A DEEP DIVE

FROM ALLOCATION TO DELIVERY: CLOSING INDIA'S INDUSTRIAL DECARBONIZATION GAP

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Key Insights

- Most new iron and steel capacity is fossil fuel-based and planned expansion may double sectoral emissions by 2030.
- Large parts of the iron and steel and green hydrogen sectors are uncompetitive, and innovation investment is thin. A small number of steel firms have the resources to decarbonize. Key technologies are imported and research spending is below 1% of GDP.
- Constraints for both sectors are commercial, not technological, and green premiums are steep. Gas-based direct reduction of iron costs 2.5 times its coal equivalent to build and green steel carries a 6% premium. Just 8,000 of 862,000 tonnes of hydrogen capacity, for which subsidies were awarded to firms by the government, were actually built.
- Weak policy clarity depresses expected returns. No purchaser must buy certified green steel, so decarbonizing producers capture no premium while capital, skills, and demand signals stay uncoordinated.

Methodology

This policy brief is a part of the Climate Policy Lab's Implementation Gap Analysis (IGA) project, which examines the discrepancy between climate policies and their intended outcomes. A previous policy brief (Jain & Gopalakrishnan, 2025) assessed 31 Indian climate policies to identify which implementation gaps affected the most policies.

Building on the previous study, this deep dive draws on five semi-structured expert interviews conducted in 2026 with: an official at the Bureau of Energy Efficiency (1); a former Ministry of Steel official (2); an executive at a large integrated steel producer (3); a consultant advising the Ministry of Power and Bureau of Energy Efficiency (4); and a secondary steel association representative (5) in order to ask why three well-specified instruments – Perform, Achieve and Trade (PAT), the National Green Steel Mission, and the National Green Hydrogen Mission – have not delivered at scale, particularly in relation to the decarbonization of the steel sector. Evidence was triangulated against policy documents,

official statistics, and the results of a previous report published by the Climate Policy Lab as part of the IGA.

Country Context

India has committed, under its Nationally Determined Contribution to the Paris Agreement, to reduce the emissions intensity of its economy by 47% below 2005 levels by 2035, to raise the installed capacity of non-fossil fuel energy to 60%, and to create an additional carbon sink of 3.5 to 4 billion tonnes of CO_2 equivalent by 2035, alongside a net-zero target for 2070.

The country is the world's second-largest steel producer, at approximately 151 million tonnes of crude steel in FY2024–25, with capacity targeted to reach 300 million tonnes by 2030–31. The sector accounts for 10–12% of national CO_2 emissions, roughly 260 $MtCO_2$ annually, and is among the most emissions-intensive globally at 2.54 tCO_2 per tonne of crude steel against a world average of 1.91 tCO_2. India has set a national goal of 2.2 tCO_2 per tonne by 2030.

Coal-based direct reduced iron (DRI), of which India is the world's largest producer, accounts for close to 30% of crude steel output at 2.7–3.1 tCO_2 per tonne and is concentrated in small standalone units clustered in the states of Chhattisgarh, Odisha, and Karnataka. Induction furnace production, largely dependent on coal-based DRI, has risen from 29.5% to 35.4% of output since 2019–20, while the electric arc furnace share has fallen from 26.0% to 21.9%. Because *nearly all announced new capacity is fossil-based,* sector emissions are projected to roughly double by 2030 even as intensity targets tighten. Draft emission-intensity targets covering 255 iron and steel units and 358.6 $MtCO_2e$ take effect under the Carbon Credit Trading Scheme from FY2026–27.

> "Because nearly all announced new capacity is fossil-based, sector emissions are projected to roughly double by 2030 . . ."

Three instruments govern this transition. First, the National Green Steel Mission, with an estimated outlay of ₹15,000 crore, brings together a production-linked incentive for green steel, renewable energy incentives, a mandate for government agencies to procure green steel, hydrogen pilot projects, and scrap recycling measures. Its analytical foundation is the September 2024 report, Greening the Steel Sector in India: Roadmap and Action Plan, prepared on the recommendations of 14 task forces; its measurement framework is the Green Steel Taxonomy of December 2024, which made India the first country to define green steel formally, setting a threshold of 2.2 tCO_2e per tonne of finished steel. The procurement mandate has not yet been enforced.

