Climate Compatible Growth (CCG) in the iron and steel industry in India: rethinking patterns of innovation

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Key Messages

- India possesses the potential to become a global sustainable steel production leader, but present efforts are not enough to achieve Climate Compatible Growth (CCG) within the steel sector.
- Transition of the Indian iron and steel sector must be looked at through the lenses of industrialization, energy security, and self-reliance alongside sustainability.

Primary fume extraction from Electric Arc Furnace (EAF) at a steelmaking unit in India (Source: TERI in-house archives)

- Decarbonizing industry actions must tackle the making of primary crude steel given limited scrap availability and the projected demand for steel in India.
- Indian firms are pursuing various innovation pathways in primary steelmaking processes but slowly. Moreover, for novel technologies there is too much 'going it alone' – firms are generally working in isolation or separately pursuing partnerships with technology suppliers from the west.
- The promotion of international collaboration and technology diffusion, such as through setting up pilot and demonstration projects to advance sustainable pathways for the sector, is required.

Introduction – the importance of sustainable shifts for steel production in India

Iron and steel are deeply integrated within our societies, serving as key components of various products including buildings, infrastructure, and vehicles [1]. Among growing calls for sustainability [2], the sector is expected to grow, particularly in the Global South as more countries industrialize. Furthermore, decarbonizing our societies will see a major rise in demand for materials such as iron and steel [3, 4, 5].

Termed one of the 'hard to abate' sectors, due to a reliance on carbon-based technologies with limited commercially viable alternatives at present, the sector is a large carbon emitter [6].

In 2019–20, India's crude steel production was 111 Mt, or 5% of global production [7]. It is currently the world's second-largest steel producer, the third-largest consumer, and one of the most energy-intensive countries that produce steel in the world. Steel production is expected to grow [8, 9, 10]. The steel sector is very emissions intensive (the largest single energy consumer and largest CO_2 emitter in the industrial sector), due to a heavy reliance on coal (85% of energy inputs), numerous small production facilities, and the low proportion of scrap as an input [1]. For instance, while the global greenhouse gas (GHG) intensity of steel produced through Blast Furnace-Basic Oxygen Furnace (BF-BOF) is 2 t CO_2/t of steel, in India steel produced through BF-BOF is 2.5–2.85 t CO_2/t. The GHG emissions of steel in India produced through direct reduced iron Electric Arc Furnaces is 3 t CO_2/t of steel [11].

The Indian steel industry is also heterogeneous: steel production consists of BF-BOF (45%), Electric Arc Furnace (EAF) (29%), and Induction Furnace (IF) (26%) methods [12].

The six major producers in India produce about 64% of steel [13]**.** However, there are also a large number of small and medium scale steel producers using mini-BFs. Moreover, steel produced using

EAF and IF is mainly done by these small and medium steel producers.

In addition, 21% of steel production is by State Owned Enterprises (SOEs). India is also the largest producer of sponge/direct reduced iron (DRI). Sponge iron production is estimated to be 34.15 Mt (2020–21) [13]. DRI is mainly coal-based at 82% with the remainder being natural gas-based at 18% [13]. The use of electric furnaces is also higher (56%) compared to the global average (28%) [1].

Innovation is needed for decarbonization of the iron and steel industry in a sustainable way. New technologies are being developed that cut down carbon emissions significantly in this sector [14], making their adoption in countries like India an important pathway toward decarbonization [5]. Moreover, government must play a central role in any transition [15]. Given the important role of the iron and steel sector in Low and Middle Income Countries (LMICs), including India, in meeting decarbonization and sustainability goals, how can we bring about systems-wide changes? Should we be thinking about innovation differently?

