

SUSTAINABLE STEEL FOR SUSTAINABLE INDIA



A Status Report on India's Green Steel Initiative

Founded in 2008, the **Environment Conservation Society (ECS)**, also known as SwitchON Foundation, actively offers **sustainable solutions** for the vulnerable Indian population. With a commitment to **clean and renewable energy**, climate-resilient agriculture, and **sustainable cities**, ECS is working towards creating opportunities for 10 million people by 2030, promoting equitable growth through innovative business models and technologies.

Recognizing the crucial role of the steel industry in India's green transition, ECS is dedicated to fostering sustainable steel production and consumption. Our work focuses on integrating renewable energy solutions, resource efficiency, and circular economy principles into steel manufacturing. By engaging with industry leaders, policymakers, and research institutions, we aim to drive innovation, reduce emissions, and promote responsible sourcing of raw materials.

Through **evidence-based research** and stakeholder engagement, ECS advocates for policies that encourage low-carbon steel production and responsible mining practices. Our efforts also include capacity-building initiatives to ensure that industries, workers, and communities are equipped to participate in this transition towards sustainable industrialization.

ECS's commitment to sustainability extends to fostering collaborations for green infrastructure and decarbonizing hard-to-abate sectors. This audit report, **Sustainable Steel for Sustainable India**, critically examines the current landscape of green steel in India, identifying challenges and opportunities to align the sector with national and global climate commitments.

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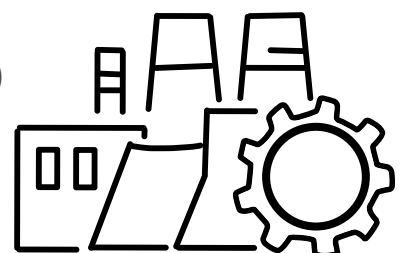
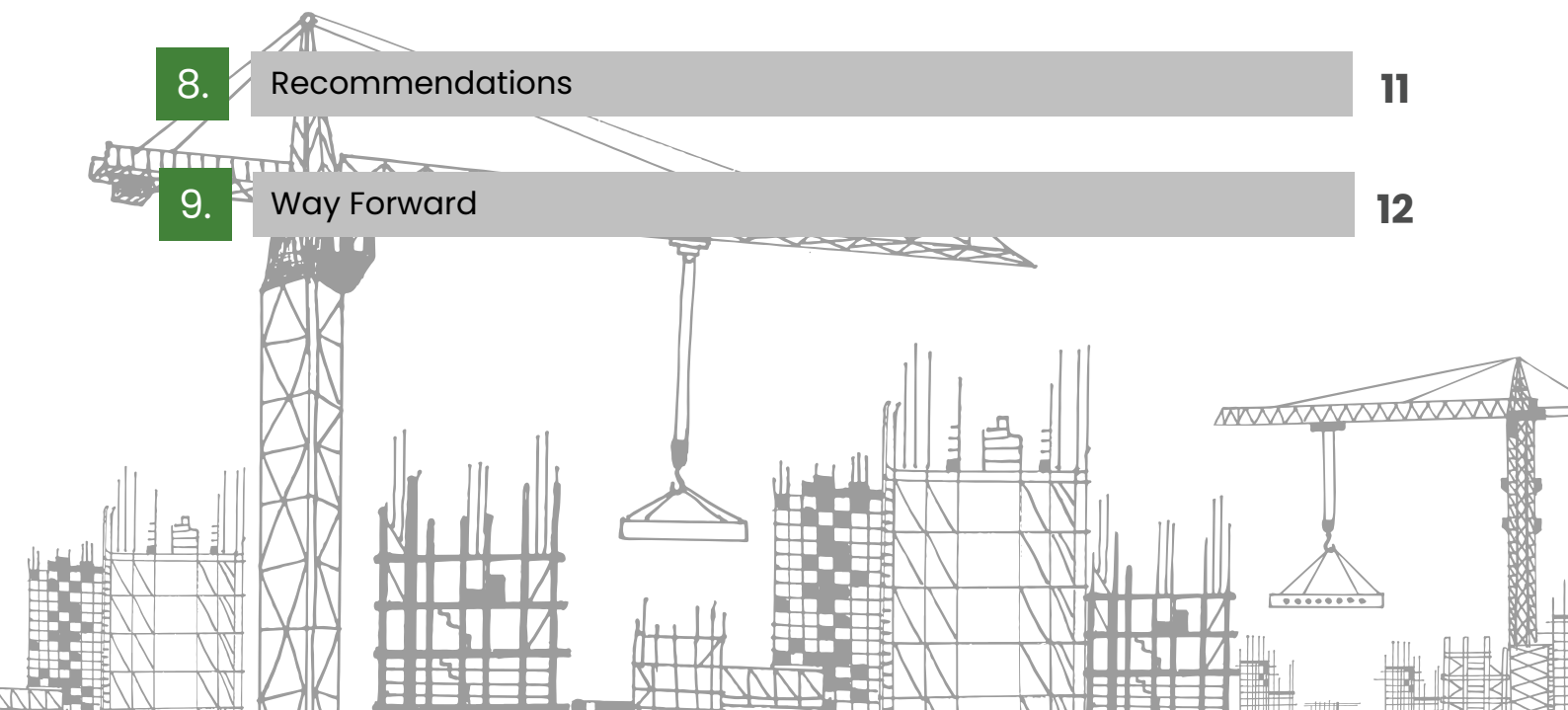


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Executive Summary

Steel production contributes **7–9% of global greenhouse gas (GHG) emissions**, with **India being the second-largest producer**, generating approximately 141 million tons of crude steel in 2023. This sector is responsible for **12% of India's industrial emissions**, primarily due to the carbon-intensive Blast Furnace–Basic Oxygen Furnace (BF–BOF) route and coal-based Direct Reduced Iron (DRI) processes. With steel production expected to expand until 2050, decarbonising this industry is critical for India to meet its net-zero emissions target by 2070. Green steel production, using environmentally friendly technologies and alternative fuels, presents a viable solution.