Second, the National Green Hydrogen Mission, approved in January 2023, targets 5 million tonnes of annual production by 2030 through the Strategic Interventions for Green Hydrogen Transition (SIGHT) programme, and has allocated ₹455 crore to pilot projects in the steel sector. As of May 2025, 19 companies held production allocations totaling 862,000 tonnes per year; commissioned capacity as of February 2026 stood at approximately 8,000 tonnes per year. Third, Perform, Achieve, Trade (PAT), launched in 2012 and now covering roughly 1,343 designated consumers across 13 sectors, is India's longest-running industrial efficiency instrument, with its large industrial sectors now transitioning to the Carbon Credit Trading Scheme.

Climate Policy Lab's previous policy brief addressing implementation gaps in Indian climate policies (Jain & Gopalakrishnan, 2025) found evidence that the National Green Hydrogen Mission suffered from *policy design, technology,* and *competing goals* related implementation gaps. The policy was found to reflect strong ambition but limited planning for market creation; it focusses too heavily on supply side measures and overlooks mechanisms to generate domestic demand; higher cost and risk means that private investment is confined to export markets. Further, electrolyzers were found to be largely imported with domestic manufacturing capacity absent and storage and transport

infrastructure underdeveloped. Hydrogen production was also found to compete for limited renewable electricity, such that prioritizing it could exacerbate short term emissions. PAT was hindered by implementation gaps related to *policy design* and *data, communication, and information*. The policy was found to combine ambitious targets with inconsistent timelines and limited follow-through. It was also found that while monitoring is relatively strong among large industries, data collection from micro, small, and medium enterprises (MSMEs) remains inconsistent and often relies on self-reporting. Finally, results regarding the National Green Steel Mission were relatively inconclusive aside from the identification of technology as an important implementation gap.

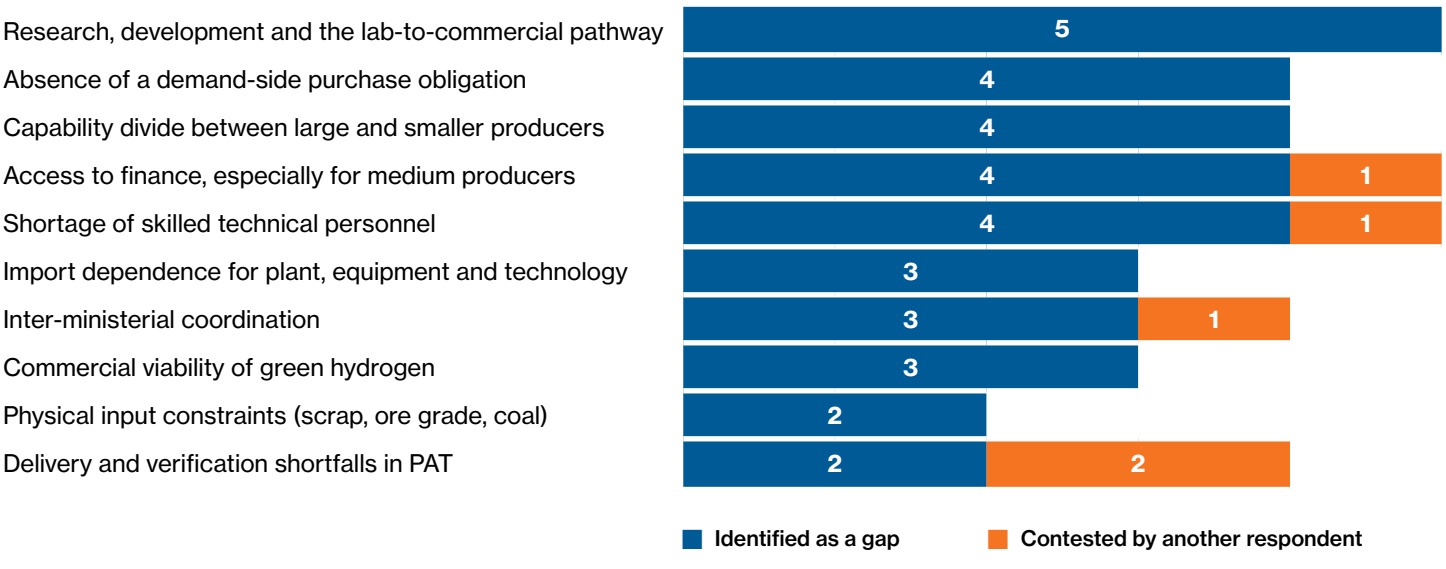
Consequently, this deep dive aims to better understand the extent of and reasons for implementation gaps specific to the green steel and green hydrogen industries through the study of the aforementioned three policies. The brief asks the following questions: (A) What is the industrial structure of the sectors and how does it affect competitiveness? (B) Do the sectors invest in research, development, and demonstration (RD&D) and does the country have adequate policies in place for the incentivization of RD&D? (C) What are the chief factors holding back the decarbonization of the sectors and to what extent is technology really a binding constraint? (D) Do policies provide an adequate signal to firms and are they enacted compatibly?

