The Energy and Resources Institute
Creating Innovative Solutions for a Sustainable Future

DIW BERLIN

FINANCING DECARBONIZATION OF THE SECONDARY STEEL SECTOR IN INDIA

Towards an Enabling Environment

vivideconomics
CLIMATE Strategies
IKEM
NEW CLIMATE INSTITUTE
UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD
FGV SÃO PAULO SCHOOL OF BUSINESS ADMINISTRATION
Office of International Programs

FINANCING DECARBONIZATION OF THE SECONDARY STEEL SECTOR IN INDIA

Towards an Enabling Environment

Suggested citation

TERI. (2023). *Financing Decarbonization of the Secondary Steel Sector in India: Towards an Enabling Environment.* New Delhi, India: The Energy and Resources Institute.

Authors

Dr Manish Kumar Shrivastava
Mr Uday Veer Singh
Mr K Sai Dinesh
Mr Sangeeth Raja Selvaraju
Dr Karsten Neunoff

Internal Advisors

Mr R R Rashmi
Mr Girish Sethi
Mr Prosanto Pal
Mr Sobhanbabu PRK

PUBLISHED BY

The Energy and Resources Institute (TERI)
TERI, Darbari Seth Block IHC Complex, Lodhi Road, New Delhi 110 003, India
Tel: +91 11 2468 2100 or 2468 2111 I Fax: +91 11 2468 2144 or 2468 2145
Email: info@teri.res.in I Web: www.teriin.org

Acknowledgments

This study is an outcome of an extensive literature review and consultations with experts on climate change, mitigation technologies, financial institutions, and the secondary steel sector. We acknowledge the insights and feedback of domain experts from various organizations who participated in expert consultations across the tenure of the project. The insights offered by experts in these discussions have enabled a deeper understanding of the needs of the secondary steel sector and policy requirements to enabling a conducive environment for the timely access to international climate finance for the sector. We are indebted to our internal advisors Mr R R Rashmi, Mr Girish Sethi, Mr Prosanto Pal, and Mr Sobhanbabu PRK for their valuable guidance and mentorship and for their continued support throughout the process of developing this document. We would also like to extend our heartfelt gratitude to our colleague Ms Dorothy Ashmita Biswas for her support in conducting consultations with sectoral experts.

About the Project

The SNAPFI (Strengthening National Climate Policy Implementation: Comparative Empirical Learning & Creating Linkages to Climate Finance) project explores how international climate finance can support the implementation of NDCs in emerging economies and EU countries through comparative analyses and by providing a better understanding of the interface between finance and policy implementation. It is coordinated by DIW Berlin, the German Institute for Economic Research.

Financial support

The International Climate Initiative (IKI), Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection.

Contents

LIST OF Figures

LIST OF Tables

LIST OF Graphs

Abbreviations

ADB	Asian Development Bank
BAT	Best Available Technologies
BEE	Bureau of Energy Efficiency
BEE-SME	National Program on Energy Efficiency and Technology Upgradation of SMEs
BF/BOF	Blast Furnace/ Blast Oxygen Furnace
CIF	Climate Investment Fund
CGTMSE	Credit Guarantee Fund Trust for Micro and Small Enterprises
CLCSS	Credit Linked Capital Subsidy Scheme for Technology Upgradation
CTF	Clean Technology Fund
DRI	Direct Reduction Iron
EAF	Electric-Arc Furnace
EE	Energy Efficiency or Energy-efficient
EEFP	Energy Efficiency Financing Platform
EERF	Energy Efficiency Revolving Fund
GCal	Giga Calories
GCF	Green Climate Fund
GEF	Global Environment Facility
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
IF	Induction Furnace
ICF	International Climate Finance
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau Development Bank
LCT	Low-Carbon Transition
MDB	Multilateral Development Bank
MoEFCC	Ministry of Environment, Forest and Climate Change
MSME	Micro, Small, and Medium Enterprises
MT	Million Tonnes
MTOE	Million Tonnes of Oil Equivalent
MTPA	Million Tonnes Per Annum
NAPCC	National Action Plan on Climate Change
NBFI	Non-Banking Financial Institution
NMEEE	National Mission for Enhanced Energy Efficiency
PAT	Perform, Achieve, and Trade
PRGFEE	Partial Risk Guarantee Fund for Energy Efficiency
RAMP	Raising and Accelerating MSME Performance
SAPCC	State Action Plan on Climate Change
SBI	State Bank of India
SEC	Specific Energy Consumption
SECF	State Energy Conversation Funds
SIDBI	Small Industries Development Bank of India
SSRM	Secondary Steel Re-rolling Mills
TADF	Technology Acquisition & Development Fund
TEQUP	Technology and Quality Upgradation (TEQUP) Support to MSMEs
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
UNDP	United Nations Development Programme
VCFEE	Venture Capital Fund for Energy Efficiency

Executive Summary

EXECUTIVE SUMMARY

India is the second-largest producer of crude steel as well as the second-largest consumer of finished steel in the world. The sector contributes to about 2% of the total GDP of the country and employs 2.6 million people directly and indirectly through allied sectors. The Indian steel sector is further bifurcated into the primary and secondary steel sector based on their production pathways. The secondary steel sector largely utilizes the Direct Reduction-Electric Arc Furnace (DRI-EAF) route or the DRI-Induction Furnace (DRI/IF) route for crude steel production and is also involved in the production of finished steel through re-rolling mills. Overall, the secondary sector accounts for about 40% of steel production in India.

The secondary steel sector also remains highly emission-intensive, being responsible for around 50 million tonnes (MT) of GHG emissions, annually. Excessive reliance on low-quality coal, iron ore, and low shares of scrap input coupled with heterogenous scattered units of operations add to the deep decarbonization challenge for the secondary steel sector in India. To align India's ambitious growth visions with its commitment to reach net-zero emissions by 2070, it is vital to enable the low-carbon transition (LCT) of the secondary steel sector, particularly through the development of a suitable enabling environment to scale-up the flow of finance for the adoption of low-carbon technologies by the sector.

The Secondary Steel Sector Value Chain Potential Pathways for Decarbonization

The value chain of the secondary steel sector involves the production of sponge iron through the direct reduction route (DRI plants), which is followed by the production of crude steel (semi-finished steel) through Electric Arc Furnaces (EAF) or Induction Furnaces (IF). Lastly, finished steel products are produced through steel re-rolling mills. There are approximately 333 DRI plants, 55 EAFs, 1103 IFs, and 1313 Steel-rerolling mills scattered across the country. The DRI process accounts for about 30 $MTCO_2$ emissions annually, while the IFs and EAFs emit 13.4 $MTCO_2$ and 0.1 $MTCO_2$, respectively. Additionally, the re-rolling mills are responsible for 6 $MTCO_2$ emissions annually.

Potential Pathways for Decarbonization and their Financing Needs

The potential pathways to decarbonization for the secondary steel sector in India involve short-term incremental pathways with limited potential and low investment requirements, and long-term transitional pathways which would require greater investment. The incremental pathways include integrating the best available technologies (BATs) in DRI, EAF, IF, and Re-rolling mills' production processes, integrating input-based solutions, and renewable energy utilization. The transitional pathways involve converting coal-based DRI plants to hydrogen/natural gas-based plants, and direct re-rolling integration with the DRI-EAF route.

Notably, for 333 DRI plants, 55 EAF units, 1103 IF units, and 1257 re-rolling units (TERI-GIZ, 2022), the financing requirements for incremental pathways would be USD 15,129 million and further rise to a cumulative total of USD 169,583 million when transitional pathways are accounted for as well.

Finance for the Secondary Steel Sector

The secondary steel sector receives finance from diverse international, national, private, public, formal and informal sources. However, its overall access to institutional financing for decarbonization technologies remains low. Several barriers hinder the secondary steel sector's access to financing for LCT technologies. These can be broadly classified into:

» **Knowledge-based barriers** such as awareness gaps, documentation requirements, lacking financial expertise, and high perceived risks from financiers.

» **Cost of Capital-related barriers** such as high transaction costs, low margins for institutions, high interest rates, payback periods, due diligence requirements, and inadequate maximum funding limits from financiers.

» **Creditworthiness-based barriers** such as poor cashflow, delayed payments, low credit scores, and low collateral holdings.

While several financial tools such as revolving funds, credit lines, technical grant programs, guarantees and risk-sharing facilities have been deployed around the world to support the uptake of clean-tech, the unique case of the secondary steel sector in India – in terms of its twin requirements of financing and technical handholding, suggest that unique considerations for an enabling environment would be required to support its decarbonization goals. Furthermore, a combination of diverse financial instruments might to be required to address sub-sectoral diversity and needs.

Recommendations for Financing the Secondary Steel Sector

Keeping in mind the unique composition and sub-sectoral necessities of the secondary steel sector in India, the report lays out the following recommendations.

Interventions at the National-Level

- **Development of a Multi-Stakeholder Platform** with the participation of government institutions, knowledge institutions, industry associations, financial associations, and technology providers. The platform can crucially address information gaps for the industry on financial provisions and due diligence, as well as enable financiers to know better about emerging technologies.
- **Cluster-level Interventions** to essentially map secondary steel units into clusters which could be supported through securitization to secure loans for working capital requirements, and large-scale revolving funds. Up-take of clean technologies could be initiated in clusters with programmatic partnerships, performance-based mechanisms, technical support, and hand-holding.
- **Development of a Dedicated National Fund for Steel Decarbonization** to facilitate the financing of low-carbon transition of the Indian steel sector. Such a fund could be housed with the Ministry of Steel and SIDBI could be assigned a facilitative role for financing.
- **A Financially backed Scheme for the Integration of Waste Heat Recovery Systems** which could provide incentives for adoption to facilitate energy efficiency and emission-reduction in a short amount of time.
- **Dedicated Renewable Energy Supply for the IF/EAF Units** to effectively mitigate scope 2 emissions from the sector. Importantly, centre-state policy coordination on power supply would need to be streamlined, alongside an overall expansion of the power grid.
- **Enhancing Scrap Availability and Collection** to amplify scrap utilization and promote a circular economy model for the secondary steel sector's sustainable future. To ensure material availability, the successful implementation of policies such as the National Vehicle Scrappage Policy would be essential.

Interventions to Enhance the flow of International Climate Finance

- **Multi-level Risk Guarantee Mechanisms** dedicated to de-risking financing low-carbon transition technologies with longer payback periods need to be developed to attract private investment. For layered-risk funding mechanisms, the first layer of guarantee can be provided at the sub-national/national level, which could be further supported by international climate finance. Consequently, requirements of due diligence on documentation, reporting, and monitoring can also be assigned at local levels to overcome the cost of capital-related barriers to accessing international climate finance.
- **A Sector-Level Modernization Programme supported by ICF** – International climate finance needs to be viewed as a major source to finance the LCT of the secondary steel sector. A sector level modernisation programme could be prepared to address the decarbonization challenge in phases – starting with the adoption of energy efficiency measures and alternative fuels; and shall be posed to the World Bank or the GCF for funding and accessing international climate finance.

SECTION 1:

Introduction

INTRODUCTION

1.1 Background to the Study

The iron and steel industry forms the backbone of development and is essentially the lifeline for the growth of several sectors of an economy. With high strength, durability, and recyclability, steel provides input for sectors like infrastructure, buildings, and transport. Consequently, it plays an indispensable role in ensuring a sustained growth trajectory for an economy. Globally, the iron and steel sector generates a revenue of about USD 1.6 trillion directly and employs over 6 million people.[1]

India is the second-largest producer of crude steel as well as the second-largest consumer of finished steel in the world. The sector contributes to about 2% of the total GDP of the country and employs 2.6 million people directly and indirectly through allied sectors.[2] The Indian steel industry comprises primary and secondary steel producers, differentiated by their size and routes of steel production. The primary producers largely utilize the Blast Furnace/Blast Oxygen Furnace (BF/BOF) route, while the secondary producers are involved in the Direct Reduction-Electric Arc Furnace (DRI-EAF) route or the DRI-Induction furnace (DRI/IF) route for crude steel production. Additionally, the secondary steel sector is also involved in the production of finished steel through steel re-rolling mills, forging, and foundries. In total, the secondary sector accounts for about 40% of steel production in India.[3]

In India, about one-fifth of industrial energy consumption comes from the iron and steel sector, and of its total energy input of 70 Mtoe (million tonnes of oil equivalent), 85% comes from coal. Consequently, the excessive reliance on low-quality coal, iron ore, and smaller share of scrap input as compared to the global average (23% as compared to the global average of 32%), adds to the deeper transitional challenge for the hard-to-abate steel sector in India (IEA, 2020). The secondary steel sector further remains highly emission-intensive, being responsible for around 50 million tonnes (MT) of GHG emissions annually – about 60% of which comes from the DRI process, 26.8% from IFs, 0.2% from EAFs, and 13% from Steel-re-rolling mills (TERI & GIZ, 2022). Significantly, the secondary units are also relatively smaller in their operation, scattered, and quite heterogeneous in their production routes and functions, which makes their low-carbon transition a greater challenge.

