Final Report

Evaluation of the Scheme

"Promotion of Research & Development in Iron and Steel Sector"

Submitted to

Ministry of Steel

Government of India

By

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EXECUTIVE SUMMARY

India's steel industry has emerged as a global powerhouse. As of 2024, India stands as the second-largest producer of crude steel globally. It is also the third-largest consumer of finished steel worldwide, following China and the United States. It contributes about 2% to India's GDP.

Modern steel making in India is rapidly adopting green technologies such as hydrogen-based steel production, and extensive recycling programs.

1. Terms of Reference for the Study

The terms of the assignment as given by the Ministry for this study are given as below:

i. Analysis of objectives of the scheme vis-à-vis the national perspective.
ii. To evaluate the Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis of the Scheme.
iii. To study and evaluate the performance of the scheme by taking into consideration all objectives of the scheme and interventions/support measures provided, so as to bring in further improvements in implementation of the scheme.
iv. To study and assess to what extent the various R&D projects under the scheme have yielded results vis-à-vis the objectives of the individual R&D projects as well as the overall objectives of the scheme.
v. To study the utilization of funds by the institutions vis-à-vis sanctioned projects/scheme guidelines and whether the funds have been utilized for the purpose for which it has been given.
vi. Few case studies to be prepared while evaluating the scheme, in terms of the success and failure and analysis of the reasons for failure & success.
vii. To give suggestions and recommendations for further improvement in the scheme.
viii. To recommend justification for continuation of the scheme or otherwise.

2. Methodology

This study is both descriptive and analytical in nature, designed to thoroughly evaluate the "Promotion of Research & Development in Iron & Steel Sector" scheme. The aims is to assess the effectiveness, efficiency, and impact of the scheme, with a focus on both ongoing and completed projects. Relevance, Efficiency, Effectiveness, Impact, Sustainability, and Equity framework has been used for analysis and evaluation.

The evaluation has been carried out in two parts. The first part focuses on the overall objectives, design, implementation and performance of the scheme. This includes the analysis of the scheme's alignment with national priorities such as the National Steel Policy. Similar R&D initiatives in other leading steel-producing countries have been studied to identify best practices and their usefulness for our context.

The second part involves an assessment of individual projects, including both completed and ongoing projects but more so the ongoing projects, as the earlier evaluation of R&D scheme was done in 2020, which covered the earlier projects. The study covers 3 completed projects initiated before the agreed timeline to assess their impact and 28 of the remaining 35 for in-depth investigations. Field visits were undertaken to a sample of projects, and interactions were held with Principal Investigators, project teams, and other stakeholders.

The evaluation also assesses the contribution of projects to knowledge generation, skill development, and capacity building within the Indian steel sector. The primary data has been supplemented with secondary information from Ministry Annual Reports, project proposals, monitoring committee reports like Project Review Committee, and other relevant documents.

3. Findings

3.1 The Sector

- National Steel Policy (NSP) 2017 was introduced with an ambitious vision of achieving 300 million tonnes (MT) of crude steel production capacity and 255 MT of production by 2030–31, while increasing per capita steel consumption from 97.7 kg to 158 kg.
- The production of each type of steel is continuously increasing. Private sector producers make up most of the output. The overall steel production for the country grew from 103,545 in 2020-21 to a peak of 144,299 in 2023-24.
- India's steel consumption has been growing at an impressive compound annual growth rate (CAGR) of 14% over the last four years. However, per capita finished steel consumption is very low in India. It was 214.7 kg for World and 601.1 kg for China in 2024 25. The same for India was 108 kilogram.
- The steel sector currently contributes to 7 – 10% of India's total CO2 emissions. the average emission intensity of steel production in 2023-24 in India was 2.54 tonne of CO2 per tonne of crude steel, whereas the global average for the same

is 1.85 – 1.91. Similarly, the energy intensity of India's steel sector is approximately 6-6.5 Gigacalories (Gcal) per tonne of crude steel, which is significantly higher than the global average of 4.5-5 Gcal/tonne.

