Green Hydrogen's Role in Decarbonization of India's Iron & Steel Industry

Background

India is the world's second largest steel producer with a crude steel capacity of 154 Mt and production of 118 Mt (2021). The per capita steel consumption is 77 kg (world 233 kg, China 700 kg). India's steel industry consumed around 70 Mtoe of energy and the emissions were 252 Mt of CO_2 in 2019. The demand for steel will increase as the growth rate for finished steel is high in India. There are three technologies commonly used. Blast Furnace-Basic Oxygen Furnace (BF-BOF), direct Reduced iron (Coal)-Electric Arc Furnace (dRi-coal-EAF) and Scrap-Electric Arc Furnace (Scrap-EAF). CO_2 emissions per ton of steel by these technologies range from 2.5-2.85, 3.1 and 0.5-1 tCO2 per ton of crude steel (tcs) respectively. Emissions from natural gas based DRI-EAF route are about 1.5 tCO2/tcs, almost 50% less than the DRI (coal) – EAF route, however, India lacks domestic natural gas resource. Green hydrogen-based technologies have emissions as low as 0.05 tCO_2 per ton of crude steel. Given the target of Net Zero by 2070, we explore the role of green hydrogen in the industry.

India's Current Initiatives

The National Green Hydrogen Mission in india supports setting up pilot projects in the steel sector to promote the use of green hydrogen. The mission focuses on various thrust areas, including the use of 100% hydrogen in the dRi process, hydrogen injection in blast furnaces, and substitution of fossil fuels with hydrogen in a gradual manner. The mission focuses on developing a roadmap for green hydrogen deployment in the country and fostering collaborations between industry stakeholders, research institutions, and government agencies to drive the adoption of green hydrogen technologies in the steel sector.

The Mission focuses on using hydrogen in dRi processes, blast furnaces, and gradually substituting fossil fuels with hydrogen; companies like Nippon Steel and Tata Steel are conducting trials to inject hydrogen into blast furnaces. This process has shown potential in reducing coke consumption and emissions. initiatives like the Swedish Hydrogen Breakthrough ironmaking Technology (HYBRiT) and H_2green steel are pioneering the use of green hydrogen in dRi plants and EAFs. These projects aim to produce fossil-free steel using green hydrogen, with significant emission reduction targets. Studies have shown that the cost of steel production using green hydrogen technologies can be 10% to 60% higher in Europe and up to 120% more expensive globally. The cost depends heavily on the price of hydrogen and green electricity. The share of EAFs in steel production is projected to increase by 2030, as they are considered more environment-friendly compared to the traditional blast furnaces as they use scrap avoiding carbon-intensive iron making process, leading to lower carbon emissions. Currently, India is in its developing stage and does not have enough scrap for EAF.

The expansion of dRi plants using green hydrogen technology is expected to contribute to decarbonization efforts, by producing iron using hydrogen as a reducing agent. The implementation of supportive policies and regulations by the Indian government can further drive the adoption of low-carbon steel-making technologies, for which the National Green Hydrogen Mission provides a framework.

Key Aspects

Shaping the future of decarbonization in the Indian steel industry

Recently, European Union (EU) has thrown a challenge to all exporters by announcing the Carbon Border Adjustment Mechanism (CBAM), where all exporters would have to declare the CO_2 content in the exported goods, starting with steel, aluminum, cement, fertilizers, etc. The adoption of green hydrogen-based technologies, such as hydrogen injection in blast furnaces and H_2-dRi-EAF processes, is expected to increase significantly by 2030. This transition will be crucial in achieving sustainability targets and reducing

environmental impact. Government policies and regulations such as National Green Hydrogen Mission, India's Nationally determined Contributions (NdCs) commitments, and then Net Zero emissions by 2070, and other sustainability programs, provide a framework for promoting green practices in steel manufacturing.

The industry will require substantial investments in sustainable infrastructure and technology upgrades to support these decarbonization initiatives – in green hydrogen production, renewable energy integration, energy efficiency increase in the entire production chain, and carbon capture technologies to reduce emissions. The H_2-dRi technology, currently at Technology Readiness Level 6, requires significant advancements in production, storage, and transport infrastructure for scaling up. The cost of green hydrogen and the necessity of high-grade iron ore can make Indian steel less competitive than before. The Indian steel industry would require investments in the range of USd700-800 billion to achieve emission reduction targets through the adoption of green hydrogen and other low-carbon technologies.

Partnerships that focus on knowledge sharing, collaboration, and technology transfer, along with joint R&d projects, could accelerate the adoption of sustainable practices.

Projected Shares & Cost

Different steel-making technologies in India

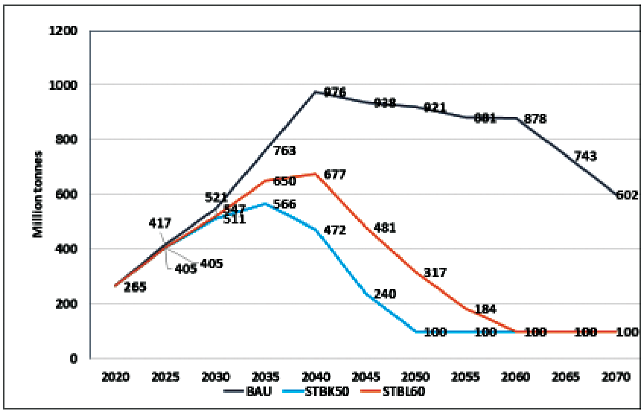
Integrated Research and Action for Development (IRADe) developed a model to determine the roadmap for decarbonizing steel industry. The projected shares of different steel-making technologies in India by 2030 play a crucial role in the decarbonization efforts. Starting from the current technology mix, it charts two optimal cost minimizing low-carbon pathways, considering the Net Zero goal by 2050 and 2060.