For India to align its ambitious growth vision with its commitment to reach net-zero emissions by 2070, it is vital to enable the low-carbon transition (LCT) of the secondary steel sector, particularly by scaling up finance for the adoption of low-carbon technologies in the sector. Low-carbon transition for the secondary steel sector simply implies an approach to replace current high-emitting production processes with relatively lower emitting options- in a phased manner. While certain commercially viable energy-efficient technologies have been available to the secondary steel sector, their adoption remains lukewarm. Several technical barriers relating to low awareness and technological unfamiliarity, alongside limited access to institutional finance, restrict the low-carbon transition of the secondary steel sector. Furthermore, beyond the scope of targeting technological low-hanging fruits in the short term, the long-term decarbonization strategy for the secondary steel sector would require large-scale financing from domestic, as well as international sources. Consequently, directing focused attention towards developing a favourable enabling environment to attract large-scale financing for the secondary steel sector garners great imminence. It emerges fundamental to addressing the financing needs of the sector. The promotion of circularity and greater scrap availability and utilization by the secondary

---

1 World Steel in Figures 2022. (2023, June 1). World Steel Association. https://worldsteel.org/steel-topics/statistics/world-steel-in-figures-2022

2 JSW - Steel and Indian Economy: An Upward Curve. (n.d.). https://www.jsw.in/steel/steel-and-indian-economy-upward-curve#:~:text=Steel%20now%20contributes%20about%202,in%20the%20global%20steel%20market

3 Ministry of Steel - Annual Report 2022-23. (2023, June 20). https://steel.gov.in/sites/default/files/MoS%20AR%202022-23.pdf

steel sector would also hinge on the development of an conducive ecosystem, and shall further support the lowering of standalone investment costs.

This study focuses on understanding the secondary steel sector's access to finance, and the possible ways of enhancing its access to international climate finance through the development of a suitable enabling environment.

The Study utilizes an extensive literature review and draws from stakeholder consultations for the validation of preliminary findings. A diverse group of stakeholders was consulted for the study, varying from industry associations to research experts and financial associations. A list of stakeholders consulted for this study has been provided in Annexure-1.

Structurally, section 2 of the report elaborates on the value chain of the secondary steel sector and gives a breakdown of its energy and emission intensity. Section 3 discusses various potential pathways to decarbonize the secondary steel sector in the short and the long term, alongside the financial requirements for each of the pathways. Section 4 focuses on aspects of finance. It discusses the sources of finance for the secondary steel sector and the challenges faced by the sector in accessing finance. Furthermore, it elaborates on the role that international climate finance can play in facilitating the decarbonization of the sector, citing examples of international experience alongside, and mapping the financial instruments that can be deployed. Lastly, section 5 provides recommendations for scaling up the flow of international climate finance to the secondary steel sector in India, through the enrichment of an enabling environment, in order to accelerate the low-carbon transition of the sector.

SECTION 2:

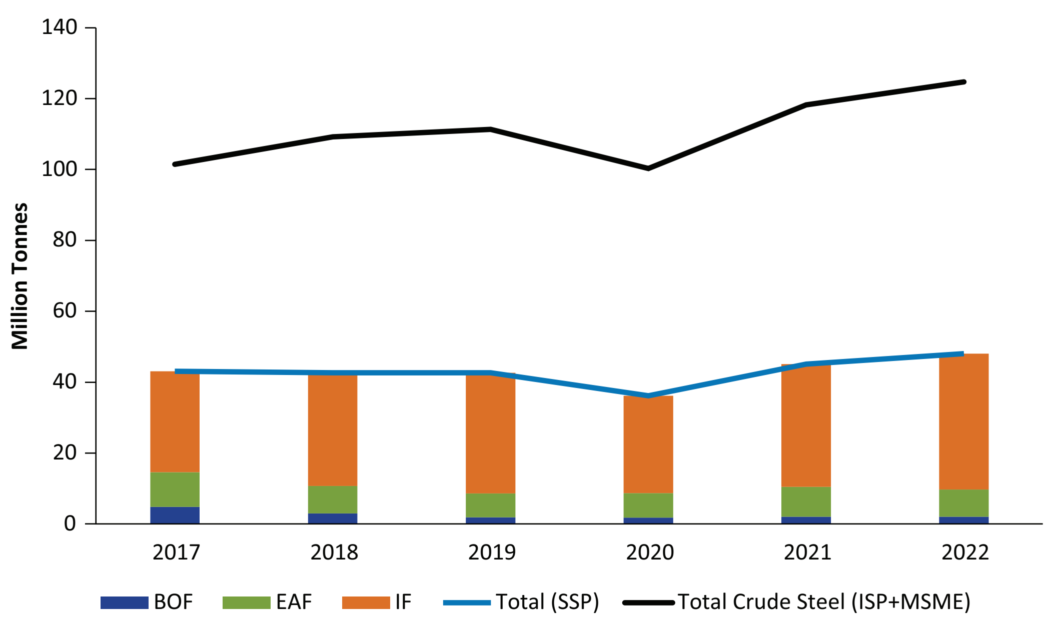
Dynamics of the Secondary Steel Sector in India

2. DYNAMICS OF THE SECONDARY STEEL SECTOR IN INDIA

2.1 The Secondary Steel Sector Value Chain

The value chain of the secondary steel sector involves the production of sponge iron through the direct reduction route (DRI plants), which is followed by the production of crude steel (semi-finished steel) through Electric Arc Furnaces (EAF) or Induction Furnaces (IF). Lastly, finished steel products are produced through steel re-rolling mills which involve hot and cold rolling units, as well as galvanizing units. There are approximately 333 DRI plants, 55 EAFs, 1103 IFs, and 1313 Steel-rerolling mills scattered across the country contributing to the value chain of the secondary steel sector (TERI & GIZ, 2022).

Graph 1 represents the total volume of crude steel production by the secondary steel sector between the years 2017 and 2022, through different production routes. As the graph highlights, the average steel production by the secondary steel sector during the period is approximately 42 MT - accounting for 38-40% of total crude steel production in the country, annually (Ministry of Steel, 2023). Deductively from the total production output, the integrated steel plants have recovered substantially post the COVID-19 pandemic. On the contrary, sluggish demand, poor cashflow liquidity, and technological backwardness has seen a slow recovery for the secondary steel sector.



GRAPH 1: Total Volume of Crude Steel Production by the Secondary Steel Sector in India

Source: MoS, 2022-23

2.2 Energy and Emission Intensity of the Secondary Steel Sector

The secondary steel sector is highly energy and emission-intensive due to its excessive dependence on coal and inefficient technological processes. Figure 1 represents the share of each sub-segment of the total emissions made by the secondary steel sector. The DRI process is the most emission-intensive, greatly due to its dependence on coal. Although IFs are responsible for about 14% of the total emissions and EAFs add up to only 0.2% of the total emissions, it is important to note that their individual efficiencies are identical and require similar amount of attention to improve energy-efficiency. As affirmed by the industry stakeholders, it is largely due to the historical development of the secondary steel industry that there are more indigenous IF units in the country, as compared to the EAFs, that had to be imported. Furthermore, another contributing factor to more emissions from the IF segment is its greater reliance on sponge iron from the DRI route, rather than on scrap for input. In comparison, the EAF segment has more utilization of scrap.

Since the largest mitigation potential is in the top value chain of the secondary steel sector (DRI, IF, EAF, and rerolling processes), the next section discusses these segments individually.

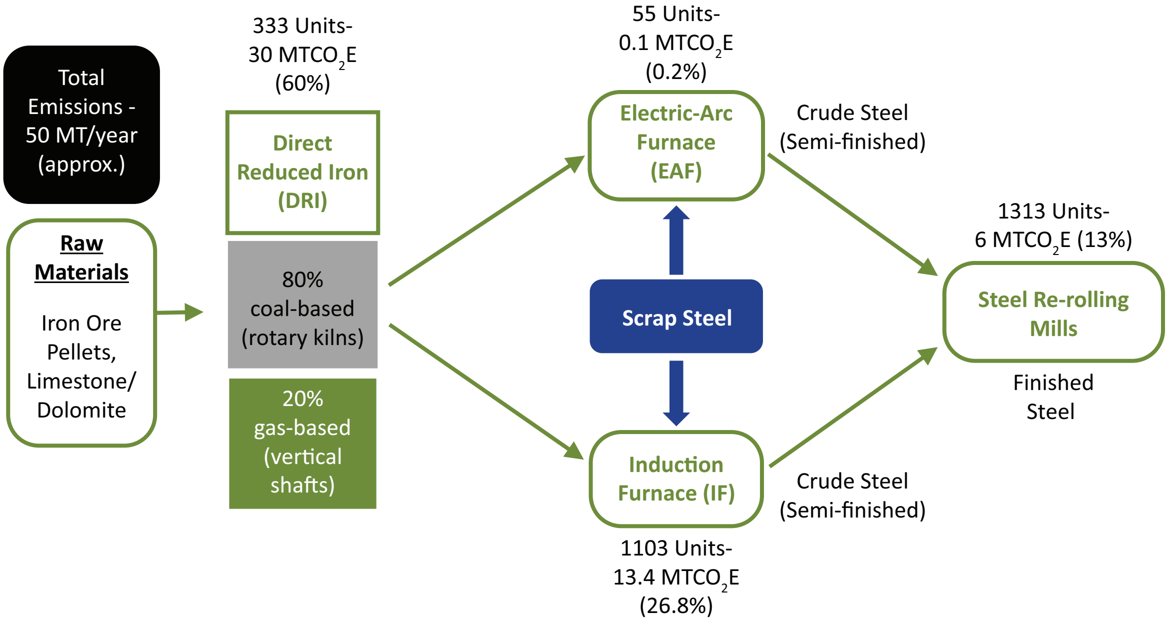


FIGURE 1: Value Chain and GHG Emissions of the Secondary Steel Sector

Data Source: TERI & GIZ, 2022

2.2.1 Direct Reduction Iron (DRI)

India is the largest global producer of sponge iron through the DRI route – accounting for 36% of the total global production (Ghosh et al., 2021). In this process, the iron ore is reduced directly to produce metallic iron. For the reduction of iron ore, coal, natural gas, and hydrogen can be used as reducing agents. Most sponge iron production in India comes from coal-based rotary kilns - with a total installed capacity of 36.74 MT (about 80% of the total sponge iron production), while the remaining capacity of 11.10 MT is constituted by natural gas-based vertical shafts (Ministry of Steel, 2023).

About 98% of the energy consumption of coal-based DRI plants comes from thermal sources, while the remaining 2% comes from electricity utilized to power motors and other allied equipment. The average specific energy consumption (SEC) of coal-based DRI plants is 4.51 Giga calories per ton (Gcal/t) (varying from 4.10 to 5.26 Gcal/t). On the other hand, the SEC of natural gas-based DRI plants is much lower, but due to the limited availability of natural gas pipelines, and the easy availability of coal, most of the DRI plants rely on coal-based fuel (Ghosh et al., 2021)

2.2.2 Electric Arc Furnaces and Induction Furnaces (EAF & IF)

The EAF & IF plants are crucial mid-stream segments in the production of crude steel through the melting pig iron, sponge iron, or scrap. The notable difference between EAFs and IFs lies in their heating and thermal efficiency. IFs tend to heat faster and are more efficient.

