidiary, JSW Energy. As part of the agreement, JSW will establish a combined wind-solar project with a capacity of 825 MW (comprising 225 MW from solar energy and 600 MW from wind energy) to supply power to its Vijayanagar manufacturing unit. Additionally, JSW Steel is also developing 133 MW of wind energy capacity in other states, bringing the capacity to 958 MW.

The renewable capacity of 375 MW (225 MW + 150 MW) is operational. JSW Steel expects its renewable capacity to reach 2200 MW by 2025.

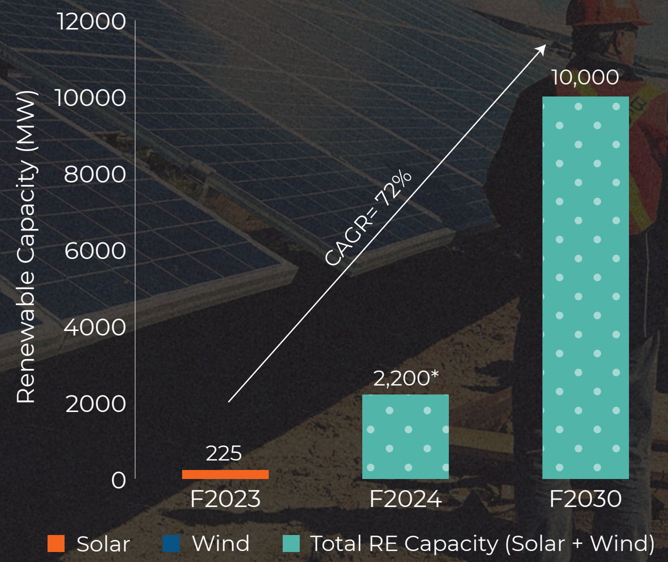
Table 4: Current status of Renewable projects at JSW Steel

Parameters	Description
Project Developer	JSW Renewable Energy Vijayanagar Ltd (a subsidiary of JSW Energy Ltd)
Project Type	25-year Group Captive PPA based, Wind Solar Hybrid
Capacity	958 MW (Operational: 375 MW solar, Pipeline: 583 MW wind)
Area	Approximately 1000 acres
Project off-taker	JSW Steel Ltd.
Off-taker plant location	JSW Steel Vijayanagar Works, Vijayanagar, Karnataka
RE project location	Thimlapura Village (> 200 km from JSW Steel Vijayanagar Works), Karnataka
Transmission line capacity	400 kV
Commissioning Date	7th April 2022
Annual generation	Approximately 400 GWh*
Capacity Utilization Factor (CUF)	Approximately 20%*

Source: JSW Annual Report, JSW Energy, JMK Research
*Note: Values for operational solar capacity figures will change when wind capacity gets added

In order to achieve the targeted carbon emission intensity of 1.95 tCO_2/tcs by 2030, JSW Steel has outlined plans to increase its renewable capacity by 44 times, reaching 10 GW with an impressive compound annual growth rate (CAGR) of 72%. The graph below illustrates the projected trajectory of renewable capacity additions.

Figure 19: JSW Steel renewable energy capacity growth trend



Source: JSW Annual Report, JMK Research
*Note: Augmented by 320 MWh BESS

The deployment of this 10 GW renewable energy capacity is crucial as it allows the company to use renewable energy in its EAF units, which currently relies on electricity from coal-based captive power plants.