By increasing the share of green hydrogen-based technologies, EAFs, and dRi plants in the steel-making process, India can make significant strides towards decarbonizing its iron and steel industry by 2030. The figures give the emissions trajectories of the scenarios and the technologies selected. The cost of green hydrogen has been assumed to be USd5.37/kg in 2035 falling to USd2.75/kg by 2050.

The scenarios for integration of renewable power, either directly through the grid or through site-based hydrogen production, are also considered. in the long

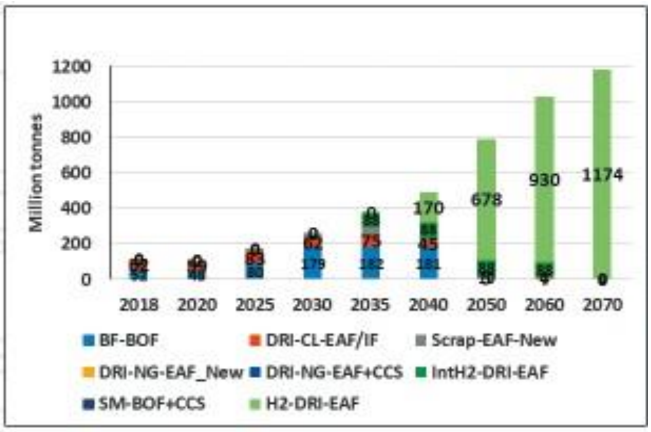
CO_2 Trajectory for the Indian Steel Industry

Scenario	Peaking Year	Peak CO_2 MT
STBL50	2035	566
STBL60	2040	677

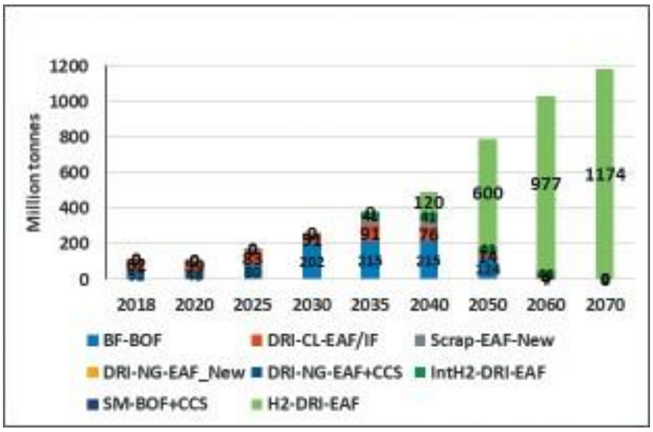


BAU: Business as usual with no constraint on CO_2 emissions.
STBL50: CO_2 emissions peak in 2035 and then declined gradually to stabilize at 100 MT in 2050 and continue thereafter
STBL60: CO_2 emissions peak in 2040 and then declined gradually to stabilize at 100 MT in 2060 and continue thereafter

Technologies Selected in Both Scenarios



STBL50 Scenario



STBL60 Scenario

run, site-based hydrogen production is advantageous. However, the allocation of Rs 80,000 crores for the GH2 mission, if well spent, could bring forward the transition earlier than indicated here.

Conclusion

The road ahead is not without challenges. Effective policy support and substantial investment in infrastructure are needed, such as for hydrogen transport, storage, and building substantial renewable energy capacity, for scaling up hydrogen-based steel production. The adoption of hydrogen can reshape the global steel value chain, open new trade routes, and bring economic shifts in regions with higher renewable energy sources. Transition to hydrogen-based production requires addressing social implications such as job shifts and ensuring that the reduction of carbon-intensive capacity aligns with the growth of green steel production.

Green hydrogen thus presents a promising solution for decarbonizing India's iron and steel industry. The Indian government's initiatives and the industry's growing recognition of the need for change, position green hydrogen as a viable pathway for a sustainable steel sector. As technology advancements bring down costs and production scales up, green hydrogen is poised to play a transformative role in decarbonizing India's iron and steel industry, ensuring its continued growth on an environmentally responsible path.

IRADe, in collaboration with FiCCi (Federation of Indian Chambers of Commerce and industry), organized a webinar in May 2024 on 'decarbonization pathways for the Indian steel industry: Role of green hydrogen'. 300 participants from around the world attended it, including Shri Ajay Raghava, Adviser, Ministry of Environment, Forest and Climate Change, panelists from international Energy Agency (iEA), Organisation for Economic Co-operation and development (OECd), Dr Jyoti and Kirit Parikh of IRADe, steel industries such as Jindal Steel, and iiT Bombay. The lead presentation was given by Dr Anjana Das, Senior Advisor, IRADe.

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