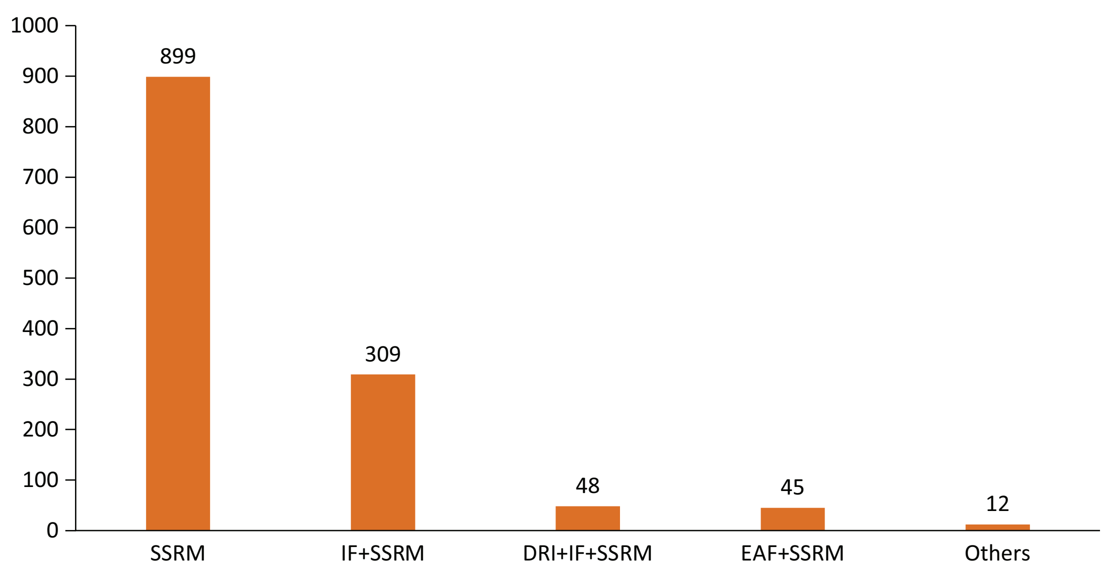
These units exist as both, standalone, and composite units. The total production capacity of IFs in India is about 52 MTPA, with the average capacity utilization of plants being around 70-75% annually (TERI & GIZ, 2022). For EAF units, the production capacity is about 42 MTPA and the average capacity utilization is about 65-68% by producing about 25-28 MT annually (TERI & GIZ, 2022). The major energy input for EAFs and IFs comes from electricity (75-80%), while the remaining comes from chemical energy (20-25%) (TERI, 2017).

The current proportion of utilization of scrap in the EAF units to produce steel ranges from 40-80%, while the remaining proportion is made up by utilizing sponge or pig iron. The proportion of scrap usage fluctuates, depending on the availability and pricing of scrap. For EAF and IF routes, the estimated SEC is 420 to 755 kWh per ton of liquid steel - much lower than the DRI route. (TERI, 2017). Thus, while the usage of scrap offers great energy and emission-saving potential, its utilization remains limited due to scrap deficiency in the country.

2.2.3 Secondary Steel Re-rolling Mills (SSRM)

The majority of secondary steel sector units in India are involved in the production of finished steel through re-rolling processes. About 65% of finished steel produced in India comes from secondary steel sector re-rolling mills (TERI & GIZ, 2022). Moreover, about 75% of the 1313 steel re-rolling mills in the country are small-scale units with an installed capacity of 24 to 240 Tonnes per day (TPD) (TERI & GIZ, 2022). These re-rolling mills can also be differentiated on the basis of their processes, into – 1) standalone units (reheating and rolling) and 2) composite units (melting and rolling in the same plant). Graph 2 breaks down the number of re-rolling units based on the plant type.

Conventionally the key equipment for re-rolling mills includes reheating furnaces, compressors, blowers, rolling mill strands, and roller tables. The direct energy utilization of the segment comes from the fuel used for reheating furnaces, i.e., coal, gas, or oil, and electrical energy. The share of thermal energy (coal, gas, or oil) for finished steel production through re-rolling mills accounts for 77% of total energy consumption, while the rest 23% is met by electricity (UNIDO, 2020). The use of reheating furnaces and the dependency on coal for sourcing fuel are two major reasons for high energy consumption and CO_2 emissions from the re-rolling segment.



GRAPH 2: Number of Steel Re-rolling Mills based on Plant Types

Source: TERI & GIZ, 2022

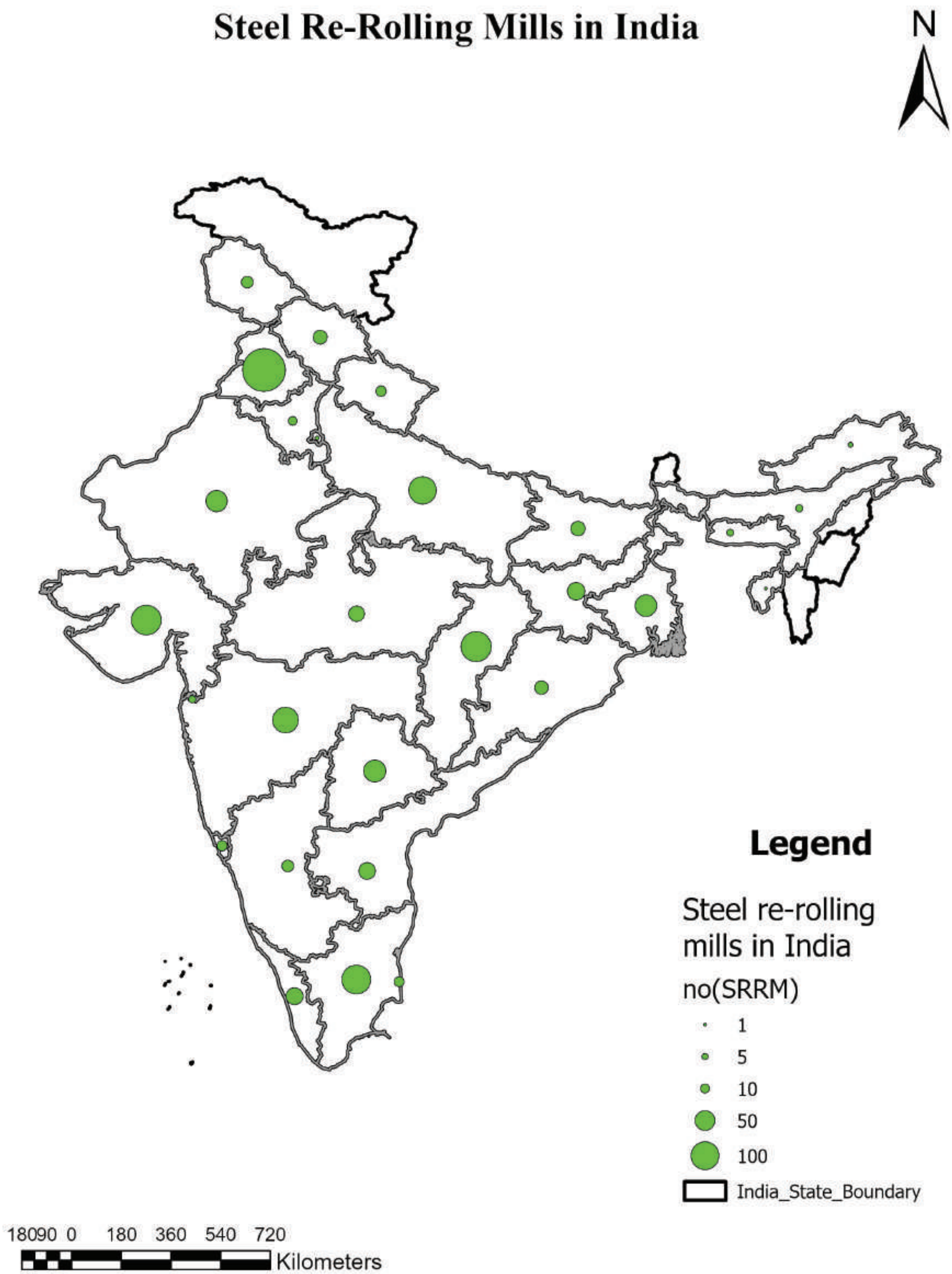


FIGURE 2: Distribution of Steel Re-rolling Mills in India

Source: TERI & GIZ, 2022

SECTION 3:

Potential Pathways for Decarbonization

3. POTENTIAL PATHWAYS FOR DECARBONIZATION

Section 3 discusses two potential pathways for decarbonizing the secondary steel sector, alongside their mitigation potential, investment requirements, and the maturity status of concerned technologies. The short-term pathway focuses on targeting low-hanging fruits and focuses on incremental options – to integrate the best available technologies (BATs) in DRI, EAF, IF, and Re-rolling mills' production processes. The rationale behind the incremental approach is targeting emission-reduction by replacing outdated technologies with relatively lower investment. Additionally, as an incremental option, input substitution for DRIs, EAFs and IFs could also be a game changer for both - short-term and long-term low-carbon transitioning.

The long-term strategy for decarbonization identifies potential transitional options for the secondary steel sector. These include the replacement of coal-based DRI plants to natural gas/hydrogen based DRI plants, and integration of direct re-rolling with DRI, EAF and IF units.

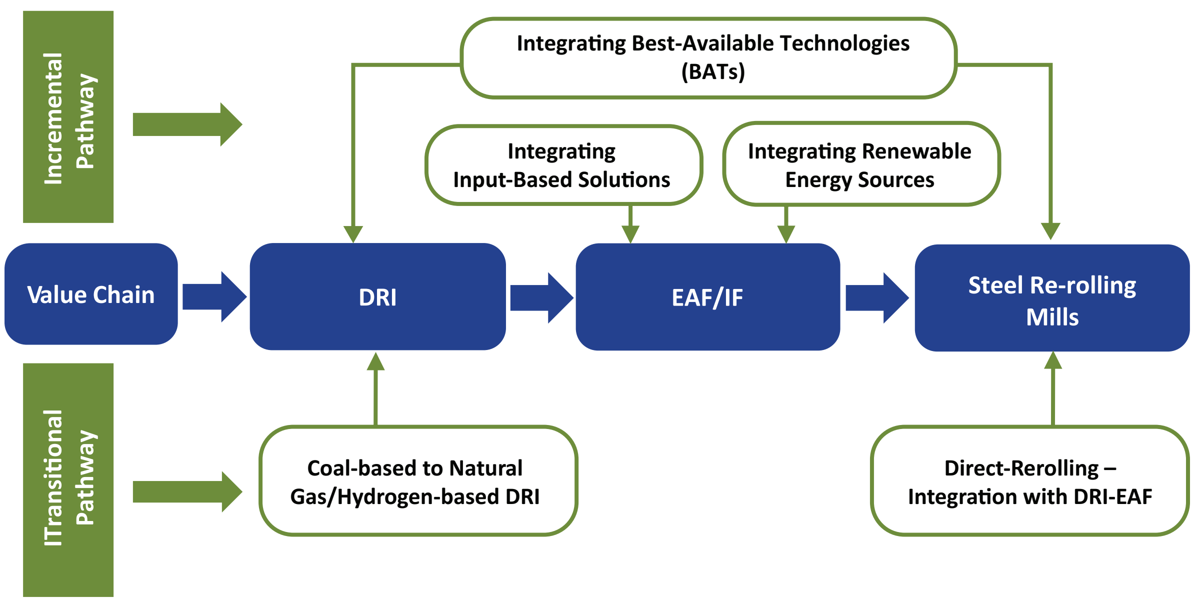


FIGURE 3: Potential Pathways for Decarbonization of the Secondary Steel Sector

3.1 Incremental Pathways

3.1.1 Integrating the Best Available Technologies (BATs)

a) DRI Process

In coal based DRI rotary kilns, the flue gases generated in the kiln are emitted at temperatures of about 950-1025 °C and are a major source of emissions. For a 100 TPD capacity plant, the volume of off-gases generated varies in the range of 24,000±1500 Nm^3 per hour. Conventionally, off-gases are cooled down–increasing energy consumption and reducing efficiency. These off-gases generated from the rotary kiln during the process can be recovered by using the Waste Heat Recovery (WHR) system to generate a high-pressure system for power generation, and preheating raw materials (coal, iron ore, etc.) for moisture reduction. Integration of WHR system by DRI plants for power generation and pre-heating raw materials can have a GHG reduction potential of 28,960 tCO_2/year (reduction about 40 per cent of the total emissions) (Ghosh et al, 2021). However, as gathered by TERI from the stakeholder consultation with the industry associations, only 50 DRI plants in India have adopted waste heat recovery systems yet.