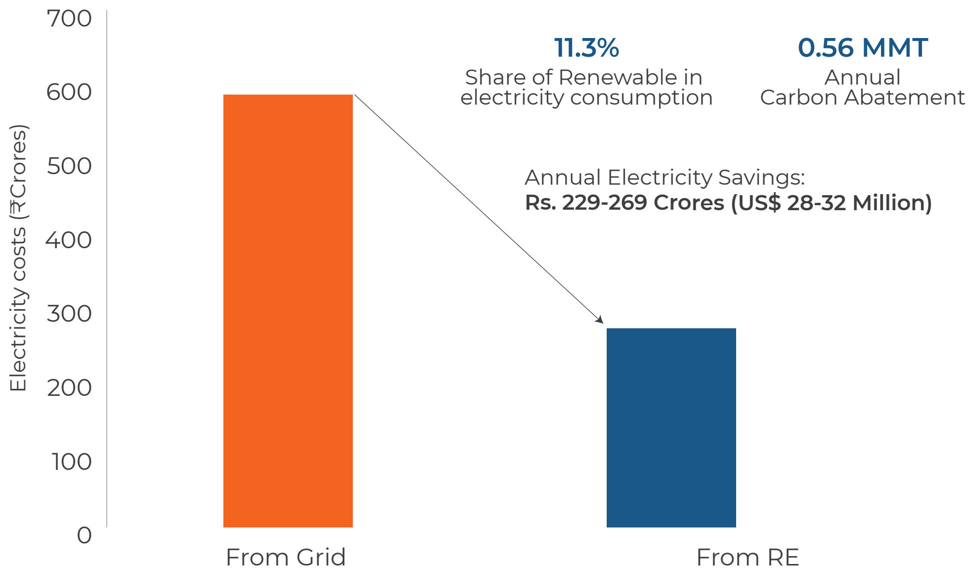
DECARBONIZATION EFFORTS
BENEFITS

Decarbonization levers, such as adopting renewable energy, improving energy efficiency, installing waste heat recovery systems, and optimizing resources, have enabled JSW Steel to achieve financial and environmental benefits.

The adoption of renewable energy sources for energy consumption has resulted in significant cost savings on electricity and a reduction in carbon emissions. Using renewable energy also provides protection against potential increases in coal prices.

JSW Steel's operational 375 MW solar plant has allowed the company to achieve annual savings of approximately ₹229 - ₹269 Crore (US$ 28 - 32 million) in electricity costs and a corresponding reduction in carbon emissions totaling 0.28 million tCO_2. Currently, renewable energy accounts for only 11.3% of the company's total electricity requirement, with non-renewable sources meeting the rest. However, with the company's ambitious plan to reach 10 GW installed capacity by FY2030, the proportion of renewables in energy consumption is expected to increase significantly.