• Decarbonisation Pathways

Key pathways for decarbonising steel include transitioning from BF–BOF to DRI and Electric Arc Furnace (EAF) technologies, adopting renewable energy, using alternative fuels like green hydrogen and biomass, and implementing **Carbon Capture Utilization and Storage (CCUS)**. The **National Green Hydrogen Mission** focuses on integrating hydrogen into steel production through pilot projects targeting DRI production, blast furnace substitution, and gradual fossil fuel replacement.

• Green Steel Mission and Policy Initiatives

The Government of India's **Green Steel Mission**, with a budget of **₹15,000 crore**, includes a **Production-Linked Incentive (PLI) scheme**, renewable energy incentives, and procurement mandates for green steel. A **Steel Scrap Recycling Policy** and the **Taxonomy of Green Steel (2024)** define standards for low-emission steel production, introducing a star rating system to categorize greenness based on emission intensity. Additionally, the roadmap **"Greening the Steel Sector in India"** outlines 14 actionable strategies to reduce emissions, optimize value chains, and promote innovation.

• Current Status and Pilot Projects

India's crude steel production in 2023 was 124 million tons, with less than 1% classified as green steel. Companies like Tata Steel, JSW Steel, and Kalyani Steels are leading pilot projects. Tata Steel aims to reduce emissions by 20% by 2030, while JSW Steel is integrating renewable energy to target a 42% emission reduction. ArcelorMittal-Nippon Steel India has committed \$1 billion toward decarbonisation, focusing on hydrogen-based steel production.



Challenges in Decarbonisation

Several barriers hinder the transition to green steel:

- | | |
|----------------------------|---|
| 1. Technical: | High renewable energy requirements, inadequate infrastructure, and costly hydrogen storage solutions. |
| 2. Economic: | Green steel production costs ₹55,000–₹65,000 per ton, compared to ₹45,000–₹50,000 for traditional steel, with limited investment and high green hydrogen costs. |
| 3. Policy: | Weak carbon regulations and limited R&D investments. |
| 4. Supply Chain: | Low scrap recycling rates and underdeveloped markets for recycled steel. |
| 5. Market Dynamics: | A price-sensitive market with low demand for green steel. |

• Strategic Focus and Way Forward

India's roadmap emphasizes renewable energy adoption, value chain optimization, CCUS technology integration, and the development of hydrogen-based production. Increased investments, robust policies, enhanced R&D, and international collaborations are crucial to overcoming current challenges. The focus on recycling, innovation, and partnerships will ensure the competitiveness and sustainability of India's steel industry while aligning it with global climate goals.

In summary, while India's steel sector faces significant decarbonisation challenges, the government's proactive measures and private sector initiatives provide a pathway for transforming the industry into a low-carbon, sustainable model.



1. Introduction

Steel production is one of the most carbon-intensive industrial processes worldwide, contributing to 7–9% of global greenhouse gas (GHG) emissions (Kim et al. 2022). As the second-largest steel producer (PIB Delhi, 2024), India plays a significant role in this context. In 2023, India produced approximately 141 million tons of crude steel (PIB Delhi, 2024), with the sector responsible for 12% of the country's industrial emissions (Garg et al. 2023).

Production & Consumption (April – June)
(In Million Tonne)

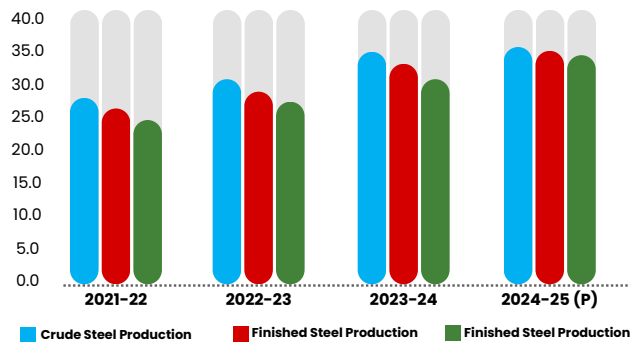


Figure: Steel Production and Consumption Scenario of India
Source: Ministry of Steel, 2024

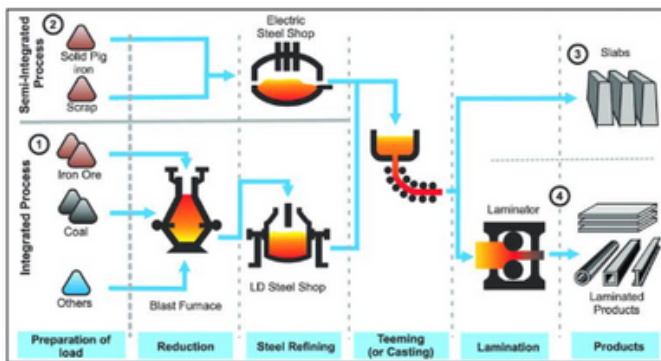


Image: Stages of Steel Production in India
Source: de Magalhães Ozorio et al. 2013

With the expansion of steel production in India, primarily driven by the carbon-intensive Blast Furnace-Basic Oxygen Furnace (BF-BOF) route, emissions are projected to rise until 2050 (Vipul, 2024). India's reliance on coal-based Direct Reduced Iron (DRI) processes, fueled by domestic coal availability, presents additional challenges to the country's steel decarbonisation efforts. In this context, alternative green steel has become a futuristic alternative.

Acknowledging the urgent need for

decarbonisation, India has committed to transitioning to green steel as part of its goal to achieve net-zero carbon emissions by 2070. This report audits the present status of the green steel sector in India.

2. Green Steel Production and Decarbonization Pathways

Green steel production seeks to address the challenges of decarbonising the carbon-intensive steel industry by adopting environmentally friendly alternatives. Key decarbonisation pathways include transitioning from the Blast Furnace (BF) to Direct Reduced Iron (DRI) and Electric Arc Furnace (EAF) technologies, adopting renewable energy, utilising alternative fuels like natural gas, green hydrogen, and biomass, and incorporating Carbon Capture Utilization and Storage (CCUS).