For 333 DRI plants with an overall production capacity of 52 MT, the estimated investment requirement is about USD 9,309 million for all BATs, including the WHR system

Some adoption barriers for WHR systems in secondary steel plants have been the high upfront investment and long payback periods associated with them. Other barriers such as space limitations, seasonal operation of units, added operational costs, and the complexity of integrating WHR system controls with the existing processes also limit their adoption. However, the plants that encounter such limitations can still integrate other possible BATs (as listed in Annexure-3). These include technologies such as coal-gasification for partial substitution, energy-efficient motors and pumps, and decentralized VFDs for shell air fans, which have a cumulative mitigation potential of 7,603 tCO_2/year (Ghosh et al, 2021). The integration of these technologies would need a low amount of investment, in the range of USD 12,000-120,000 each. For 333 DRI plants with an overall production capacity of 52 MT, the estimated investment requirement is about USD 9,309 million for all BATs, including the WHR system (listed in Annexure-3).

b) EAF & IF Processes

Even though energy and emission intensities are the lowest in the EAF segment of secondary steel producers, their current utilization of outdated technologies suggests a significant scope for energy savings and GHG emissions reduction through technological improvements. In EAFs currently, about 15-20% of heat is lost in the form of off-gases generated during the production process (TERI, 2017). The majority of EAF units use cooling water to reduce the temperature of these off-gases. WHR systems offer the potential to effectively recover and reuse the off-gases for pre-heating scrap and to save feedwater by reducing heat losses. For instance, for a 50-tonne EAF, integrating WHR for boiler feed water requires an estimated investment of USD 0.012 million and can mitigate CO_2 emission by 1510 tCO_2/year. Similarly, integrating WHR for scrap pre-heating for a 50-tonne furnace requires an estimated investment of USD 0.50 Million, and can mitigate CO_2 emissions by 8,860 tCO_2/year (TERI, 2017).

Considering the highest mitigation potential for EAF units, the best way to utilize off-gases would be through pre-heating of scrap materials. But a particular barrier towards its adoption has been the space constraints for these units. Besides the WHR systems, other potential mitigation solutions include integrating energy-efficient systems in pumps (cooling water systems) and variable frequency drives for fumes extraction, which would require an estimated investment of USD 0.017 million (TERI, 2017).

For IF units, similarly, the adoption of WHR systems offers a high potential for energy savings and emission-reduction. However, none of the IF units in India have adopted WHR systems due to space constraints and a lack of technical capacity.

For a total 55 EAF units and 1,103 IF units with an overall production capacity of 93 MT, the estimated cumulative investment requirement would be about USD 2,381 million for all BATs, including WHR systems (Listed in Annexure-4).

For a total 55 EAF units and 1,103 IF units with an overall production capacity of 93 MT, the estimated cumulative investment requirement would be about USD 2,381 million for all BATs, including WHR systems

c) Re-rolling Process

Standalone re-rolling mills are highly energy intensive in their production processes. To produce one ton of long steel, about 100-200 kg of coal or 35-40 litres of furnace oil and 80-150 KWh of electricity are required by the re-heating furnaces in the re-rolling process. This accounts for 66% share of the total energy utilized in the re-rolling process.

In most of the re-rolling mills, the re-heating furnaces are powered by pulverized coal systems with very low levels of automation. Remarkably, the integration of an energy-efficient and automated control system alongside a high-efficiency metallic recuperator in a re-heating furnace can mitigate about 2,883 tCO_2/year. Both these technologies are importantly at the mature-level of technological readiness (TRL-11, see Annexure-7), and viably deployable.

The integration of BATs (Listed in Annexure-5) in the existing re-rolling mills offers a saving potential in the range of 5-35%, depending on the technology, and has a GHG mitigation potential of 43,800 tCO_2/year (UNIDO, 2020). For 1257 steel re-rolling units with an overall production capacity of 91 MT, the estimated cumulative investment requirement for enlisted BATs would be about USD 3,524 million.

For 1257 steel re-rolling units with an overall production capacity of 91 MT, the estimated cumulative investment requirement for enlisted BATs would be about USD 3,524 million

3.1.2 Integrating Input-based Solutions

Input-based solutions such as the substitution of fossil-fuel-based fuel inputs with cleaner fuels, utilization of iron ore pellets for DRI, and scrap steel for EAFs and IFs hold the potential to be a big game-changer for reducing the carbon intensity of steel production, as well as in the achievement of circular economy targets. The advantages of input substitution are that it doesn't require any significant technological modification at the plant level and requires low investment, given the suitable availability of inputs.

For instance, pelletized iron ore fines can be directly charged into the DRI process. This utilization of iron ore pellets instead of iron-ore lumps has an energy-saving potential of about 15% and can further improve the yield and reduce thermal load during the production process. Additionally, the substitution of fossil fuels-based fuel inputs with natural gas, biomass, and coal-based methane for powering re-heating furnaces in steel re-rolling mills can increase efficiency and offer a high mitigation potential in the range of 9,000 – 14,500 tCO_2/year. (UNIDO, 2020). The maturity status of the technologies for fuel substitution in re-rolling mills, however, is in TRL-8-9 and faces shortages in the availability of alternative fuels (natural gas, biomass and coal-based methane).

In terms of scrap utilisation, EAF and IF units use scrap steel in combination with pig iron and sponge iron to produce steel. The overall domestic supply of scrap steel in India is around 25-30 MT, and around 6-7 MT is imported. The National Scrap Policy estimates the requirement of 70 scrap processing centres to produce the currently imported amount of scrap steel (1 Lakh tonne per scrap processing centre). Additionally, 300 collection and dismantling centres would also be required (Steel Scrap Recycling Policy, 2019). In terms of prospective future requirements, 2800-3000 collection and dismantling centres would be needed to process the future demand of 70-80 MT of steel scrap, if at all it could be sourced domestically (Steel Scrap Recycling Policy, 2019). Notably, to set up 70 steel recycling centres with a plant capacity of 1 MT each, as needed to match the current scrap requirements, an estimated cumulative investment of about USD 114 million would be required.

Crucially, the lack of availability of quality scrap can result in poor quality of steel production with the EAF/IF route. Barriers such as contamination of steel with other metals (copper, alloys, etc.) and low-quality recycling challenge the utilization of scrap steel. However, more optimistically, the Scrap Recycling Policy and the Vehicle Scrappage Policy envision increasing the availability of scrap steel by 50 MT by 2030, by targeting scrap collection, processing, and utilisation, which could aid the sector's emission reduction. It can also help reduce the dependence on the DRI process, since EAFs can produce steel with 100% scrap sourcing.

3.1.3 Integrating Renewable Energy Sources

Most of the IF and EAF units in the secondary steel sector are standalone units. About 70% of the energy input for these units comes from electricity and the dominant share of this electricity is sourced from fossil-fuel-based power plants. Thus, the integration of renewable energy sources for these standalone units can accelerate the low-carbon transition of the secondary steel sector. A mix of solar rooftops and grounded solar panels installed at the cluster level could meet the energy requirements for steel production. For the installation of a solar power plant with a capacity of 1 MW, and an electricity generation potential of about 4,000 kWh per day, the capital investment required is about USD 0.6 million.[4] Considering the energy requirements for the current production of steel through EAF and IF routes, the cumulative estimated investment required to set up solar panels would be about USD 200 million.

3.2 Transitional Pathways

3.2.1 Coal-Based DRI to Natural Gas DRI

Currently, less than 20% of the total sponge iron production in India is undertaken through the natural gas route. On the other hand, the use of natural gas as a reducing agent in the DRI route has a high mitigation potential. For instance, the emissions from natural gas-based DRI are about 0.415 tCO_2 per

[4] https://amplussolar.com/blogs/1mw-solar-power-plant

ton of crude steel- much lower than coal-based DRI. In combination, the emissions from the natural gas-based DRI-EAF route are only about 1.0 tCO_2/t of steel produced. However, in India, only 3 plants produce sponge iron through the natural gas-based DRI route as of yet.[5] The transition of coal-based DRI plants would be challenging as it would require a complete transition from coal-based rotary kilns to gas-based vertical shafts. Additionally, high investment requirements and limited availability of natural gas pose substantial challenges as well. The estimated capital investment required for the transition of a coal-based DRI plant to Natural Gas-based DRI plant is about USD 220 million assuming a plant capacity of 1 MT (Table 1).

TABLE 1: Estimated Investment Requirements for Transition to Natural Gas-based DRI

Capacity	Estimated Investment required USD million	Estimated Savings/ year	Energy saving (Gcal/year)	Emissions tCO_2/t
1.0 Mt	219.512	NA	NA	0.415

Source: Stakeholder consultation with sectoral experts

3.2.2 Coal-based DRI to Hydrogen-based DRI

In the DRI process, hydrogen (H_2) can also be used as a reducing agent instead of coal or natural gas. Green hydrogen is produced through renewable energy, and currently, the cost of producing green H_2 is approximately 4-5 USD/kg. Owing to such a high production cost, hydrogen can be blended with natural gas or syngas to decrease the operational cost during the transition phase. Significantly, the cost of production of steel would remain high initially, and only decrease over time (Table 2). The investment required for blending hydrogen in the DRI process in various ratios is highlighted in Table 2 for a plant with 0.5 MTPA production capacity. For producing one tonne of steel using green hydrogen with emissions as low as 0.25 tCO_2/t, the estimated cost would be about USD 386. Consequently, the estimated cost of producing the current total output of the sponge iron (41 MT) would be about USD 15.82 million. Since the utilization of hydrogen is still in the demonstration stage (TRL-5-8), it remains an option for only large-scale steel production. Its application for the secondary steel segment remains unlikely in the foreseeable future.

TABLE 2: Estimated Investment Requirements for Hydrogen based-DRI

Green H2 blend in process	Estimated Investment required (USD million)	Production Cost in USD per ton of crude steel	Emissions tCO_2/t
9%	18.163	443	0.74
60%	17.384	424	0.41
100%	15.826	386	0.25

(Source: CEEW, 2021)

3.2.3 Integrating Direct-Rerolling with DRI-EAF/IF

Considering that the re-heating furnaces in standalone re-rolling mills are highly energy intensive, their utilization can altogether be eliminated potentially- by directly rolling hot billets through continuous casting machines that would be integrated with DRI-EAF/IF units. For a composite plant with a re-rolling capacity of 15 tonnes/hour, the integration of continuous casting machines has a GHG reduction potential of 15,015 tCO_2/year. This would require an estimated capital investment of USD 0.12 Million (Table 3). This mitigation potential and investment cost may vary based on existing plant capacity.

However, it is important to note that the adoption of continuous casting machines would be faced with technical barriers in terms of their exclusive applicability for composite units and varying physical feasibility, depending on the plant layout.

5 Sponge Iron Manufacturers Association. (2021). DRI Update. https://www.spongeironindia.com/images/publications/DRI-UPDATE%20March,%202021.pdf

TABLE 3: Estimated Investment Requirements for Integrating Direct-Rerolling with DRI-EAF/IF

Estimated Investment (USD million)	Estimated Savings/year (USD million)	Energy saving (Gcal/year)	GHG reduction (tCO_2/year)	Payback (Year)
0.12	0.61	39,196	15,015	Less than 1 Year

Source: UNIDO, 2020

3.3 Overall Financial Requirements

Table 4 summarizes the cumulative investments required for the potential pathways. As a short-term strategy, the integration of BATs in the three segments of the secondary steel sector would require about **USD 13,000 million** (which is greater than the Just Energy Transition Partnership for South Africa). On the other hand, the transitional pathways of converting the coal-based DRI process to natural gas and hydrogen-based DRI production would require an estimated capital investment of **USD 150,750 million**. Considering the high investment requirements for both pathways, the flow of international climate finance becomes indispensable for the LCT of the secondary steel industry in India.