Figure 20: Annual energy savings due to the adoption of renewables



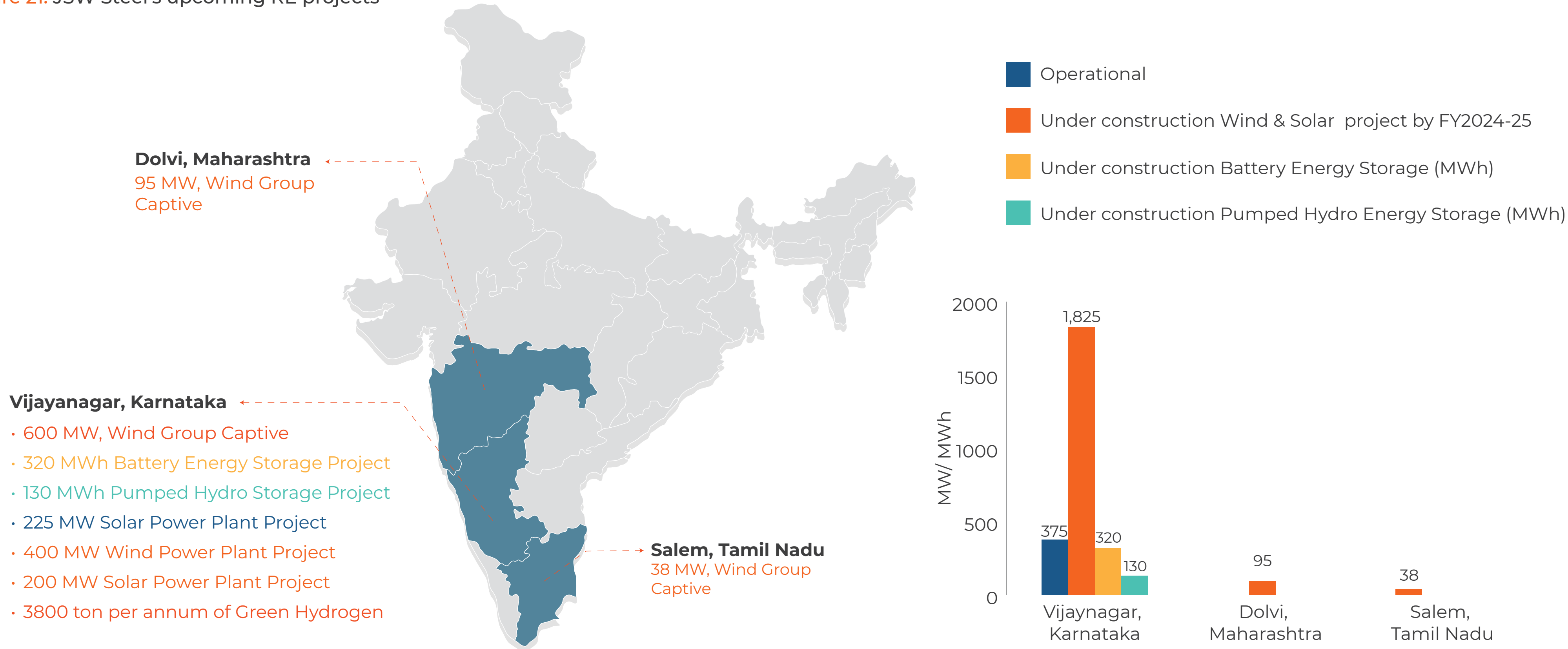
Source: JSW Annual Report, JMK Research
Note: Savings estimated at PPA price of Rs. 4-4.5/unit against a baseline Rs. 7.4/unit HT industrial tariff. Above graph depict the minimum annual savings quantum, it can go as high as Rs. 229 crore with varying ppa tariff

UPCOMING RE PROJECTS

JSW Steel aims to achieve an installed clean energy portfolio of about 1.6 GW capacity with the inclusion of solar and wind projects along with 320 MWh of Battery Energy Storage project and 130 MWh of pumped hydro storage project by FY2027.[19] The majority of this capacity is being established in Karnataka to supply power through intra-state open access mechanism to JSW Steel's largest manufacturing facility at Vijayanagar.

JSW Steel is addressing the peak power requirements of its Vijayanagar manufacturing unit by setting up a greenfield off-stream pump hydro project in Bellary, Karnataka. The project will have a capacity of 130 MW/780 MWh with a 6-hour storage duration. JSW Steel estimates that the levelized tariff for this project will be in the range of Rs. 4.6/kWh to Rs. 6/kWh, based on varying input pumping energy costs.

Figure 21: JSW Steel's upcoming RE projects



Source: JSW Steel integrated report 2022-23, JMK Research

In Oct 2023, JSW Steel has signed MoU with JSW Energy to set up 8 GW of renewable generation capacity and energy storage of 3.7 GWh by 2030. Out of this 8 GW, 1.8 GW is earmarked solely for generating green hydrogen.