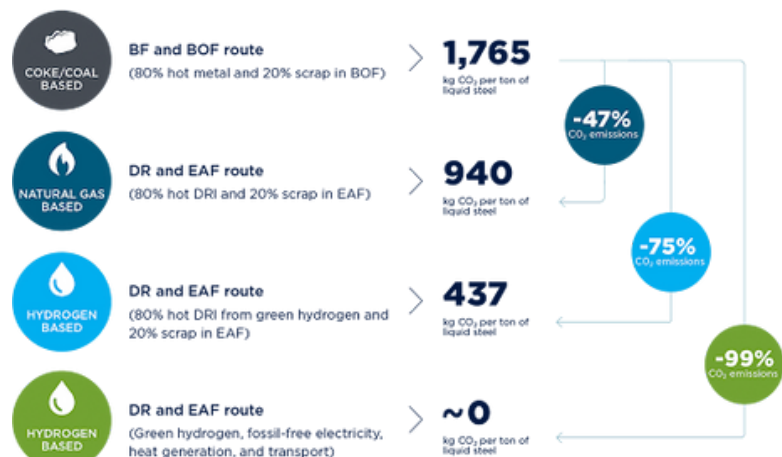


Figure: Comparing CO₂ emissions reduction potential of different process routes for liquid steel.

Source: Primetals Technologies, 2024

• Energy Audit of Green Steel Production

Green steel production offers a significant reduction in energy consumption compared to conventional steelmaking methods by utilizing renewable energy sources and innovative processes such as electric arc furnaces (EAF). This approach has the potential to lower energy usage by up to **80% per ton of steel produced** (Afry, 2022). In contrast, conventional steelmaking relies heavily on fossil fuels, particularly coal, leading to higher energy consumption and increased carbon emissions.

Energy Consumption in Green Steel Production

For the production of **one ton of crude steel from iron ore**, the energy requirements are as follows:

- **Hydrogen Generation:** The production of green hydrogen, which serves as a reducing agent instead of coke, requires approximately **2,633 kWh (2.6 MWh) of power** (Mishra, 2023).
- **Direct Reduction & Electric Arc Furnace (EAF) Operations:** The EAF process and direct reduction consume an additional **816 kWh (0.8 MWh)** of electricity.
- **Total Energy Requirement:** The overall energy needed for green steel production ranges between **3 to 4 MWh per ton** of crude steel (Worldsteel, n.d.).

Energy Mix and Cost Considerations

For the production of one ton of crude steel from iron ore, the energy requirements are as follows:

- The **energy mix** in green steel production includes a higher proportion of electricity, accounting for up to **50% of total energy input**, with a significant share coming from renewable sources.
- Despite its environmental benefits, the **cost of green steel production** is estimated to be **20-30% higher** than conventional methods due to higher energy and infrastructure expenses (Mishra, 2023).
- While the total energy consumption for green steel production is around **3.6 MWh per ton**, conventional steelmaking still relies on **89% of its energy from coal** and only **7% from electricity**, underscoring the shift in energy sources with green steel technologies.

Aspect	Conventional Steel Production	Green Steel Production
Energy Requirement (MWh/ton)	3.6	3 to 4
Main Energy Source	Coal (89%)	Electricity (up to 50%)
CO2 Emissions (tonnes/ton)	1.5 - 2.0	Minimal to none
Recycling Rate	Low	Up to 93%
Technologies Used	BF-BOF	EAF, Hydrogen Reduction

By integrating renewable energy and reducing fossil fuel dependency, green steel production presents a viable path toward a more **sustainable and energy-efficient** steel industry.

• Green Steel Mission

The Government of India is advancing steel sector decarbonisation through the Green Steel Mission, with an estimated budget of ₹15,000 crore. This mission includes a PLI Scheme for Green Steel, renewable energy incentives, and mandates for government agencies to procure green steel. The National Green Hydrogen Mission, led by MNRE, integrates the steel sector, with ₹455 crore allocated for pilot projects until FY 2029–30. Key projects include producing Direct Reduced Iron (DRI) using 100% hydrogen and hydrogen injection in blast furnaces to reduce coal consumption.

A Steel Scrap Recycling Policy enhances resource efficiency, while the Taxonomy of Green Steel (released on December 12, 2024) defines standards for low-emission steel and establishes green star ratings. The taxonomy supports green steel production, market creation, and financial assistance. The "Greening the Steel Sector in India" roadmap, based on recommendations from 14 task forces, was released on September 10, 2024, outlining actionable decarbonisation strategies.