TABLE 4: Summary of Overall Financial Requirements for the Potential Pathways

	Potential pathways for decarbonization	No. of Plants	Current Production Capacity (MTPA)	Mitigation Potential $MTCO_2$/yr	Estimated Capital Cost USD Million	Comments
Incremental Pathways	Integrating BATs - DRI	223	52.30	0.66	9,309.4	Based on the existing production capacity, the cost of technology is for 100 TPD, assuming 300 production days
	Integrating BATs – EAF and IF	1037	93.00	0.42	2,380.8	Based on the existing production capacity, the cost of technology is for 100 TPD, assuming 300 production days
	Integrating BATs - Re-rolling	1257	91.00	1.49	3,124.3	Based on the existing production capacity, the cost of technology is for 150 TPD, assuming 300 production days

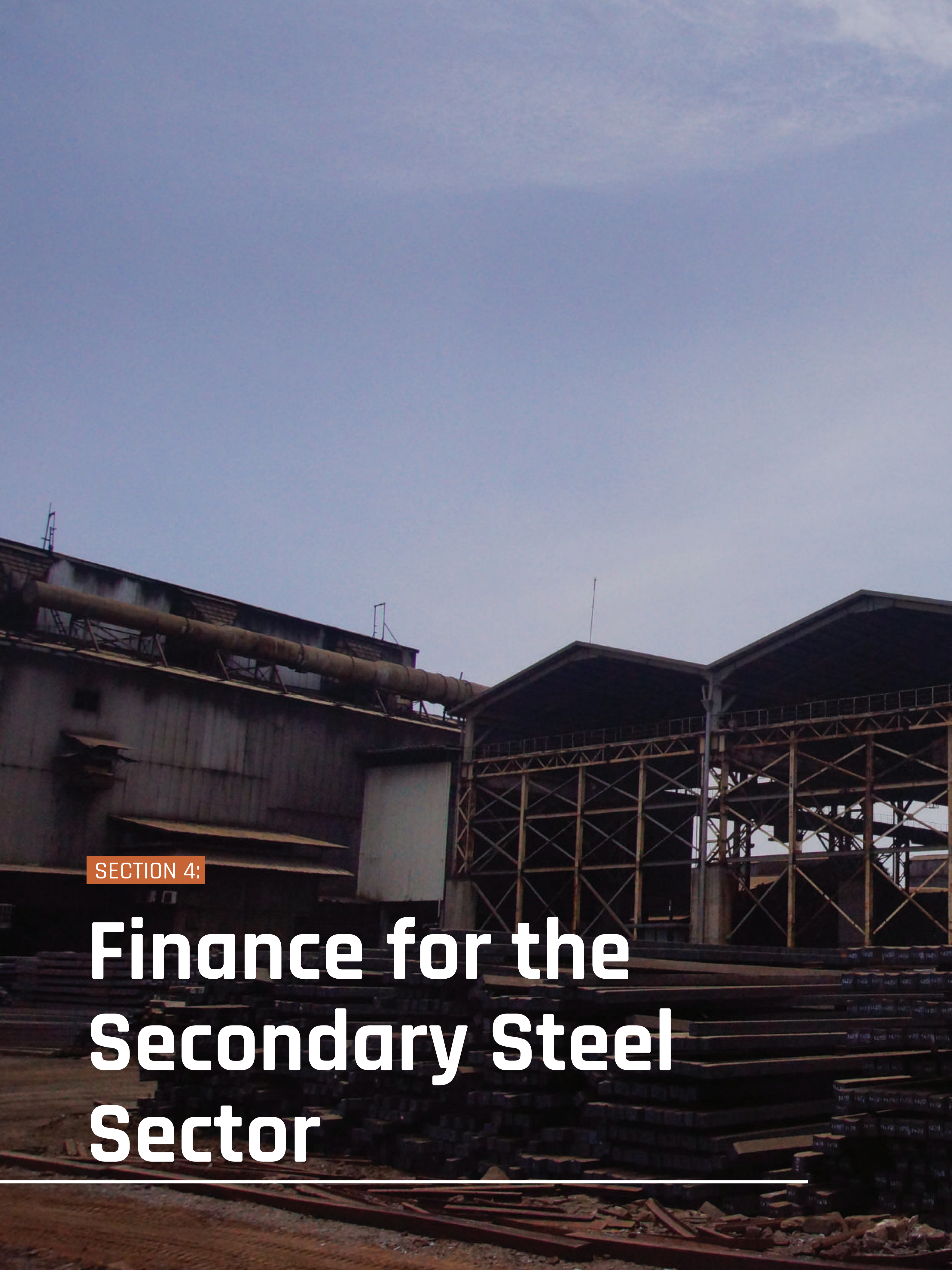
TABLE 4: Summary of Overall Financial Requirements for the Potential Pathways

	Potential pathways for decarbonization	No. of Plants	Current Production Capacity (MTPA)	Mitigation Potential $MTCO_2/yr$	Estimated Capital Cost USD Million	Comments
	Material Substitution – Increasing Scrap Input		30.00		114.00	For installing scrap processing units with additional capacity of 30MTPA
	Integrating Renewable Energy in EAF and IF	1037	93		200.5	Based on actual production 60MTPA.
Transitional Pathways	Coal to natural gas based DRI	223	52.30		20,000	Not suitable for SSP MSMEs as min. capacity needed is 1 MT.
	Coal to hydrogen based DRI	223	52.30		130,750	
	Direct-Rerolling – Integrating with DRI-EAF	899	91.00	0.51	3,699.19	Converting standalone units to composite.
				TOTAL	**169,583.2**	

Colour coding is based on the Technological Readiness level for the potential pathways (Annexure-7).

TRL-11 Proof of Stability Reached; TRL-6 Full Prototype at Scale; TRL-9 Commercially Viable

Source: Gosh et al. (2021), TERI (2017), UNIDO (2021), CEEW (2021), & Authors Analysis.



SECTION 4:

Finance for the Secondary Steel Sector

4. FINANCE FOR THE SECONDARY STEEL SECTOR

4.1 Sources of Finance for the Secondary Steel Sector

The secondary steel sector receives finance from diverse sources. These sources can be broadly classified into four categories – (1) International sources, (2) Domestic public sources (including national institutions, as well as national and state-level schemes and funds), (3) Domestic private sources, and (4) Self-financing or informal sources.

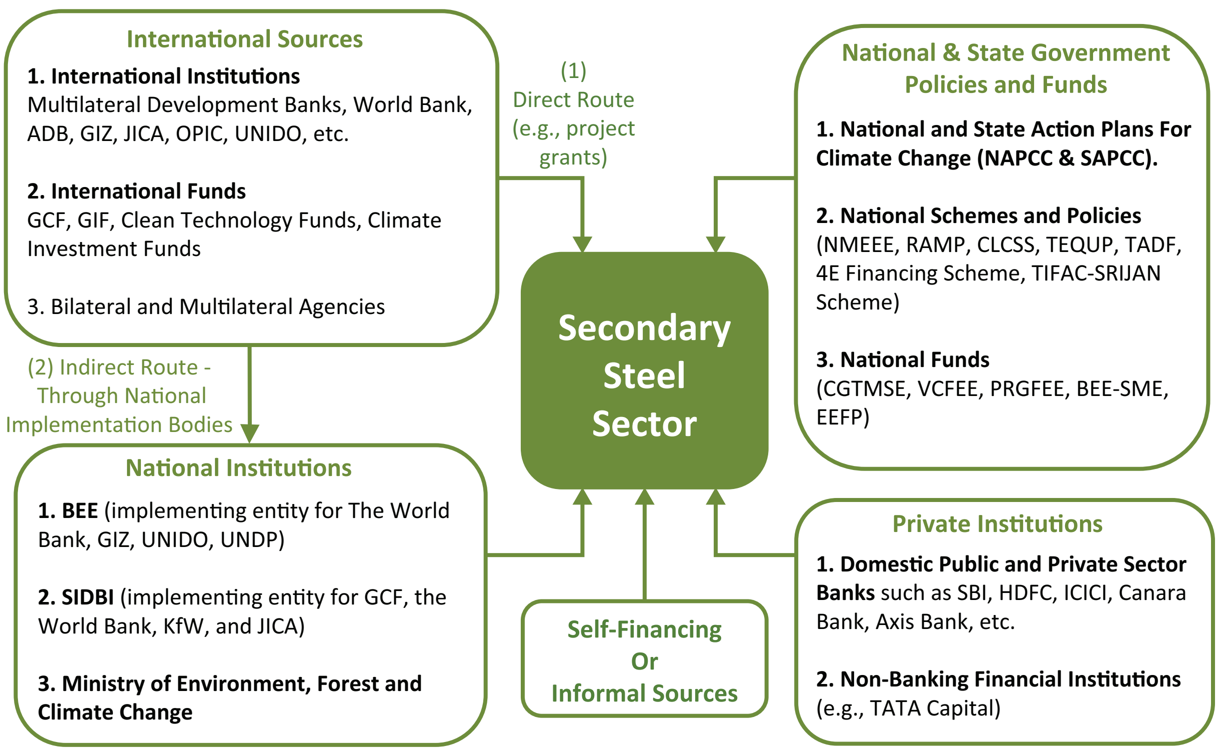


FIGURE 4: Financial Sources for the Secondary Steel Sector

a) **International Sources**: International sources of finance for the secondary steel sector include several international institutions such as the World Bank, Japan International Cooperation Agency (JICA), and United Nations Industrial Development Organization (UNIDO), multilateral development banks such as the Asian Development Bank (ADB), international funds such as UNFCCC's Green Climate Fund (GCF), and Clean Technology Funds (CTFs), and bilateral and multilateral agencies. International climate finance is either extended directly in the form of grants, concessional loans, venture capital, or partial risk guarantees (such as the World Bank Group's Partial Risk Sharing Program), or indirectly disseminated into different projects through domestic implementation agencies and financial institutions.

b) **Domestic Public Sources:** National and state-level policies, schemes, and funds form a major part of domestic public finance for the secondary steel sector. The National Action Plan on Climate Change (NAPCC) and the State Action Plans on Climate Change (SAPCCs) articulate the climate policy at the national and sub-national levels, respectively, and include the National Mission for Enhanced Energy

Efficiency (NMEEE) which forms the rationale behind several policies that are rolled out through ministries and implementation bodies. National-level implementation bodies include the likes of the Bureau of Energy Efficiency (BEE), and the Small Industries Development Bank of India (SIDBI), which is the apex financial institution serving the financing and development of MSMEs in India. Both SIDBI and BEE channel domestic and international finance into several projects concerning the development, capacity-building, and greening of MSME units- including those under the secondary steel sector.

Domestic policies, schemes, and funds providing financial support to the secondary steel sector include the likes of the NMEEE, the Venture Capital Fund for Energy Efficiency (VCFEE), the National Program on Energy Efficiency and Technology Upgradation of SMEs (BEE-SME), etc. A table in Annexure 2 enlists the provisions of several national schemes providing finance to MSMEs in the secondary steel sector. Even though these schemes have been operational for a considerable number of years, there remains a lack of dedicated attention towards financing the low-carbon transition of the secondary steel sector and technological upgradation, in particular. Furthermore, the scale of project financing for energy-efficiency uptakes remains small, and the sector itself remains reluctant to avail several institutional schemes for various reasons such as documentation requirements, due diligence, and lacking awareness.

c) **Domestic Private Sources:** Private finance is also extended to the secondary steel sector in the form of debt financing through loans via public and private sector banks, as well as non-banking financial institutions (NBFIs). Several banks such as the State Bank of India (SBI), HDFC Bank, Axis Bank, etc., have lending policies for the industrial sector. Some examples of NBFIs that extend loans to the sector include TATA Capital and JSW One Platforms.

d) **Self-Financing and Informal Sources:** A majority chunk of units in the secondary steel sector is made up of MSMEs which notably lack a sizeable scale of operations, collateral holdings, credit history, and organized bookkeeping to source their financial requirements from organized sources. As a result, they remain largely dependent on self-financing or informal sources, particularly to meet their working capital needs.