Results

Discussions with various informants working on this sector in India and globally[1], complemented by reviewing further studies on this topic, revealed the following insights:

- **Sustainability is one of several goals including industrialization, self-reliance, and energy security in India**
- Decarbonizing this sector **must tackle primary steel production** given limited scrap availability and the projected demand for steel in India.
- India is concerned about being too dependent on other countries for the import of materials and manufacture of goods as manifested in campaigns such as 'Make in India' [16]. Therefore, efforts aimed at decarbonization and sustainability must be considered **alongside industrialization, energy security, and self-reliance goals.**
- Hence, decarbonization options that can concurrently support these goals are likely to be favoured as demonstrated by the recent National Hydrogen Mission, including **policy support to become a global hub for green hydrogen production and export** [17]. Rapid developments in hydrogen production technologies could promote the use of hydrogen as a reducing agent in place of coal, especially for making DRI.
- At the same time, **blast furnaces (BF)** (which have technical limitations regarding the amount of hydrogen that can be used as a fuel) **will remain an attractive option in the near future** for Integrated Steel Plants (ISPs) in India. These are considered the most efficient technology for large-scale production.
- Governments must account for **social implications** when transitioning the steel sector in India, as the economies of India's Steel Belt (particularly West Bengal, Odisha, Jharkhand, and Chhattisgarh) in eastern India are heavily based around steel and coal [18].

Innovation drivers and barriers for Indian steel majors:

- The market for steel in India is more insular versus other regions, and costs prevail in company decisions. Also, there is virtually no demand for green steel in India. Thus, **Indian steel firms do not see a first mover advantage** in developing and / or adopting green steel technologies.
- **Commitments by senior executives** are required to shift mindsets and direct resources within firms towards greening the steel production process.
- **The market is very heterogenous** with respect to iron and steel production. For instance, there are about 16 large-scale BFs, which are typically over a decade old, and 57 mini BFs, which are quite inefficient [19]. This suggests a **differentiated approach to steel production transitions**, such as initially targeting older plants to adopt new technologies rather than firms with recent and/or advanced BFs that are too new to be dismantled.
- **Efforts to shift production processes are happening but slowly**.
- **Intellectual property (IP)** is less of an issue on individual technologies; however, it may become an issue in thinking about the integration and optimization of the production process.
- **ISPs are actively pursuing partners and multiple technology avenues.** This is good as it reflects the diversity of the sector and can

[1] After obtaining approval from Carleton University's Research Ethics Board, we conducted thirteen semi-structured interviews with various experts including representatives from Indian steel firms, as well as representatives from academic, intergovernmental, and governmental organizations who have been working on the global and / or Indian iron and steel or coal sectors during Summer 2021.

help to avoid 'lock in' with respect to one or two technologies.

- However, firms are playing more of an **adopter versus developer role**.
- There is **too much 'going it alone'** – firms are generally working in isolation making these approaches fragmented and slow.
- Therefore, there is a need for more **government research, development, and demonstration (RD&D) support, and collaboration amongst firms and other players,** such as academia, suggesting the need for a sectoral approach. This is important within the Indian iron and steel sector and globally as there is no collaborative platform for most steel RD&D worldwide. Moreover, in India, support for low carbon RD&D appears heavily weighted towards localizing nuclear technological development [20], but support for developing some low carbon options such as renewables and process technologies for heavy industries is rather limited.

Policy recommendations

India possesses the potential to become a global sustainable steel production leader, but present efforts are not enough to achieve Climate Compatible Growth (CCG) within the steel sector.

Bold policy incentives for green steel are required. These include:

- **Promote international collaboration and technology diffusion** through setting-up of pilots and demonstration plants for hydrogen-based steel production (possibly using bilateral/multilateral climate mechanisms like the Green Climate Fund (GCF)), seeking climate finance, and technology collaboration.

  More government procurement is required to help foster market demand: Spurring innovation is different in India in that the government is more directly involved in the economy, such as through State Owned Enterprises (SOEs), including the Steel Authority of India Limited (SAIL). At the same time, there is more general acceptance that the government should help firms. This more active government involvement in the Indian economy can be leveraged to foster CCG in the steel sector in India, such as through forward-thinking procurement policies.
- **Develop a robust policy framework to transform the industrial sector in India, including steel**: CCG within the steel sector in India requires nothing less than a transformation of this sector. Building on existing initiatives to support innovation in the steel sector such as the Steel Research and Technology Mission of India, this visioning, coordinating, and executing role could be taken on by an agency charged with Industrial Transformation.

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Notes

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