- Key initiatives such as the "Greening the Steel Sector in India: Roadmap and Action Plan" and the newly announced Green Steel Taxonomy aim to promote low-carbon steel production through process innovations, technological advancements, and investment in cleaner alternatives.
- Equally crucial is the issue of raw material security, it remains heavily dependent on imported coking coal. To mitigate this strategic vulnerability, the Ministry of Steel is aggressively pursuing initiatives such as increasing domestic production through Mission Coking Coal, beneficiation of iron ore, optimizing coking coal blends, and expanding the use of pellets.
- In parallel, India is making significant strides in specialty steel development, a crucial segment that underpins high-tech applications in defence, automotive, electronics, and other strategic industries.

3.2 R&D in the Steel Sector

- World Steel Association reports that in 2023, the steel industry invested 7.25% of its revenue in new products and processes which includes capital expenditure and R&D investment.
- Research and development in the steel industry globally encompass a wide array of activities aimed at improving processes, enhancing product quality, and reducing environmental impact. From exploring new alloys to refining manufacturing techniques, R&D initiatives drive innovation across every facet of steel production.

3.3 *R&D in Steel in other countries*

- In China, there's an increase of 3.37% in R&D expenditure from 2024 to 2025. China's steel R&D is linked to its "dual-carbon" goals: to peak CO_2 emissions before 2030 and reach neutrality by 2060. The plan includes raising electric arc furnace (EAF) share from about 10% to 15% by 2025 and 20% by 2030. The government funds hydrogen steelmaking, direct reduction iron (DRI), and CCS

projects. It also gives subsidies for early-stage research. Companies, universities, and institutes are encouraged to form alliances, supported by green credit, low-interest loans, and innovation grants.

- The Technology Roadmap Program (TRP) in the United States set a 20-year vision for the steel sector, identifying the main research challenges and opportunities. The researches are carried out by the universities, national labs, and private firms. Only projects with industry cost-sharing are funded. Normally, Department of Energy covers about half the cost, while steel companies provide the rest through money, facilities, or staff. **The** Industrial Demonstrations Program is investing US$6 billion in 33 large projects, including several for clean steel.
- The European Commission (EC) funds steel research through the Research Fund for Coal and Steel (RFCS), which provides about €111 million per year. In 2025, an additional €175 million was allocated: €100m for breakthrough steel technologies, €35m for coal transition, and €40m for the annual call.
- Japan's New Energy and Industrial Technology Development Organization (NEDO) runs major steel R&D programs as part of its 2050 carbon-neutral goal. Its Green Innovation Fund (2021–2030) supports hydrogen steelmaking, EAF development, and CO_2 capture. NEDO also backs international research.
- ULCOS (Ultra-Low CO_2 Steelmaking) began in 2004 with 47 partners from 15 countries. Its target is to reduce steel CO_2 emissions by 50%. It tested new processes like Hisarna smelting reduction**,** Top Gas Recycling Blast Furnace (TGR-BF)**,** ULCORED DRI**,** and electrolysis routes.

3.3 ***R&D in Iron and Steel in India***

- Expenditure on R&D in steel is very low in India, which is less than 1%, far below the global average of nearly 2%.
- The Ministry launched the Scheme "Promotion of Research & Development in Iron and Steel Sector" to address the need.
- The Ministry provides funding under the R&D Scheme for research in green steel technologies, waste utilization, and energy efficiency to support innovation.

- A key focus of the NSP 2017 is on Research & Development (R&D), recognizing that innovation is essential for India to achieve global efficiency benchmarks, develop high-end steel products, and reduce its dependence on imports for specialty steels.
- As of 2024-25, out of 70 projects funded under this scheme, 35 have been completed and 35 remain ongoing.
- Ministry of Steel prefers R&D project proposals in joint collaborative mode, made by reputed academic institutions, research laboratories and steel companies for pursuing R&D projects for development of new alternate processes and technologies.
- The thrust areas have been identified in consultation with the stakeholders for providing support under the scheme.