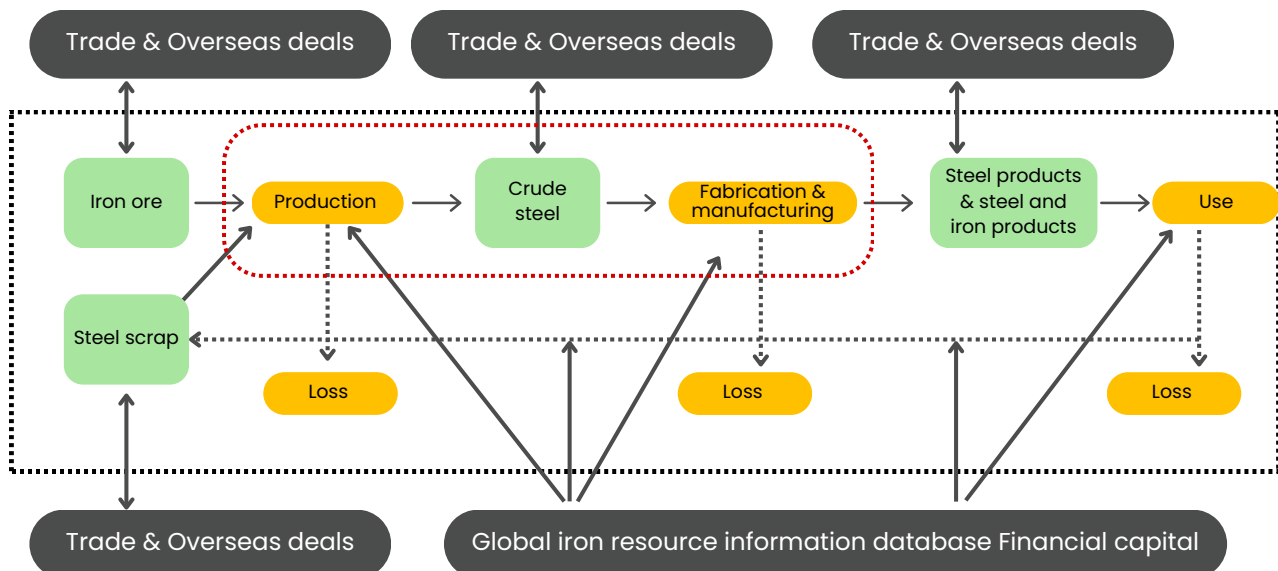


Figure. Target processes in the production process for GHG reduction

Source: Liu et al., 2017

• National Green Hydrogen Mission for the Steel Sector

The Government of India, under the National Green Hydrogen Mission, issued the "Scheme Guidelines for Implementation of Pilot Projects for Use of Green Hydrogen in the Steel Sector" on February 2, 2024 (PIB Delhi, 2024a). These guidelines, issued by the Ministry of New and Renewable Energy (MNRE), focus on pilot projects aimed at replacing fossil fuels with green hydrogen and its derivatives. The scheme supports greenfield projects that aim for 100% green steel production, aligning with global sustainability goals.

Capital outlay allocation in the National Green Hydrogen Mission

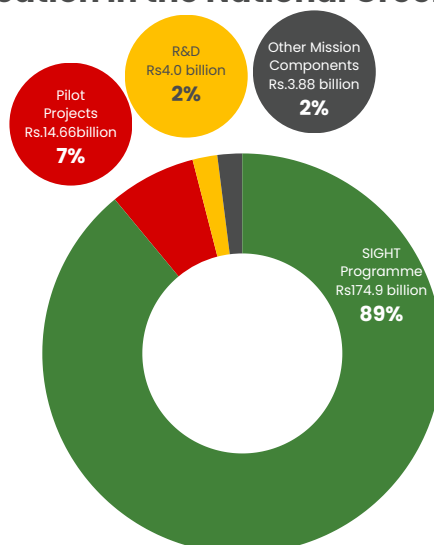


Figure: Capital outlay allocation in the National Green Hydrogen Mission

Source: MNRE & IEEFA, 2024

Pilot Projects

i. Companies Involved:

- SAIL (Steel Authority of India Ltd) – Leading project in Ranchi.
- Matrix Gas and Renewables Ltd – Consortium includes Gensol Engineering, IIT Bhubaneswar, and Metsol AB.
- Simplex Castings Ltd – Partners with BSBK, Ten Eight Investment, and IIT Bhilai.

ii. Project Capacity:

- SAIL: 3,200 TPD (largest project).
- Matrix Gas and Renewables: 50 TPD.
- Simplex Castings: 40 TPD.

iii. Funding & Timeline:

- ₹347 crore allocated by the Indian government.
- Projects to be commissioned within three years under the National Green Hydrogen Mission.

The scheme also encourages other innovative uses of hydrogen for reducing carbon emissions in steel production.