4.2 Barriers to Accessing Finance

The secondary steel sector is vastly heterogenous in its composition and consists of a large number of MSME units that struggle with poor creditworthiness alongside several knowledge-based and cost of capital-related barriers that hinder their access to institutional finance.

a) Knowledge-based Barriers

The units in the secondary steel industry often lack awareness about financial assistance provisions available to them through primary lending institutions. Additionally, the utilization of business development services, preparation of syndication for loans, and familiarity with digital platforms are largely absent as well. Often, these units also struggle with information on documentation requirements to acquire commercial loans. An overall lack of financial expertise and poor financial management alongside limited handholding support makes the sector particularly weak in acquiring formal credit.

As their business operations often underperform under a lack of skilled guidance, credit risk perception from the domestic financial sources against the sector sharpens as well. Consequently, from the supply side, the secondary steel sector is perceived with high risks. Furthermore, a lack of consistency in bookkeeping and reporting financial data develops opacity around the information on the financial affairs of MSMEs in the sector and further contributes to risk perception over their business profitability. Besides, among financiers, the knowledge of mitigation technologies, their maturity status, and their payback periods remains meagre. Thus, they find it hard to ascertain the suitability of various financial instruments to support the deployment

TABLE 5: Barriers to Accessing Finance for the Secondary Steel Industry

	Industry	Domestic Financial System	International Financial System
Knowledge-based barriers	• Awareness gaps • Documentation requirements • No financial expertise	• Low technological awareness • High perceived risks	• Limited direct exposure to the sector • High perceived risks
Cost of Capital-related barriers	• High transaction cost • High interest rates • Long payback periods	• Low margin • High transaction cost • Interest rates • Inadequate (low) maximum funding limits	• Lending prerequisites • Due diligence • High transaction cost • Larger scale of operations
Creditworthiness-based barriers	• Irregular cash flow • Delayed payments	• Lack of collateral • Seasonal operations • Low credit score	• Low credit score

of low-carbon technologies. The international sources of finance, additionally, have limited direct exposure to the sector. Green finance in India largely remains concentrated on projects around adaptation or renewable energy.

b) Cost of Capital-related Barriers

Commerical lending to the secondary steel sector for low-carbon technologies can have a high cost of capital due to the long payback periods on the technologies, the need for monitoring and engagement with the MSME units, and low-profit margins from such loans. For the industry, non-concessional rates of interest on commercial loans raise the cost of loans and disincentvize a shift to low-carbon technologies.

Due diligence and limiting pre-requisites and standards from financiers also limit the capabilities of the secondary steel sector to mobilize upfront investment. For instance, ICF institutions require structured procedures, verification processes, and channels for the processing and accreditation of finance, which the secondary steel sector finds hard to keep up with. Additionally, conditionalities such as existing WHR system installations are required to be eligible to access finance (Banerjee et al., 2022). Significantly, ICF often has a larger scale of operations, and the high transaction costs of servicing the MSME sector furthers the divide between the two.

c) Creditworthiness-based Barriers to Finance

Secondary steel sector units, particularly the MSMEs, often have a low credit score which makes it difficult for them to acquire finance. Inadequate collateral holdings, the seasonal nature of their operations and consequent irregularities in cash-flow, high non-performing assets, and limited equity, all restrain the creditworthiness of the industrial units.

Moreover, the secondary steel sector MSMEs also face the problem of delays in payments and aid. The steel ministry in its December 2022 year-end review said its central public sector enterprises had made a payment of INR 4,747.53 crore (approx. USD 578 million) to steel MSMEs between April and November 2022 - 41.35% higher than the same period last year.[6] However, at the same time, as of March 2, 2023, the amount pending

[6] 41% higher payment made by steel CPSEs to MSMEs during April-Nov 2022 from year-ago period: Govt. (2022, December 26). Financial Express. https://www.financialexpress.com/industry/sme/msme-fin-41-higher-payment-made-by-steel-cpses-to-msmes-during-april-nov-2022-from-year-ago-period-govt/2927216/

to be cleared by CPSEs to MSMEs overall (in all sectors), stood at INR 2,679.22 crore (approx. USD 326 million) in 2,886 delayed payment applications (Soni, 2023). Such delays pile up with liquidity crunches and further strangle MSME operations.

4.3 The Role of International Climate Finance (ICF)

As elaborated by the earlier sections, the goal of decarbonization of the Indian secondary steel sector would require a significant amount of policy attention, technical handholding, and importantly, financial support to be realized. The sheer scale of finance that would be required to decarbonize the industrial sector cannot be met by domestic sources of finance alone in the long run. International finance can play a significant role in enabling the transition to low-carbon steel production. International finance can instrumentally enable the de-risking of private investments and mobilization of private capital through various sources.

4.3.1. Indian Secondary Steel Sector's Exposure to ICF

In the past decade and a half, the flow of ICF in India has greatly remained focused on climate adaptation, or on specific sectors such as renewable energy and electric vehicles. The steel industry, particularly the secondary steel sector, has largely remained underattended through dedicated ICF initiatives or investments. For instance, the World Bank recently approved USD 1.5 billion in financial assistance to accelerate India's development of low-carbon energy. The crux of financing under the initiative would be on renewable energy expansion, the development of green hydrogen, financing green energy investments, funding a national carbon credit trading scheme, and the issuance of sovereign green bonds.[8]

At the same time, financial assistance that has been serviced to the sector from international financial institutions has come indirectly through energy efficiency initiatives for the MSME sector (such as World Bank-GEF-BEE's 'Financing Energy Efficiency at SMEs' project), through MSME investment programs (such as UNIDO's SME Investment Promotion) and credit guarantees, or in some instances, through project grants.

JICA and SIDBI's 'Financing Scheme for Energy Saving Projects' is one such initiative that was availed by the secondary steel sector MSMEs during the last decade. The scheme focused on providing financial assistance at concessional rates of interest to promote energy-saving projects. Concessional financing was provided through banks, state finance corporations, and non-banking financial companies. Eligible sub-projects under the scheme included the acquisition of energy-saving equipment, building equipment/heating systems/lighting in compliance with the energy conservation building code, and projects involving intervention at the cluster level for technological or procedural upgradation.[9]

Other major international schemes facilitating the secondary steel sector include the World Bank-GEF funded 'Partial Risk Sharing Facility in Energy Efficiency' and the 'Financing Energy Efficiency at SMEs' project being implemented by SIDBI and BEE, respectively. The World Bank and GEF's Partial Risk Sharing Facility in Energy Efficiency is a USD 37 million de-risking facility that provides partial credit guarantees to cover a share of default risk for financial institutions in extending loans for EE projects through Energy Service Companies (ESCOs).[10]

UNIDO's SMEs Investment Promotion Programme in India was undertaken between 2008 and 2011 with a budget of 800,000 Euros, in cooperation with the Italian organization CONFIDI to train SIBDI staff members for 4 years in international best practices for the management of mutual credit guarantee scheme. It helped strengthen SIDBI and develop mutual credit guarantee schemes suitable to the Indian ecosystem.[7]

7 UNIDO Partnership Strategy with Development Finance Institutions. https://www.unido.org/sites/default/files/2015-05/DFI_Publication_0.pdf

8 World Bank Approves $1.5 Billion in Financing to Support India's Low-Carbon Transition. (2023, June 29). https://www.worldbank.org/en/news/press-release/2023/06/29/world-bank-approves-1-5-billion-in-financing-to-support-india-s-low-carbon-transition

9 JICA – SIDBI Financing Scheme for Energy Saving Projects in MSME Sector (Phase III). (n.d.). Foundry Informatics Centre. http://www.foundryinfo-india.org/pdf/JICA_Brochure.pdf

10 Partial Risk Sharing Facility in Energy Efficiency. (2021, May 12). IEA. https://www.iea.org/policies/6203-partial-risk-sharing-facility-in-energy-efficiency

Table 6 further elaborates on some programs that have been implemented with funding from international agencies like GEF for improving EE. These programs were remarkably effective in providing financial as well as much-needed handholding support to enable emission reductions for the units. However, the scale of these initiatives was small and focused on only specific target groups of MSMEs and clusters.

TABLE 6: Energy Efficiency (EE) Programs for MSMEs in the Indian Secondary Steel Sector[11]

Program	Time Period	Target Areas	Funding	Objectives / Achievements
GEF-UNDP-MOS EE in Steel-Rolling Mills (Phase-1)	2004-13	14 states; 38 Model MSME units	USD 14.03 million (GEF – USD 6.75 million & Steel Development Fund – USD 7.28 million)	**Aim**- To improve the level of adoption of EE technologies and reduce emissions. Achievements **a.** Establishing low as well as high investment benchmarks for eco-tech packages, effective knowledge dissemination, and capacity-building of units. **b.** Reduction of specific electrical energy consumption by 10-20% & Specific Thermal Energy Consumption by 20-50% & reduction of GHG by 1000-2500 tCO_2/per unit per year.
UNIDO, GEF & BEE - Financing EE at SMEs Project	2011 - (active)	14 MSME Clusters 80 MSMEs	USD 26.1 million (overall)	**Aim-** Market development for EE and renewable energy technologies. **Achievements (until 2019)**[12] **a.** Energy savings of 7,894 toe, and reduction of carbon emissions by 49,896 Tonnes, annually. **b.** Monetary savings of USD 6.62 million.
UNDP, AusAID-MoS (Phase - 2)	2013-16	PAN India; 285 MSME units	USD 2.44 million	**Aim**- To improve EE, mitigate GHG emissions, and enhance technical capacity and productivity. Achievements **a.** Technical assistance to enable energy audits, implementation of energy efficiency measures, cost-benefit interventions, & knowledge development. **b.** 24% energy savings and 28% reduction in GHG emission per ton of mill output.

4.3.2 International Examples of Financing LCT and MSME Support

International experience in financing low carbon transitions of hard-to-abate sectors such as steel can crucially provide insights into technology transfer, capacity-building initiatives, and financial instruments that can be deployed to facilitate the decarbonization of the Indian secondary steel sector.

[11] Upscaling Energy Efficient Production in Small-Scale Industry in India. (2016, January). In UNDP. https://info.undp.org/docs/pdc/Documents/IND/00074684%20Terminal%20Evaluation%20Report%2000086974.pdf

[12] GEF-UNIDO-BEE Project. (n.d.). Bureau of Energy Efficiency. https://beeindia.gov.in/en/programmesdemand-side-managementsmall-medium-enterprise/gef-unido-bee-project

For instance, Energy Efficiency Revolving Funds (EERF) have been established around the world with support from international institutions such as the World Bank and the GEF. These EERFs have performed diversified functions and undertaken various routes to support LCT initiatives. Some have provided guarantees (for e.g., in Bulgaria, Hungary, and Slovenia) or credit lines (in Thailand) to commercial banks to mobilize private sector financing. Some have exclusively financed EE investments, while others have included the scopes of renewable energy (in Armenia and Mexico), environmental protection (in Slovenia), and urban infrastructure (in India) (Lukas, 2018). In India, The State Energy Conversation Funds (SECF) are also being promoted to facilitate the implementation of EE projects. A major part of the funds disseminated under the SECF initiative would be designated as Revolving Investment Fund, to support various EE initiatives.[13]

International financial institutions in the past couple of decades have also shown a growing interest in circular business models, and sustainability-linked financing. Between 2010 to 2015, for instance, the Russian government leveraged European Bank for Reconstruction and Development (EBRD) and UNIDO's expertise to overcome barriers relating to EE in Russian industries. In partnership with the Russian Energy Agency, enhanced policy frameworks were developed for dedicated capacity building of market stakeholders and investment amplification to generate a push for industrial energy efficiency and reducing GHG emissions.

In Africa, credit guarantee schemes have facilitated MSME financing post the covid-19 pandemic by ensuring lesser market distortions than other policy interventions such as direct lending programs. They have also encouraged a greater financial inclusion of MSMEs, enabled opportunities for service providers, helped unlock private capital to optimize scarce resources, and tackled issues of information asymmetry and creditworthiness-based barriers to finance for MSMEs.[14] Credit guarantees have also been successful in several other parts of the world. Chile's *FOGAPE*, for instance, is one of the most efficient public credit guarantee schemes in the world and takes only 15 days (about two weeks) to make the full payment to the lender. In comparison, the CGTMSE in India takes up to 30 days to pay 75% of the guaranteed amount to the lender. Such delays in the processing of payment discourage lenders from using public guarantees for lending to small enterprises.