Findings

Large sections of Indian green industries are not globally competitive, and the sector as a whole is constrained by a lack investment in innovation.

Indian heavy industry is not one sector but two. Of roughly 1,200 entities in iron and steel, the top 30 to 40 possess the capital, technology access, and skilled personnel to decarbonize, are internationally partnered, and are already implementing measures; the remainder run older technology without monitoring, reporting, and verification systems. The latter segment often lacks reliable tax data, let alone emissions data, leaving these firms invisible to any instrument

Figure 1: Where the evidence converges, and where it does not
Implementation gaps identified in India's industrial decarbonization policies, across five expert interviews



premised on measurement and unable to compute embedded emissions for the EU's Carbon Border Adjustment Mechanism.

Both the relatively advanced organized section and the small firm section of Indian green industries, however, are technology receivers rather than innovators. Plant and equipment are overwhelmingly sourced abroad: complete plants from China for electric arc furnace and DRI routes, blast furnaces from Germany and France among other countries, and electrolyzer and advanced- technology vendors – from predominantly foreign vendors.

This is because India's RD&D ecosystem is inadequate – the one proposition on which every respondent agreed. Research expenditure remains below 1% of GDP and is concentrated in four or five large producers; the unorganized sector conducts effectively no RD&D, confining itself to process improvement. What research does occur is largely incremental rather than novel, and the technologies that reach Indian plants are typically imported. Of particular importance is the lack of funding for transitioning technologies to commercial scale – a lack of demonstration facilities, risk-sharing arrangements, and financing that persists across the time horizon a novel plant requires. The recent consolidation of research funding is a positive development but has yet to translate into manufacturing outcomes.

Industrial decarbonization is limited by commercial rather than technological concerns.

The binding constraint on India's industrial decarbonization is commercial rather than technological viability and is most visible in the distance between what has been funded and what has been built. What prevents adoption is cost and handling. A gas-based vertical shaft reactor, a vessel used to convert solid metal oxides into reduced metals – crucial for the production of steel – is 2.5 times as expensive to install as a coal-based system of equivalent capacity, so smaller producers will not convert voluntarily; and because they are steelmakers rather than gas producers, they cannot finance their own feedstock supply. Interviewee 3 locates the frontier further upstream, in low-cost electrolysis, hydrogen storage and transport, and carbon capture and long-duration storage, compounded by the geographic mismatch between renewable resources in the west and south and steel capacity in the east.

The green hydrogen incentive demonstrates the consequence. Under one SIGHT funding allocation tranche awarded for capacity expansion, ten companies accepted production awards; a single awardee has built, and then only partially, while the remainder have neither implemented nor retained the funds. The capital outlay, as designed, was insufficient to establish a viable business case: the instrument offered production support without a demand-side incentive, an offtake mechanism, supporting infrastructure, or sufficient industrial application. National figures follow the same pattern: only approximately 8,000 of the 862,000 tonnes per year of awarded capacity has been commissioned.

> "Policy interventions have failed to adequately coordinate capital, labor, and demand…"

Lack of policy and institutional clarity further constrain returns on decarbonization investment for firms.

Policy interventions have failed to adequately coordinate capital, labor, and demand – thereby slowing the pace of decarbonization. Capital is available but unevenly distributed: the largest five or six producers can fund their own transition, medium-scale plants cannot, and India has no equivalent of the innovation funds available under the European or Chinese schemes. Pilots lack viability gap funding, and private investment does not match public commitment. Skilled personnel

are short at every level – senior, middle, and technician – and the pipeline is not being replenished. Engineering graduates entering manufacturing do not choose metallurgy, resulting in an inadequate supply of the engineering skills required to build and operate new process technology.