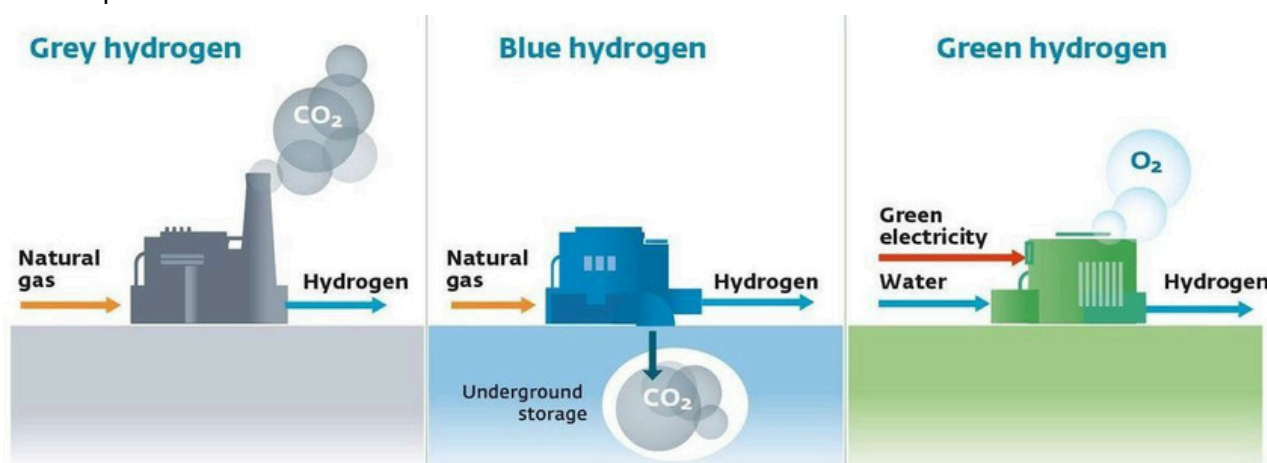


Figure: Synthesis Pathway for Grey, Blue, and Green Hydrogen

- Blending and Future Readiness

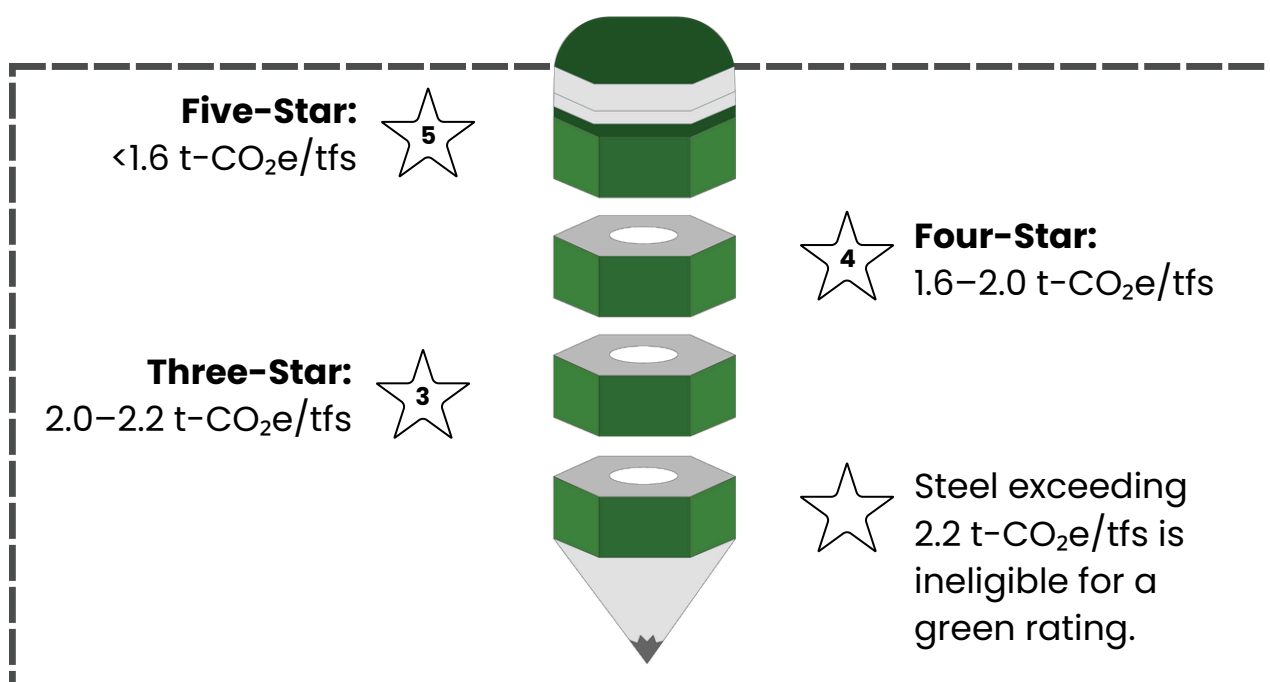
Given the high current cost of green hydrogen, steel plants are encouraged to start by blending a small percentage of green hydrogen, increasing the proportion as technology advances and costs improve. Additionally, new steel plants should be designed to operate with green hydrogen to ensure their future participation in global low-carbon steel markets..

3. India's Green Steel Taxonomy

India released its Green Steel Taxonomy on December 12, 2024 ([PIB Delhi, 2024c](#)), aligning with its net-zero emission intensity target by 2070. The taxonomy defines "Green Steel" based on emission intensity and assigns star ratings to promote low-emission steel production.

- Definition and Rating System

- Green Steel is defined as steel produced with CO₂ equivalent emissions below **2.2 tonnes per tonne of finished steel (tfs)**.
- The **"greenness"** is expressed as a percentage, reflecting how much emissions fall below the threshold.
- Star ratings are assigned based on emission intensity:



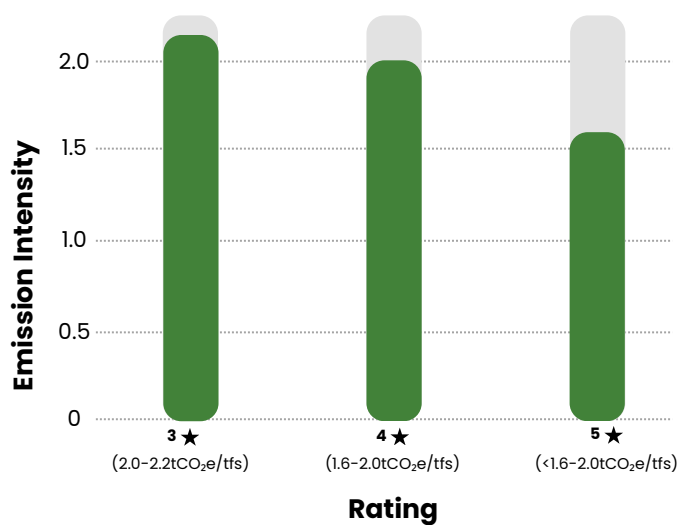


Figure: Green Steel Taxonomy
Source: Gulati, 2024

- Thresholds will be reviewed every three years.

• Scope of Emissions

- Includes Scope 1 (direct emissions), Scope 2 (indirect emissions from purchased energy), and limited Scope 3 emissions up to finished steel production.
- Scope 3 covers agglomeration (e.g., sintering, pellet making, coke making), beneficiation, and embodied emissions in purchased raw materials but excludes upstream mining, downstream, and transportation emissions.

• Monitoring and Certification

- The National Institute of Secondary Steel Technology (NISST) will act as the nodal agency for measurement, reporting, and verification (MRV) and issuing greenness certificates.
- Certificates will be issued annually but can be updated more frequently based on MRV as required.

This taxonomy provides a robust framework for encouraging sustainable practices and monitoring progress in India's steel sector decarbonisation journey.

4. India's Present Capacity on Green Steel

• India's Steel Production

India's crude steel production in 2023 was 141 million tons, with less than 1% categorized as green steel ([Stanway, 2024](#)). Traditional blast furnaces dominate 90% of production, with electric arc furnaces (EAFs) contributing the rest.

• Current Green Steel Projects

Kalyani Steels Ltd



was the first steel company in India to produce green steel in 2023. Other Indian steel companies are also transitioning to green steel production (Shetty, 2023).

Tata Steel



Tata Steel's hydrogen-based steelmaking initiative aims to reduce CO₂ emissions by 20% by 2030. Their Jamshedpur plant has an annual capacity of 11 million tons, but green steel production remains in the pilot stages.

JSW Steel



In 2023, JSW Steel produced over 23 million tons of steel, using 1,700 MW of renewable energy, targeting a 42% reduction in CO₂ emissions by 2030.

ArcelorMittal-Nippon Steel India



This joint venture has committed \$1 billion toward decarbonisation, including exploring hydrogen-based steel production.

5. Past and Timeline

➤ **2010s:** India's decarbonization efforts began in the 2010s, driven by rising emissions. By 2015, steel production contributed 275 million tons of CO₂ annually, highlighting the sector's environmental impact.