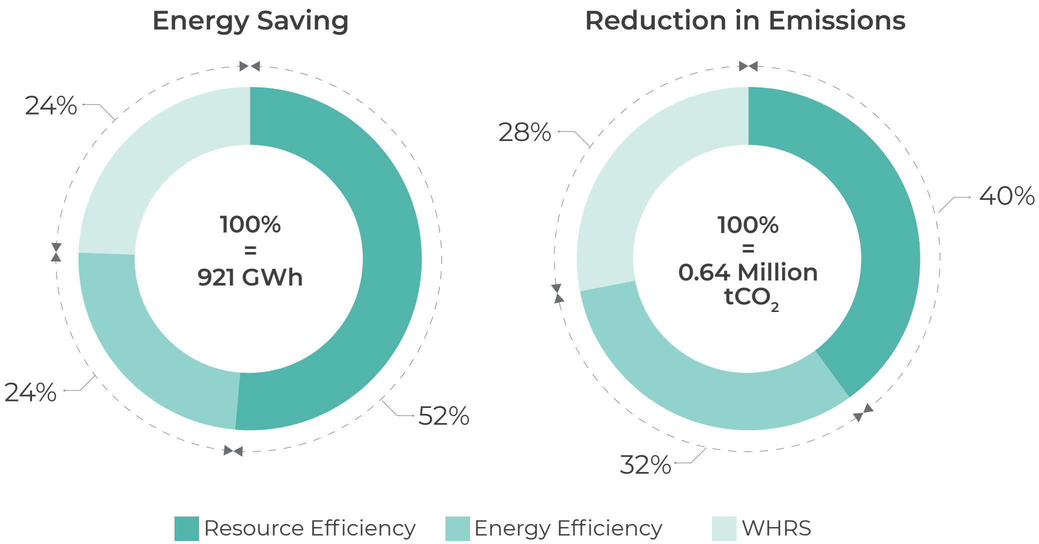
[19] JSW Steel. Vijayanagar Pumped Storage Project. March 2022

BENEFITS FROM OTHER DECARBONIZATION MEASURES

Apart from the benefits of using renewable energy, JSW Steel has also seen other advantages in the steel-making process through three approaches. These include resource efficiency, energy efficiency, and the installation of WHRS. Together, these efforts have led to energy savings of **921 Gigawatt-Hours (GWh)** and a reduction in carbon emissions by **0.64 million tCO_2.**

The adoption of resource-efficient technologies has had the most significant impact, **contributing 52% to the energy savings and 40% to the reduction in emissions.** This has been achieved through the use of technologies such as PCI (Pulverized Coal Injection), which allows for the injection of micro-sized coal particles for complete combustion, and Corex technology, which enables the direct reduction of iron ore in a single unit. The figure below provides a detailed breakdown of the benefits achieved through these initiatives.

Figure 22: Decarbonization benefits through different measures in the steel-making process, FY2023



JSW Steel is committed to reducing its CO_2 emissions to below 1.95 tCO_2 by 2030. We can assess their current status and future outlook based on the key Iron & Steel decarbonization levers discussed in the steel sector overview sections.

Table 5: JSW Steel's Status on Key Iron & Steel Decarbonization Levers

Decarbonization Levers	Current Status	Future Outlook
Renewable Electricity	Employed (Capacity 225 MW)	Target by 2030: 10 GW
Green Hydrogen	No activity as of now	A pilot project planned for 2026 with a capacity of 3800 tonnes
Carbon Capture & Utilization	Employed (Small capacity of 100 tonnes per day)	Large-scale deployment planned before 2050
Energy efficiency	Employed at small scale	Large-scale deployment planned
Scrap Steel	Employed at small scale	Large-scale deployment planned by 2030

Source: JSW Annual Report, JMK Research

As part of its efforts to reduce carbon emissions, JSW Steel is planning a pilot project to test the use of green hydrogen in its DRI unit. The company has partnered with JSW Energy to establish a green hydrogen facility with an annual capacity of 3800 tonnes. The facility, which will be powered by 25 MW of renewable energy, is scheduled to be commissioned by FY2026.

In addition, JSW Group has teamed up with Coolbrooks to implement the RotoDynamic Heater at JSW Steel's manufacturing sites in Vijayanagar. The main objective of this partnership is to minimize CO_2 emissions. The RotoDynamic Heater utilizes electrically driven heaters to replace the use of fossil fuels in high-temperature processes.