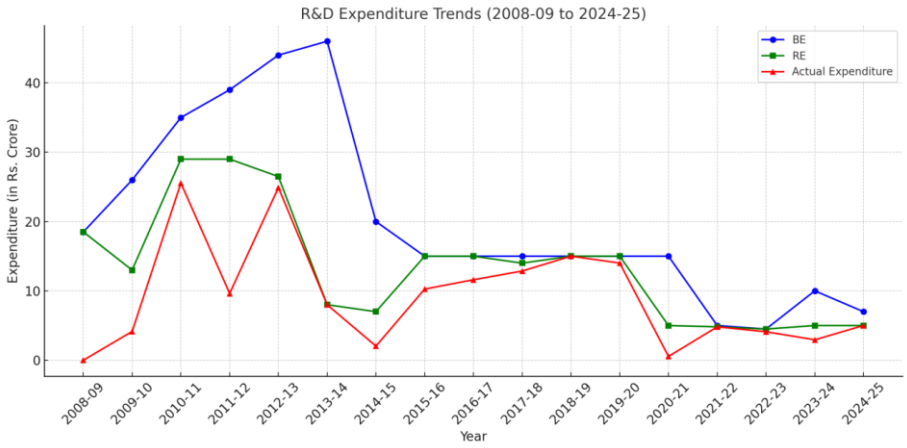
3.4 Implementation of the Scheme

- Researchers from premier institutions like IMMT, NML, IITs etc. are invited to submit the proposal for R&D in the iron and steel sector.
- An Evaluation Group comprising members from Principal Scientific Adviser to the Government of India, DRDO, DST, Premiere Academic Institutions and Industry, carry out evaluation of the R&D proposals received for funding under the scheme.
- A Project Approval and Monitoring Committee (PAMC) under the Chairmanship of Additional Secretary and Financial Adviser and Joint Secretary, Ministry of Steel, Director IIT Kharagpur, Director IMMT, Director NML are the 2nd Stage approving body for the R&D proposals recommended by Evaluation Group.
- Final approval is accorded by the designated authority based on the cost of the project as per the guidelines issued by Department of Expenditure.
- A Project Review Committee monitors the progress of the on-going projects on a regular basis.

3.5 Performance Assessment

- While the Ministry demonstrated effective fund utilization in the initial years, the recent under-utilization of R&D budgets signals a need for stronger execution mechanisms.

- From 2015-16 to 2019-20, the Ministry consistently allocated around 15 crore rupees annually, however, it became less there onwards.
- In the years 2021–22, 2022–23 and 2024–25, the money spent under the R&D Scheme was almost the same as what was planned in the revised budget. However, in 2023–24, less money was used than originally planned.



Source: Ministry of Steel

3.6 Overall Assessment

i. **Relevance**

a. The Scheme supports the development of innovative, cost-effective, and sustainable technologies to address challenges such as climate change, energy efficiency, waste utilization, and raw material conservation.

b. Advanced techniques are being applied in materials and structural design, including steel-masonry buildings, ceramic tiles from industrial residues, and enhanced binders for cement.

c. Some projects integrate modern technologies like machine learning and AI for online monitoring of industrial processes.

d. The projects funded under the Scheme emphasize resource efficiency, eco-friendly solutions, cost reduction, and improved performance, addressing gaps in conventional processes while promoting innovation in the steel and related sectors.

e. The projects outcomes are likely to be highly valuable both for industry as well as academia.

ii. **Effectiveness**

a. 18 projects (58.10%) reported collaborations with external agencies, while 13 projects (41.9%) had none, while the private organizations were the the most common partners. It may be noted that the Scheme stipulates that collaborative projects would be preferred.

b. Government research institutes were involved in 5 collaborations, such as CSIR-CIMFR (Dhanbad) and RDCIS-SAIL (Ranchi).

c. Most projects have duration of 24 months with 51.6 percent share. 18-month projects come next with 25.8 percent. 36-month projects account for 12.9 percent. Only 1 project each are of 17 months, 12 months and 7 months duration (3.2 percent).

d. Out of 31 responses, most PIs (77.43%) reported that they did not have to modify their project after PRC suggestions.

iii. **Efficiency**

a. Most of the researchers who completed their projects indicated that they have achieved the results that they had attempted.

b. Some projects were delayed, because often they could not procure the equipment in time. Sometimes the funds were received by them at a later date than they expected.

c. As per the survey responses, most of the PIs (about 87.1 percent) reported that the budget allocated for the research was sufficient. Only 6.45 percent stated that the budget was not enough, while around 6.45 percent felt it could be increased.