➤ 2015–2020

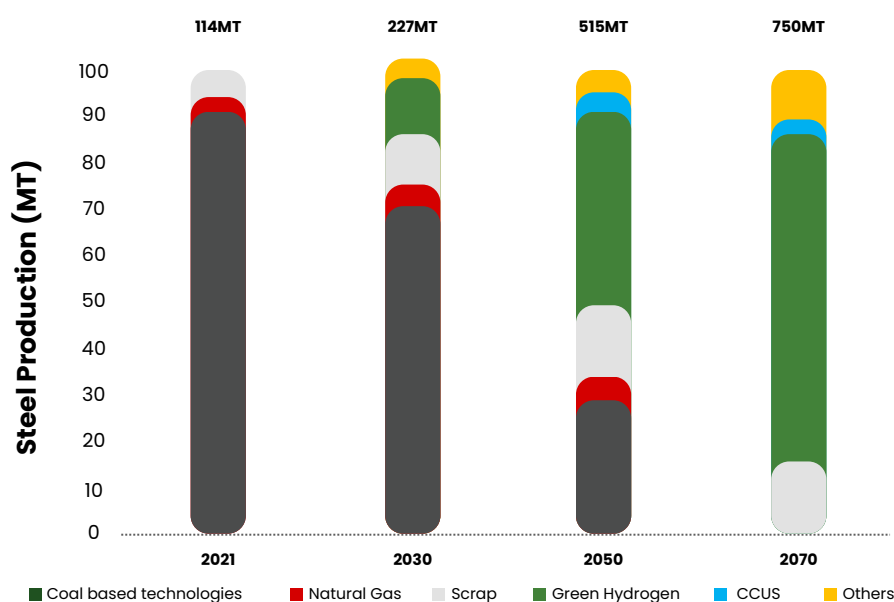
Paris Agreement (2015): India pledged to reduce its emissions intensity by 33–35% by 2030, emphasising industrial decarbonisation

Renewable Energy Integration: The adoption of solar and wind power in auxiliary steelmaking processes began, contributing to 2.8% of the sector's energy consumption by 2020.

➤ 2021–2023

India launched the National Hydrogen Mission (2021), allocating ₹25,000 crores to develop green hydrogen infrastructure.

Steelmakers pledged to cut emissions by 30–50% by 2050, with Tata Steel and JSW leading pilot projects.



Source : Industry Reports, JMK Research

Note : Coal Based Technologies include EAF , EIF and BO, Others can include Molten Oxide Electrolysis, Electrowinning etc.

As per IEEFA & JMK Research (2024), To make hydrogen technology viable and green steel competitive, the price should be US\$1-2/kg, with a carbon penalty of at least US\$50 per tonne of emissions on traditional steel. This could catalyze a 150-million-tonne shift to hydrogen-based steelmaking. India's steel sector decarbonization trajectory until 2070 is projected as follows:

- **Up to 2030:** Coal-based technologies' share reduces from 92% (2021) to 70%, with green hydrogen replacing coal in EAF/EIF routes. Commercial-scale green hydrogen production will start by 2030.
- **2030-2050:** Large-scale green hydrogen adoption phases out coal-based routes; 25-30% of grey hydrogen is replaced by green hydrogen, increasing to 80% by 2050.
- **2050-2070:** Green hydrogen fully replaces coal and gas technologies as costs decline in a competitive market.



6. Decarbonization Roadmap: Greening the Steel Sector in India

The Ministry of Steel has introduced "Greening the Steel Sector in India," a 14-point action plan aimed at creating a sustainable and competitive steel industry aligned with India's climate goals. Key Themes in the Roadmap are as follows.

i. Value Chain Optimization and Monitoring

- Development of a taxonomy for green steel, including certified systems to monitor emissions.
- Focus on optimising the entire value chain, from raw material procurement to final processing, to enhance cost efficiency and reduce emissions.

ii. Carbon Capture and Utilization

- Emphasis on carbon capture, utilisation, and storage (CCUS) technologies to mitigate emissions.

iii. Renewable Energy and Hydrogen Transition

- Increased reliance on renewable energy for steel production.
- Transitioning from coal-based Direct Reduced Iron (DRI) to gas-based DRI, using natural gas as a bridge fuel for green hydrogen.

iv. Sustainable Alternatives

- Exploration of sustainable substitutes for coal and coke, such as biochar from biomass, through its widespread adoption.
- Utilising industrial waste gases, synthesised gas, and coal bed methane (CBM) for process conversion.

v. Recycling and Circular Economy

- Increasing the use of recycled steel to reduce the need for primary steel production and associated emissions.