Nothing in India's industrial decarbonization architecture obliges anyone to buy the products whose production it attempts to incentivize. A green steel taxonomy is in force and certification available, but no purchaser, public or private, is required to buy against it. Firms therefore treat certification as desirable rather than necessary, and commercial organizations act on requirement or profitability before desirability.

> "A producer who decarbonizes consequently bears the cost without capturing a return."

A producer who decarbonizes consequently bears the cost without capturing a return. According to an interviewee from a large cement producer, the company earns no premium for manufacturing cement at roughly one-third of the global average embedded carbon intensity, only customer preference at parity pricing. Mandating green production without a buyer willing to pay the incremental cost (approximately 6% for green steel) transfers an unfunded liability to the producer. Respondents independently proposed similar remedies, differing only in instrument: public procurement through central construction agencies, a tax concession offsetting the premium, a green public procurement policy, and a compulsory purchase obligation on infrastructure and automotive buyers.

The contested assessments of the Perform, Achieve, Trade (PAT) scheme are illuminating. It is the one instrument on which this study records as much disagreement as agreement. The implementing agency's account presents the scheme as a success: compliance of 85–90% including through certificate purchase, coverage of roughly half of national final energy consumption, 110–120 $MtCO_2$ avoided annually, and targets set unit by unit rather than at flat sectoral rates (Interviewee 1). However, a different account from within the same institutional context describes a scheme that underperformed on institutional capacity – lapsed sector expert position contracts, vacant economist positions, limited delegated authority, and reports certificates issued for only the first three of seven officially declared cycles, which independent analysis corroborates (Interviewee 4).

Recommendations

The fundamental problem affecting Indian industrial decarbonization policy is a lack of coordination between demand and supply side incentives as well as between the different actors and stakeholders – capital, labor, innovation system, and institutions – in order to create the appropriate enabling conditions for successful green industrialization. These recommendations should be read in that context and applied in ways that allow policies to point in the same direction, building a coherent framework.

SUPPLY SIDE

Differentiate instruments by firm size. A single design cannot reach both a globally competitive top tier as well as the smaller segment that lacks basic reporting data. Concessional finance, standardized reporting templates, verifier training, and CBAM compliance support should target smaller producers explicitly.

Establish an industrial decarbonization innovation programme. A dedicated programme should combine commercial-scale demonstration plants for hydrogen-based reduction, carbon capture and storage, and iron ore beneficiation, funded through viability-gap support and sited in production clusters. It should establish differentiated appraisal and risk norms, so first-of-a-kind projects are not assessed on criteria designed for conventional capacity. It should also adopt removal of fiscal treatment that

penalizes industry-funded research, including the treatment of sponsored RD&D as a taxable service; establish sector-specific allocation with defined manufacturing outcomes rather than generic research funding; and provide shared access for small and medium-scale producers, who conduct almost no research of their own.

Build the technical skills pipeline. Shortages extend from technician to senior engineering levels, and the pipeline is not being replenished. Expanding metallurgical and process engineering capacity in technical institutions, and funding industry-linked training for verifiers and energy managers, would address a constraint that tightens as capacity expands.

Develop shared feedstock infrastructure at cluster level. Requiring DRI producers to develop their own syngas or hydrogen supply means asking capital-constrained firms to enter an unrelated business. Merchant supply sited within existing clusters converts a firm-level capital barrier into a shared utility.

DEMAND SIDE

Enforce the green public procurement mandate. The procurement mandate within the National Green Steel Mission converts an existing taxonomy into a market and is the most widely supported measure in this study. Enforcement should be paired with a transparent cost-offset mechanism so that infrastructure agencies do not absorb the premium unfunded.

Use procurement to develop domestic equipment manufacturing. Plant, equipment, and advanced technology are predominantly imported. Attaching phased domestic content expectations to procurement and production incentives, supported by technology partnerships and public demonstration programmes, would convert guaranteed demand into manufacturing capability.

Link hydrogen incentives to commissioning rather than allocation. SIGHT presently rewards capacity. Tying disbursement to commissioned output, and pairing production incentives with offtake obligations in fertilizer, refining, and steel, would narrow the gap between allocation and production.

INSTITUTIONAL REFORM

Establish a standing inter-ministerial coordination platform. Implementation requires the Ministries of Steel, Power, New and Renewable Energy, Coal, Finance, and Commerce, among others, to act in concert, and overlapping obligations impose duplicative burdens on firms. A permanent body with a published mandate would resolve such conflicts and track whether task force recommendations are translated into instruments.

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