Similarly, the GCF has an MSME Pilot Programme in Guatemala, Mexico, Mongolia, and Ghana, with an allocation of USD 200 million to finance MSME initiatives at different stages of growth. Despite having the world's second-largest base of MSMEs, no such program exists for the Indian MSME sector (Maltais et al., 2022). Thus, alongside a dedicated policy focus on the LCT of the sector, innovation in the utilization of diverse financial instruments would be required to service the Indian secondary steel sector.

4.4 Financial Instruments for Financing Decarbonization

The LCT of the secondary steel sector would require financing for two types of costs- the direct upfront capital cost of low-carbon technologies, and the cost of covering technical assistance and enabling these technologies. Significantly, loans can't be the primary financial instrument to enable decarbonization for the secondary steel sector. Even though there have been several ICF-based initiatives in the past, their scale of operations hasn't been adequate. Moreover, no single financial instrument would be able to definitively address all the barriers faced by the sector toward potential LCT.

The LCT of the secondary steel sector would require financing for two types of costs- the direct upfront capital cost of low-carbon technologies, and the cost of covering technical assistance.

[13] Contribution to State Energy Conservation Fund. (n.d.). Bureau of Energy Efficiency. https://saathee.beeindia.gov.in/Common/BEEContent?MID=1&SMID=21

[14] Credit Guarantee Schemes: Facilitating MSME Financing in Africa During The COVID-19 Pandemic. In Alliance for Financial Inclusion. (2022, March). https://www.afi-global.org/wp-content/uploads/2022/03/Credit-Guarantee-Schemes-Facilitating-MSME-Financing-in-Africa-during-the-COVID-19-Pandemic_070322.pdf

Various alternative instruments of finance can be utilized to service the secondary steel sector depending on the suitable risk/return arrangements and purpose-based requirements. Blended financing and innovative solutions with a focus on insurance and layered-risk mechanisms would be key to overcoming some challenges relating to the risk perception of investors servicing the sector. Deployment of financial instruments in varying combinations can help address diverse issues faced by the secondary steel sector in accessing finance, which a single instrument otherwise may not be able to cover. Some financial instruments that can be deployed for the sector include multi-layer risk funds and guarantees, cluster-level securitization, hybrid financing, and large-scale grants/equity funding for revolving funds.

Layered-risk funds can instrumentally channel finance and technical guidance to underfunded sectors, as the risk safety mechanism enables independent financing institutions to invest more while attracting investment from safeguarded private investors, who can provide technical guidance.[15] It could also help broaden the

TABLE 7: Financial Instruments & their Suitability against Barriers to Finance

Bottlenecks/ Challenges Covered	Financial Instruments and Examples							
	Asset-based Finance	Securitization	Leasing	Guarantee Funds	Technical Grants	Hybrid Financing	Risk-sharing Funds/ Facility	Revolving Funds
Examples				CGTMSE	UNIDO. GEF&BEE; GEF-UNDP-MOS	Concessional Subordinae Debt	BEE-World Bank-GEF (partial)	EERFs for credit lines, guarantees
Lengthy Documentation & Processing Time	High	High	Moderate	Moderate	High	Moderate	Moderate	Moderate
Inadequate Collateral Holdings	Low	Moderate	High	High	High	High	Moderate	Moderate
High Rate of Interest	High	High	High	High	High	High	High	High
Low Credit Scores	High	High	High	High	High	High	Moderate	Low
High Transaction Costs	Low	Moderate	Moderate	Moderate	High	High	High	Moderate
Technical/Financial Capacity Building	High	Low	Low	Low	High	High	High	Moderate
High Technological Upgradation/Capital Costs	Moderate	Moderate	High	High	Moderate	High	High	High
Investor Risk Protection	Moderate	High	High	High	High	Moderate	High	High
Large-scale Coverage	Low	Low	Low	High	Low	Low	High	High

(Source: Author's Analysis)

[Note: High efficacy against the barrier Moderate efficacy against the barrier Low efficacy against the barrier.]

15 Innovative climate finance products. (2015). European Investment Bank. https://www.climateaction.org/images/uploads/documents/innovative_climate_finance_products_en.pdf

investor base to potentially include global investment funds, as well as institutional investors like insurance companies and philanthropic capital. Guarantee funds, on the other hand, can help cover long-term, initially risky/uncertain investments in MSME firms (Csaky et al., 2017). They can be deployed for credit enhancement, and their flexibility allows lenders to extend the payment tenor for risky borrowers – shaping it to their capital expenditure requirements and monthly payment abilities.

In terms of lending, securitization can be utilized for lending based on receivables. It can also be advantageous to banks by reducing their exposure to credit risk, and consequently, their overall cost of financing (OECD, 2015). Similarly, hybrid financing instruments such as subordinate debt can be extended for diverse purposes such as technological investment and high-cost capital replacement. It offers the advantage of not diluting the firms' investors' equity and is also free from enforced operating covenants as in the case of traditional debt or leases. Lastly, blending private finance with grants and public concessional funds can unlock investments from diverse investors and multilateral climate funds.

SECTION 5:

Recommendations

RECOMMENDATIONS

To address the identified challenges for leveraging finance for the low-carbon transition of the secondary steel sector, this report makes recommendations for interventions at the national level, as well as at a broader international level to ensure a greater enabling envrionment for the flow of international climate finance to the secondary steel sector.

5.1 Interventions at the National-Level

1) **Development of a Multi-Stakeholder Platform** – A multi-stakeholder information-sharing platform could be developed with the participation of government institutions, knowledge institutions, industry associations, financial associations, and technology providers. The platform can crucially address information gaps for the industry on financial provisions and due diligence, as well as enable financiers to know better about emerging technologies, to ascertain suitable financial instruments for extending credit for their uptake. Greater organization of information about the dynamics of the sector and its requirements could also help attract international investment in the longer future.

2) **Cluster-level Interventions** need to be made to essentially map secondary steel units into clusters which could be supported through securitization to secure loans for working capital requirements. Up-take of clean technologies could also be initiated in clusters with programmatic partnerships, performance-based mechanisms, technical support, and handholding. Large-scale revolving funds could be developed as financial pipelines for such programmatic interventions for a large number of heterogenous clusters. These funds shall be supported by international climate finance through grants.

3) **Development of a Dedicated National Fund for Steel Decarbonization** – To facilitate the financing of low-carbon transition of the Indian steel sector, a dedicated national fund can be developed. Such a fund could be housed with the Ministry of Steel and SIDBI could be assigned a facilitative role for financing. Furthermore, specific SIDBI windows could be developed to support results-based financing. It could also be divergently developed as time-bound close-ended fund to support the uptake of clean technology- like the SIDBI Tex Fund Scheme which focused on investing in emerging fields in the textile industry.

   Additionally, policy frameworks and regulations would further be required to streamline the secondary steel industry's access to finance in the long run. Extension of finance through a dedicated decarbonization fund can also be allied with emission intensity reduction targets- with financial or fiscal incentives of varying quantum associated with the targeted achievements.

4) **A Financially-backed Scheme for the Integration of Waste Heat Recovery Systems** – Waste heat recovery is a disruptive technological option that can serve as a low-hanging fruit for the low-carbon transition of the secondary steel sector units. Despite a relatively low level of investment requirements and quicker payback periods, waste heat recovery remains grossly under-utilized by the secondary steel sector. A national-level scheme that subsidizes waste heat recovery technologies or provides incentives for their adoption could strongly facilitate energy efficiency and emission-reduction in a short amount of time.

5) **Dedicated Renewable Energy Supply for the IF/EAF Units** – Most of the IF and EAF units in the secondary steel sector are standalone units with constrained operating sizes to develop any captive power facilities. More than 70% of the energy input for these units comes from electricity and the dominant share of this electricity is sourced from fossil-fuel-based power plants. Dedicated allocation of a certain percentage of renewable energy supply to these units from state and private discoms could effectively mitigate scope 2 emissions from the sector. Importantly, center-state policy

coordination on power supply would need to be streamlined, alongside an overall expansion of the power grid.

6) **Enhancing Scrap Availability and Collection** – Amplifying scrap utilization and promoting a circular economy model for the secondary steel industry is key to its sustainable future. Currently, the downstream sector remains import-dependent for sourcing scrap. To reverse this dependence, India would need to remarkably improve scrap recycling. As outlined by the National Steel Scrap Recycling policy, setting up scrap recycling centres with an effective formalization of scrap collection, segregation, and dismantling would be required to attain higher recycling rates (80-90%) as in Europe, Japan, and South Korea. To ensure material availability, the successful implementation of policies such as the National Vehicle Scrappage Policy would be essential.

5.2 Interventions to Enhance the flow of International Climate Finance

1) **Multi-level Risk Guarantee Mechanisms** dedicated to de-risking financing low-carbon transition technologies with longer payback periods need to be developed. As discussed in the earlier section, private finance would play a key role in meeting the overall financial requirements of the sector and consequently de-risking mechanisms would need to be included in the fold. For layered-risk funding mechanisms, the first layer of guarantee can be provided at the sub-national/national level, which could be further supported by international climate finance. Consequently, requirements of due diligence on documentation, reporting, and monitoring can also be assigned at local levels to overcome the cost of capital-related barriers to accessing international climate finance. International climate finance needs to be viewed as a major source to finance the LCT of the secondary steel sector.

2) **A Sector-Level Modernization Programme supported by ICF** – International climate finance needs to be viewed as a major source to finance the LCT of the secondary steel sector. Consequently, a sector level modernisation programme could be targeted. Such a programme could be prepared to address the decarbonization challenge in phases – starting with the adoption of energy efficiency measures and alternative fuels. This sectoral modernization programme plan shall be posed to the World Bank or the GCF for funding and accessing international climate finance.

Conclusion

This report has laid out the complex and intertwined landscape of the steel sector when it comes to production of almost twenty-five percent of steel in India via the over 1000 MSME units. It establishes the deep dependencies on coal-based direct reduction of iron that have locked in high emitting technologies. Glaringly, the historical reasons for this have been the sector trying to avoid dependencies on imported cooking coal, the lack of affordable natural gas and regional development of industry goals. While seemingly there exists a lot of low-hanging fruit in terms efficiency improvements for the MSME steel sector like investments in waste heat recovery, whether this alone is a decarbonization and modernization strategy for this sector remains doubtful. Even with these improvements these production processes will remain disproportionately carbon and energy intensive and may thus also continue to face uncertain economic perspectives.

Thus, a clarity on strategy for how to transition the sector and its myriad moving parts and stakeholders is an essential precursor. The strategy shall take under consideration the important role of the MSME steel industry for local economies and identify what primary or secondary production technologies can offer long-term perspective for steel production and processing in the emerging national and global steel value chain. The strategy shall also enhance clarity for private investors, international public funders and domestic banks as mixed signals and uncertainties will hamstring access to capital.

Our proposition as the pathway for this strategy evolves is that we consider the challenges in getting international finance for coal based DRI as even with efficiency improvements they will remain carbon intensive. Also, a shift to CCS or hydrogen-based production technologies are challenging to apply here given the small size of installations and requisite CO_2 capture infrastructure that would be needed. We instead recommend exploring the feasibility of transitioning coal based DRI installations to recycled steel making, as these facilities keep their EAF or and get financing for those, while phasing down the coal DRI installations of their facility.

Significantly, this transformation might reduce the value add of the plant but might not have drastic implications for jobs, as labor intensity is further downstream (rolling, casting, use for manufacturing/construction). All the while there might be other co-benefits to the local firms and communities in terms of local air pollution and stabilization of the sites to realize investments in upgrading EAF's and downstream activities. The implication of this would be that a large share of steel scrap would go to the local small-scale installations. This would offer co-benefits, given the challenges in scrap collection, scrap quality and scrap processing requirements are actively worked at.

Importantly, prioritizing finance for improvements within the secondary steel sector in India becomes imperative. Such enormous shifts in production pathways of the sector might be currently uncertain to predict but unavoidable to acknowledge for the future. Crucially, as pivotal changes in the operational nature of the sector would demand substantial support in terms of financing and capacity building, access to international climate finance indubitably would need to become the facilitative landscape which would catalyse and incentivize this sectoral transformation.