CHALLENGES FACED AND MEASURES IMPLEMENTED

The steel sector is considered hard-to-abate due to its heavy reliance on fossil fuels. JSW Steel has faced obstacles such as significant dependency on coke as a raw material, volatile prices of raw materials, the predominant use of conventional technologies that contribute to substantial emissions, and addressing supply chain challenges in procuring high-quality raw materials. Despite the challenging path towards decarbonization, JSW has proactively undertaken remedial measures specified in the table to overcome those challenges.

Table 6: Key challenges and addressal measures adopted by JSW Steel

Challenge	Key measures implemented
Heavy reliance on fossil fuels, i.e. coal and coke, due to its availability at an economical price.	Implementation of fuel consumption reduction measures: 1. Oxyfuel burner- Injection of fuel at optimized pressure and speed when required. 2. Hot Charging – Hot charging circumvents reheating of steel billets or slabs and ~6% of hot charging saves 11% fuel. 3. Injection of coke oven gases in blast furnace reduced consumption of coke and resulted in reduction of emissions and costs.
Price Volatility of high-quality coal due to supply chain disruptions.[20]	Utilization of alternative fuels: 1. JSW has conducted three trials to explore the utilization of plastic granules as a substitute for coke in blast furnaces. The trial at the Vijayanagar plant resulted in savings of 14.5kg/thm CO_2 at the injection of 50 kg/thm of plastic pellets. 2. Usage of charcoal in sinter plant.
Coal based BF-BOF (which constitute 60% of all JSW steel production) is emission intensive and have a long lifespan, and a sudden transition to electricity based DRI process is not technically and financially feasible.	JSW Steel has optimized the BF-BOF process with energy efficiency methods like waste heat recovery and carbon capturing. 1. Utilization of waste heat recovery system in Blast Furnace results in a reduction of stove heat rate by ~18%, which resulted in curbing of 1,78,910 tCO_2 in FY2023. 2. JSW has installed a carbon capture and storage system at the Dolvi, Maharashtra plant with a capacity of 1000 tonnes per day (tpd) of carbon capture.
Insufficient proliferation of electricity in core industrial processes	JSW Steel has collaborated with Coolbrook to install their RotoDynamic heaters. RotoDynamic are electricity-driven heaters capable of using clean energy for manufacturing processes in traditional Blast Furnaces and the Direct Reduction of Iron (DRI) based production of iron and steel.
The conventional blast furnace entails separate units for the coking and sintering processes, posing challenges such as the need for additional high-grade raw materials, which are energy-intensive and result in high emissions.	JSW has installed Corex units which eliminates the requirement of coking unit and sintering unit. It also allows usage of low-grade coal and alkali-based iron ores in a single unit resulting in cost optimization.

Source: JSW Annual report, World Steel Association
Note: **thm** – Tonnes of hot metal