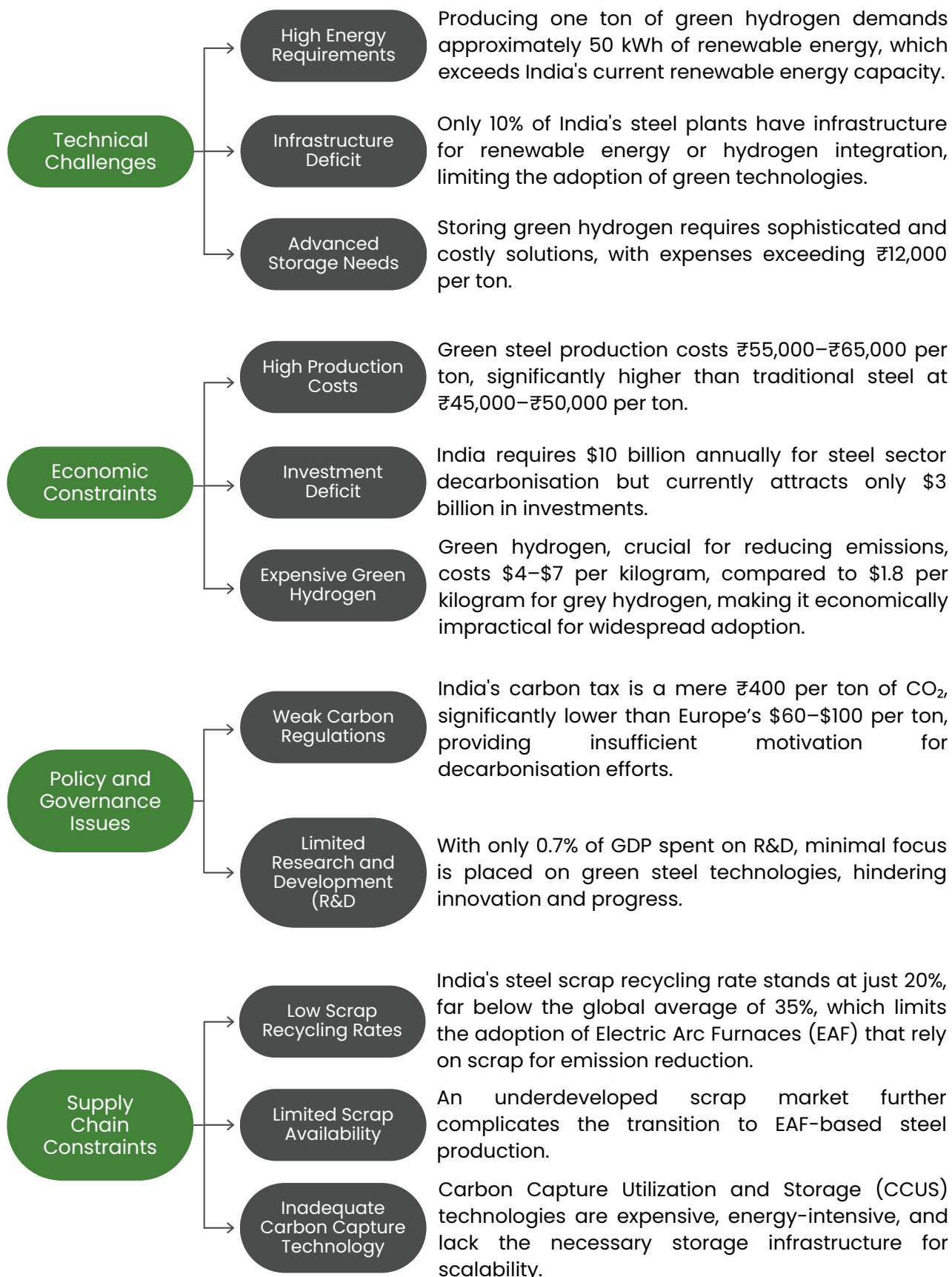
vi. Innovation and Collaboration

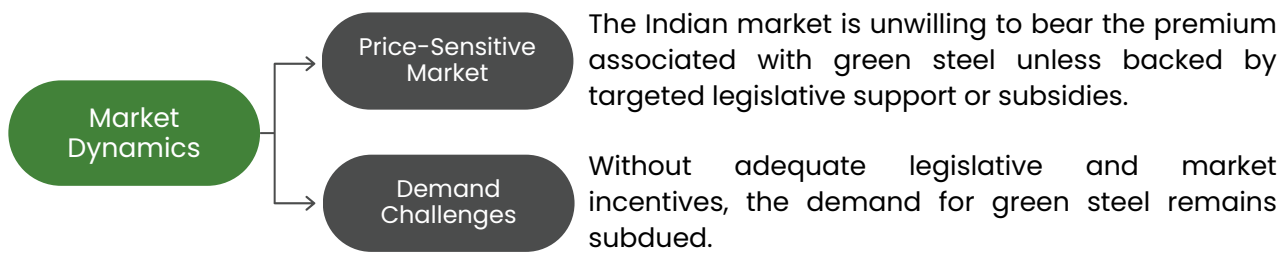
- Promotion of hydrogen-based steel production and other innovative technologies.
- Partnerships with global steel companies and technology providers to advance research and development in efficient and sustainable production processes.

• Strategic Focus

The roadmap maintains growth targets while addressing India's heavy dependence on coal. It underscores the importance of renewable energy, innovation, and international collaboration to transition toward a low-carbon steel sector