iv. **Impact**

a. 83.9% Projects have not yet reached the commercialization stage, while only a small proportion (16.1%) have successfully transitioned towards commercialization.

b. Soon to be commercialized projects focus mainly on industrial and agricultural applications.

c. Out of the 31 responses received during the survey, most PIs, about 68%, reported that their projects did not result in any patents.

d. Majority of projects, about 74.19 %, have not led to publications or working papers.

e. Out of 31 responses, about 20 projects (65%) reported papers or talks presented externally, while the remaining 11 projects (35%) have either not presented their work yet, were awaiting patent clearance, or marked as “No/NIL/NA.”

f. Most PIs (77.4%) do not receive any honorarium or royalty in IPR / project’s commercial use, while a very small fraction (3.2%) reported receiving honorarium / royalty.

v. Sustainability

a. Several of the 31 projects contribute in achieving multiple SDG goals.
b. 1 project working on safer handling of toxic wastes relates to SDG 3 goals.
c. 3 projects working on Reduced water consumption in beneficiation, effluent management relate to SDG 6 goals.
d. 6 projects working on Hydrogen, renewable energy in steel, syngas substitution relate to SDG 7 goals.
e. 12 projects working on New tech for beneficiation, AI-based automation, electrolyzers, innovation in steelmaking relate to SDG 9 goals.
f. 2 projects working on Structural steel in resilient, low-cost buildings relate to SDG 11 goals.
g. 8 projects working on Recycling waste, efficient resource use, sustainable production relate to SDG 12 goals.
h. 15 projects working on CO2 reduction, decarbonization, hydrogen-based DRI, cleaner production relate to SDG 13 goals.
i. 2 projects working on Safe sludge disposal, reduced land degradation relate to SDG 15 goals.
j. 1 project working on Public-private collaborations in R&D relates to SDG 17 goals.

vi. Equity

a. Few institutes (IMMT, IIT Bombay, NML) have received multiple projects, while many others have limited participation.
b. Government sponsored organizations, while doing few projects, command a significant share of grants.
c. Majority of respondent Principal Investigators (PI) (83.83%) have not undertaken more than one project under the same scheme, while smaller portions (16.12%), primarily from CSIR-National Metallurgical Laboratory and IIT Bombay have managed multiple projects.

vii. Coherence

Presently, there is no active collaboration for resource pooling, either financial or human, with other government schemes, while there is scope for the same with many.

4. Recommendations

i. The scheme is needed to help increase the R&D in Iron and Steel Sector.

ii. The Mission / goal(s) of the scheme may be specifically spelt out.

iii. The Ministry may include one more objective of 'creating and facilitating enabling environment for R&D'.

iv. The Ministry may consider bringing at least one multidimensional team together of researchers from different institutions to prepare a futuristic proposal and fund it under the scheme.

v. The Ministry may modify the condition of finding industrial partner for the submission of the project proposal.

vi. The Ministry needs to take care of the procedural problems being faced by the scientists, conducting the research under this scheme.

vii. The detailed and complete process of monitoring and funds release needs to be documented and provided to the scientists after a project is awarded to him or her.

viii. Incentivizing R&D for the scientists may improve the quality of researches.

ix. Some measures need to be put in place for non-performance as well.

x. The Ministry needs to include MSMEs in the process.

xi. A pool of money can be created at the scheme level, with contributions coming from industry, including the MSMEs.

xii. In view of the significance of the MSMEs for the economy, the Ministry may consider incorporating one or two representatives from their associations in the Project Approval Committee.

xiii. An inventory at the national level of equipment purchased under the scheme needs to be maintained and the facility thus created be made available to all the researchers who want to work on those equipment.

xiv. Strong linkages should be developed between the scheme with the Steel Research and Technology Mission of India.

xv. The scheme needs to be aligned with R&D initiatives and related activities of other ministries as well.

xvi. The Ministry may also explore establishing linkages with Global Capability Centres relevant to steel industry.

xvii. The Ministry may establish linkages with the startup ecosystem and invite individuals to take up their innovative ideas in the steel sector under this scheme.

xviii. There has been greater focus on the process development through R&D in the scheme. The Ministry may think of funding product development projects more.