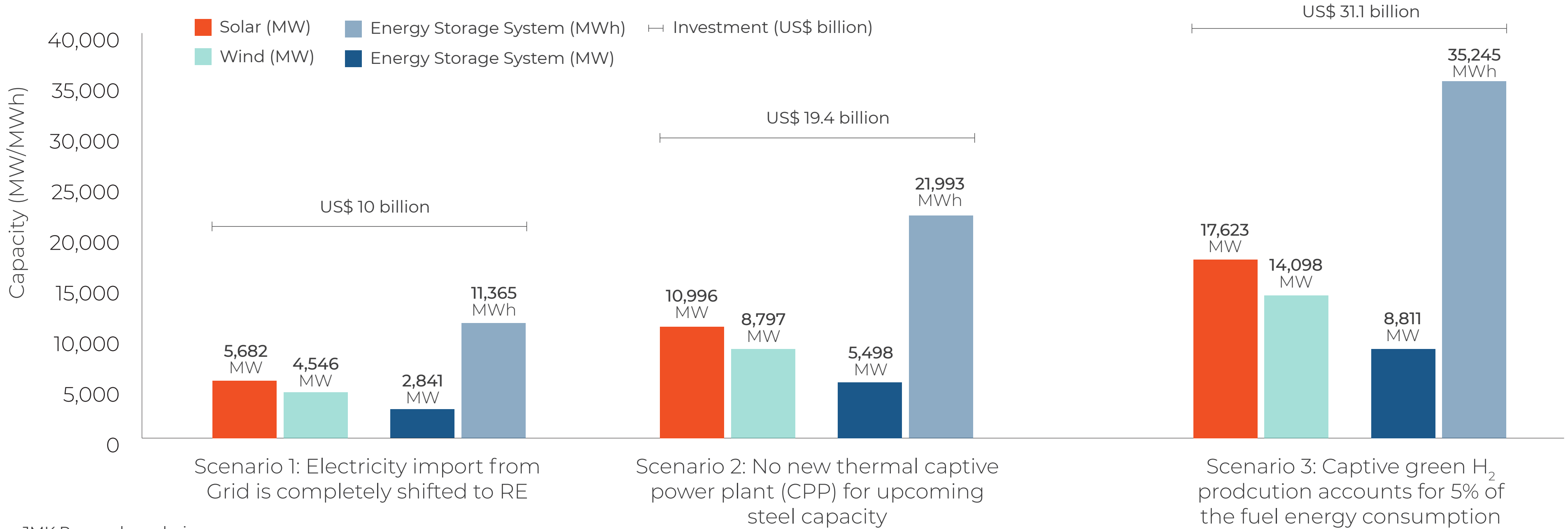
[20] JSW Steel | Decarbonising steelmaking for a better world | 2022

WAY FORWARD

The power demand of the iron and steel industry has not seen much adoption of renewable energy so far. However, major steel companies have announced plans to increase the installed capacity of renewable energy to >8.5 GW by the end of 2026. Nevertheless, this capacity is still lower than the estimated renewable energy capacity required by the steel sector in 2030. We arrived at this estimate by considering various possible scenarios:

- **Electricity import from Grid is completely shifted to RE:** Transitioning grid electricity import to green sources is the most straightforward renewable energy opportunity, especially because grid electricity is typically the most expensive source for a steel plant. This transition is expected to result in the addition of 10 GW of renewable energy and 2.8 GW of energy storage capacity by 2030.
- **No new thermal Captive Power Plant added:** To achieve decarbonization targets, steel entities must reduce their overreliance on thermal Captive Power Plants (CPPs). If upcoming steel plants opt to procure green firm power instead of setting up new thermal CPPs, it is likely to result in the addition of 20 GW of renewable energy and 5.4 GW of energy storage capacity by 2030.
- **Green H_2 utilization:** Utilizing green hydrogen for fuel energy requirements is crucial for producing green steel. If even 5% of fuel energy requirements shift to green H_2 by 2030, it is expected to result in the addition of 32 GW of renewable energy and 8.8 GW of energy storage capacity by 2030.

Figure 23: Expected RE installations in Iron & Steel Industry in various scenarios by 2030



Source: JMK Research analysis

The analysis indicates that by 2030, the Indian iron and steel sector is projected to integrate up to 25 GW of renewable energy capacity, requiring an estimated investment of over US$ 24 billion, including energy storage. This significant advancement underscores the transformative shift in power procurement by the Indian Iron & Steel industry and emphasizes the crucial need for substantial capital. Considering the competitive nature of the steel market, manufacturers must carefully balance their capital-intensive decarbonization efforts without disrupting market dynamics.

In order to achieve full decarbonization by 2070, as per the Indian Government's guidelines, it is imperative to complement renewable energy with key technologies such as CCUS, green H_2, and more. With India's steel industry surpassing the global average in emission and energy intensity, the support of the Indian government through policy formulation and incentives is crucial to encourage a successful green energy transition. The successful execution of the national green hydrogen mission is equally vital to drive down the cost of green hydrogen. The decarbonization journey of the Indian steel sector will serve as a blueprint for other energy-intensive sectors, ultimately positioning the Indian economy on a trajectory towards a net-zero, self-reliant future.

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