7. Challenges in Decarbonizing Steel Production in India

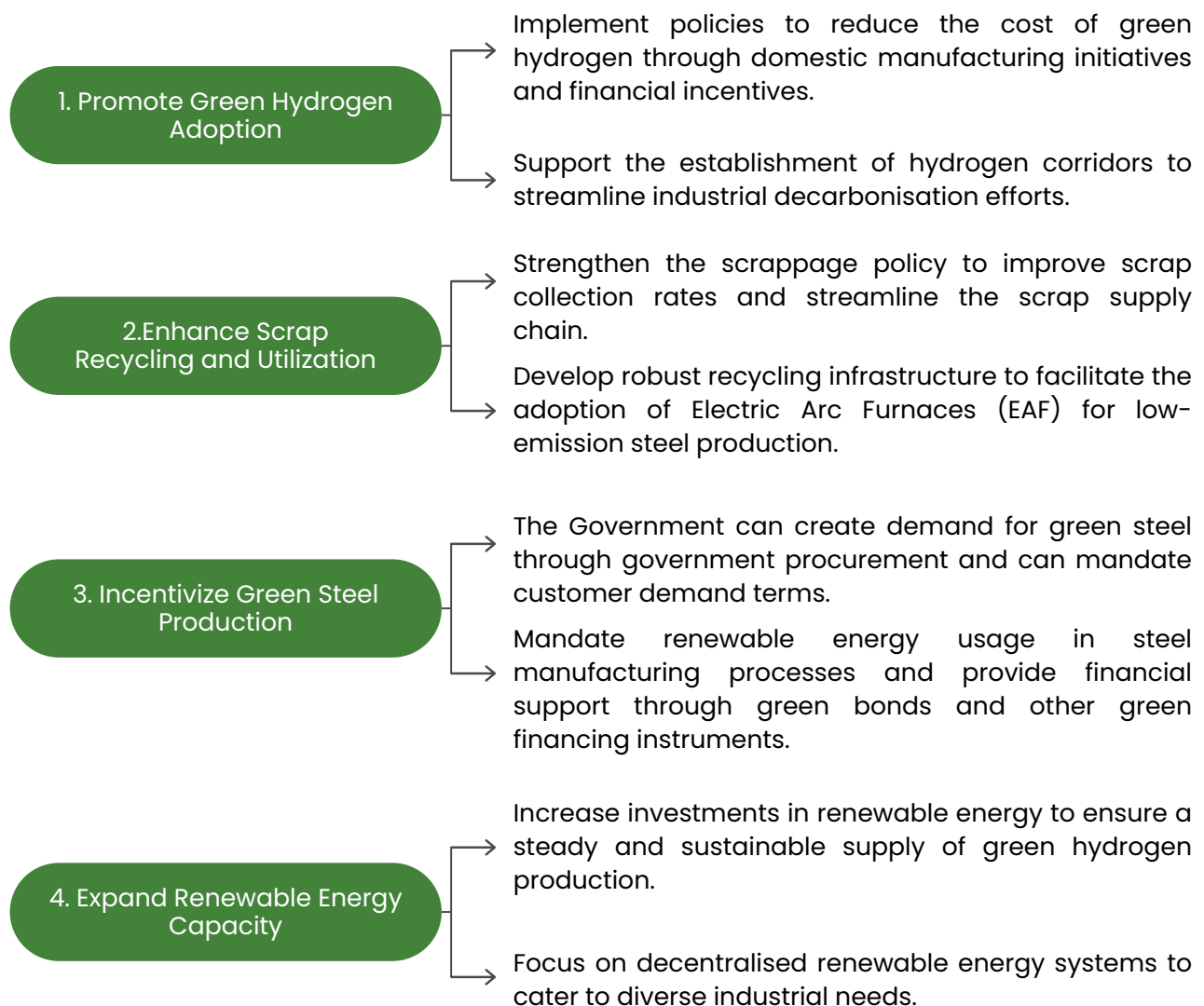




These challenges collectively highlight the need for technological advancements, policy reforms, increased investments, and market transformation to enable the decarbonisation of the steel industry in India.

8. Recommendations

Recommendations to decarbonise the steel sector of India as per [Vipul \(2024\)](#) are as follows:





9. Way Forward

Advancing green steel production in India requires a comprehensive approach involving policy reforms, technological advancements, market development, and consumer engagement. Robust carbon pricing mechanisms and subsidies are essential to incentivise low-carbon practices. Investments in R&D for green steel technologies, CCUS, and energy-efficient processes, alongside certification systems, will enhance transparency and trust. Aligning domestic standards with international regulations and fostering public-private partnerships can boost global competitiveness. Additionally, promoting awareness and incentivising the use of certified green steel in infrastructure projects will drive demand. Together, these measures will transition India's steel industry toward sustainability and support global decarbonisation goals.

References

- Afry. (2022). Green Steel. AFRY. Retrieved February 4, 2025, from <https://afry.com//competence>
- Garg, V., Gulia, J., Gupta, K., Shaik, N., & Sivastava, S. (2023, September 14). Steel decarbonisation in India | IEEFA. Retrieved January 21, 2025, from <https://ieefa.org/steel-decarbonisation>
- Gulati, K. (2024, December 24). Decoding Green Steel Taxonomy for India – Sentra World. Sentra World. <https://sentra.world/blog/green-steel-taxonomy/>
- IEEFA & JMK Research. (2024, November 8). Steel decarbonisation in India. JMK Research & Analytics. Retrieved January 27, 2025, from <https://jmkresearch.com>
- Kim, J., Sovacool, B. K., Bazilian, M., Griffiths, S., Lee, J., Yang, M., & Lee, J. (2022). Decarbonizing the iron and steel industry: A systematic review of sociotechnical systems, technological innovations, and policy options. *Energy Research & Social Science*, 89, 102565. Retrieved on 21st January 2025 from: <https://doi.org/10.1016/j.erss.2022.102565>
- Ministry of Steel. (2024, August 13). Rise of Indian Steel Sector: From PLI Scheme to Technological Advancement, Key Reforms in Steel Industry. Press Information Bureau. Retrieved January 27, 2025, from <https://pib.gov.in/>
- Mishra, S. (2023, November 16). Can green steel help us reach net zero? <https://earth.org/>
- MNRE & IEEFA. (2024, March 7). India's \$2.1bn push for local electrolyser manufacturing and green hydrogen production sees strong interest from large companies | IEEFA. Institute for Energy Economics and Financial Analysis. Retrieved January 27, 2025, from <https://ieefa.org>
- PIB Delhi. (2024, July 30). The Government acts as a facilitator, by creating Conducive Policy Environment for Dev. of the Steel Sector. PIB. Retrieved January 21, 2025, from <https://pib.gov.in>
- PIB Delhi. (2024a, February 2). Government issues Pilot Project Guidelines for utilizing Green Hydrogen in Steel Sector. Retrieved January 21, 2025, from <https://pib.gov.in/>
- Primetals Technologies. (2024, January 17). The three phases to green steel production. Spectra by MHI. Retrieved February 4, 2025, from <https://spectra.mhi.com/>
- PIB Delhi. (2024c, December 12). Union Minister of Steel and Heavy Industries, Shri H.D. Kumaraswamy, releases India's Green Steel Taxonomy. Retrieved January 21, 2025, from <https://pib.gov.in/PressRelease>
- Shetty, S. (2023, February 7). Indian steel companies begin transitioning to green steel, seek supply of renewable energy & green hydrogen. SolarQuarter. Retrieved January 21, 2025, from <https://solarquarter.com/>
- Stanway, D. (2024). Big steelmakers failing to make the switch to renewables, survey shows. In Reuters. Retrieved January 21, 2025, from <https://www.reuters.com>
- Vipul, V. (2024, October 18). Decarbonizing India's steel industry: A strategic roadmap. EY. Retrieved January 21, 2025, from <https://www.ey.com/>
- Vynohradov, O. (2023, November 20). Guide on green steel making process and Impact on the industry. M HEAVY TECHNOLOGY. Retrieved from <https://www.mheavytechnology.com>
- Worldsteel. (n.d.). Energy use in the steel industry. In Fact Sheet. <https://worldsteel.org/>





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