Strikingly, to adopt the mere best-available technologies (BATs), the Indian secondary steel sector would require upfront investments of above 14,000 million USD and considerable technical handholding. Thus, a low-carbon development strategy for the secondary steel sector becomes imperative to formulate. Phased steps towards cleaner production pathways need to be outlined to strike a balance between emission intensity reduction and ensuring a business case for the sector. And, most importantly, the development of a strategy is critical to provide an outlay to avail finance for the sector, alongside programmatic technical support. The realisation that implementation of a decarbonization strategy for the sector hinges on the availability of international financial backing is central to a cleaner future of the sector. Beyond technology transfer and upgradation, international climate finance would also be key to enabling capacity building programs, labour skill formation and overall sustainable development within the sector. The development of an ecosysystem conducive to facilitating the attraction, absorption, and dissemination of finance emerges as the need of the hour for the secondary steel sector. A clear strategy through a phased roadmap for LCT shall facilitate the overall development of an enabling environment, support both- financial and technical assistance.

References

41% higher payment made by steel CPSEs to MSMEs during April-Nov 2022 from year-ago period: Govt. (2022, December 26). Financial Express. Retrieved July 11, 2023, from https://www.financialexpress.com/industry/sme/msme-fin-41-higher-payment-made-by-steel-cpses-to-msmes-during-april-nov-2022-from-year-ago-period-govt/2927216/

All About 1 MW Solar Power Plant: Price, Specifications & More. (2023, February 14). Amplus Solar. https://amplussolar.com/blogs/1mw-solar-power-plant

Banerjee, S., Biswas, D.A., Goel, S., Kedia, S. (2022). Financing Low Carbon Transition in India's MSME Sector. In TERI. https://climatestrategies.org/wp-content/uploads/2022/09/220909_Report_India.pdf

Bureau of Energy Efficiency. (n.d.). Retrieved July 10, 2023, from https://www.adeetie.beeindia.gov.in/home/fidetail/sidbi

CEEW, Yadav, D., Guhan, A., and Biswas, T. (2021). Greening Steel: Moving to Clean Steelmaking Using Hydrogen and Renewable Energy. New Delhi: Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/ceew-study-on-clean-and-carbon-neutral-hydrogen-based-steel-production.pdf

Contribution to State Energy Conservation Fund. (n.d.). Bureau of Energy Efficiency. Retrieved July 10, 2023, from https://saathee.beeindia.gov.in/Common/BEEContent?MID=1&SMID=21

Credit Guarantee Schemes: Facilitating MSME Financing in Africa During The COVID-19 Pandemic. (2022, March). In Alliance for Financial Inclusion. Retrieved July 10, 2023, from https://www.afi-global.org/wp-content/uploads/2022/03/Credit-Guarantee-Schemes-Facilitating-MSME-Financing-in-Africa-during-the-COVID-19-Pandemic_070322.pdf

Csaky, E., Frei-Oldenburg, A., Hess, U., Kuhn, S., Miller, C., Varangis, P. & Perry, D. (2017, May). Climate Smart Financing for Rural MSMEs: Enabling Policy Frameworks. In G20 Global Partnership for Financial Inclusion. https://www.gpfi.org/sites/gpfi/files/documents/08%20GPFI%20-%20Policy%20Paper%20ClimateE%20smart%20financing%20for%20rural%20MSMEs_0.pdf

David, M. (2021, January 14). Small Scale Metal Recycling Plant Equipment. Metallurgist & Mineral Processing Engineer. https://www.911metallurgist.com/small-scale-metal-recycling-plant-equipment/

Finextra. (2023, February 6). Union budget 2023: Key highlights for startups, SMEs, and businesses. Finextra Research. https://www.finextra.com/blogposting/23686/union-budget-2023-key-highlights-for-startups-smes-and-businesses

GEF-UNIDO-BEE Project. (n.d.). Bureau of Energy Efficiency. Retrieved July 10, 2023, from https://beeindia.gov.in/en/programmesdemand-side-managementsmall-medium-enterprise/gef-unido-bee-project

Ghosh, A.M., Vasudevan, N. and Kumar, S. 2021. Compendium: Energy-efficient Technology Options for Direct Reduction of Iron Process (Sponge Iron Plants). New Delhi: The Energy and Resources Institute. https://www.teriin.org/sites/default/files/2021-08/Direct%20Reduction%20of%20Iron%20Process.pdf

IEA .(2020). Iron and Steel Technology Roadmap, IEA, Paris https://www.iea.org/reports/iron-and-steel-technology-roadmap,

IEA. (2021). ETP Clean Energy Technology Guide. https://www.iea.org/articles/etp-clean-energy-technology-guide.

Innovative climate finance products. (2015). European Investment Bank. https://www.climateaction.org/images/uploads/documents/innovative_climate_finance_products_en.pdf

JICA – SIDBI Financing Scheme for Energy Saving Projects in MSME Sector (Phase III). (n.d.). Foundry Informatics Centre. Retrieved July 10, 2023, from http://www.foundryinfo-india.org/pdf/JICA_Brochure.pdf

JSW - Steel and Indian Economy: An Upward Curve. (n.d.). JSW. Retrieved July 10, 2023, from https://www.jsw.in/steel/steel-and-indian-economy-upward-curve#:~:text=Steel%20now%20contributes%20about%202,in%20the%20global%20steel%20market

Lukas, A. (2018). Financing Energy Efficiency, Part 1: Revolving Funds. In World Bank Group. Retrieved July 11, 2023, from https://openknowledge.worldbank.org/server/api/core/bitstreams/647835bc-ffbe-5e01-baf5-e3b45120847d/content

Maltais, A., Linde, L., Sanchez, F. and Mete, G. (2022). The role of international finance institutions in the transition to low-carbon steel production. LeadIT Research Report. Stockholm Environment Institute, Stockholm. https://www.industrytransition.org/content/uploads/2022/11/report-2209a-ifis-lhv2.pdf

Ministry of Steel - Annual Report 2022-23. (2023, June 20). In Ministry of Steel, Government of India. Retrieved July 10, 2023, from https://steel.gov.in/sites/default/files/MoS%20AR%202022-23.pdf

Ministry of Steel, Government of India. (2019). National Steel Scrap Recycling Policy. New Delhi. Retrieved from https://steel.gov.in/sites/default/files/Steel%20Scrap%20Recycling%20Policy%2006.11.2019.pdf

OECD. (2015). New Approaches to SME and Entrepreneurship Financing: Broadening the Range of Instruments. https://www.oecd.org/cfe/smes/New-Approaches-SME-full-report.pdf)

Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE). (n.d.). Bureau of Energy Efficiency. Retrieved July 10, 2023, from https://beeindia.gov.in/sites/default/files/PRGFEE_0.pdf

Partial Risk Sharing Facility in Energy Efficiency. (2021, May 12). IEA. Retrieved July 10, 2023, from https://www.iea.org/policies/6203-partial-risk-sharing-facility-in-energy-efficiency

Soni, S. (2023, March 2). Over Rs 2,600 crore in MSME payment yet to be cleared by central PSUs, ministries, departments: Govt data. The Financial Express. https://www.financialexpress.com/industry/sme/msme-fin-over-2600-crore-in-msme-payment-yet-to-be-cleared-by-central-psus-ministries-departments-govt-data/2997811/

Sponge Iron Manufacturers Association. (2021). DRI Update. https://www.spongeironindia.com/images/publications/DRI-UPDATE%20March,%202021.pdf

TERI & GIZ. (2022). Indian Secondary Steel Sector Cluster Mapping and Resource Consumption Study.

TERI, Nand Gopal, E., Ganguly, A., and Vasudevan, N. (2017). Technology Compendium on Energy Efficient Technology Packages for Electric Arc Furnace New Delhi: The Energy and Resources Institute 62pp. A study for UNDP.

UNIDO Partnership Strategy with Development Finance Institutions. (n.d.). UNIDO. Retrieved July 10, 2023, from https://www.unido.org/sites/default/files/2015-05/DFI_Publication_0.pdf

Upscaling Energy Efficient Production in Small-Scale Industry in India. (2016, January). In UNDP. Retrieved July 10, 2023, from https://info.undp.org/docs/pdc/Documents/IND/00074684%20Terminal%20Evaluation%20Report%2000086974.pdf

Venture Capital Fund for Energy Efficiency (VCFEE). (n.d.). Bureau of Energy Efficiency. Retrieved July 10, 2023, from https://beeindia.gov.in/sites/default/files/VCFEE_0.PDF

World Bank Approves $1.5 Billion in Financing to Support India's Low-Carbon Transition. (2023, June 29). World Bank. https://www.worldbank.org/en/news/press-release/2023/06/29/world-bank-approves-1-5-billion-in-financing-to-support-india-s-low-carbon-transition

World Steel in Figures 2022. (2023, June 1). World Steel Association. https://worldsteel.org/steel-topics/statistics/world-steel-in-figures-2022

Annexures

Annexure – 1

List of Stakeholders for Consultation

Financing Institutions - International
United Nations Industrial Development Organization (UNIDO)
Asian Development Bank
GEF Capital Partners
Financing Institutions - Domestic
YES Bank
Small Industries Development Bank of India (SIDBI)
Energy Efficiency Services Limited (ESSL)
Industry
Confederation of Indian Industry (CII)
Minmet Consultants
Sponge Iron Manufacturers Association (SIMA)
All India Induction Furnaces Association (AIIFA)
All India Steel Re-Rollers Association (AISRA)
Alloy Steel Producers Association of India
Think Tank/Institutions
German Corporation for International Cooperation (GIZ)
The Energy and Resources Institute (TERI)
Shakti Sustainable Energy Foundation
Climate Policy Initiative (CPI)
Government Institutions
Ministry of Steel Task Force on Financing Steel Sector
Bureau of Energy Efficiency (BEE)

Annexure – 2

Selected List of Active Funding Schemes for the Secondary Steel Sector

Scheme	Year of Introduction	Implementing body	Features / Provisions
NMEEE (National Mission for Enhanced Energy Efficiency)	2011	Ministry of Power & BEE	• Includes initiatives such as the PAT scheme, EEEP, and the Framework for Energy Efficiency Economic Development (FEEED) to build capacities of institutions to fund EE projects.
VCFEE (Venture Capital Fund for Energy Efficiency) (BEE, accessed 2023)	2017	BEE	• Last-mile equity support for specific energy efficiency projects through Special Purpose Vehicle (SPV). • 15% of total equity or INR 2 Crores provided. • Union Government approved amount for the fund is INR 210 crores.
RAMP (Raising and Accelerating MSME Performance)	FY 2022-23 to FY 2026-27	Ministry of MSME	• Accelerate MSME sector's performance by strengthening financial institutions, enhancing centre-state partnerships, addressing issues with late payments and the greening of MSMEs. It involves strategic investment plans (SIPs). • 2023-24 rollout - an outlay of Rs 6,000 crore (Finextra, 2023).
SIDBI-4E Scheme (End to End Energy Efficiency)	2014	SIDBI	• Provide financial assistance to MSMEs, promote energy efficiency and sustainability. • Loan amount between ₹10 Lakhs to ₹5 Crores at 6.4% to 7.5% interest rate.
PRGFEE (Partial Risk Guarantee Fund for Energy Efficiency) (BEE, accessed 2023)	2008	BEE	• Provides financial institutions with partial coverage of the risk involved in extending loans for energy efficiency projects. • 50% of the loan amount/Rs. 10 crore per project.
CGTMSE (Credit Guarantee Fund Trust for Micro and Small Enterprises)	2000	Ministry of MSME & SIDBI	• Credit guarantee for lenders up to 50-85% on defaults made by MSME borrowers on collateral-free loans extended through primary lending institutions. • FY24 - Infusion of around Rs 9,000 crore into the fund - lowered the cost of credit by 1% to allow the MSME sector to avail cumulative collateral-free credit guarantee of Rs 2 trillion (Finextra, 2023).
CLCSS (Credit Linked Capital Subsidy Scheme for Technology Upgradation)	2000; Revamped in 2005	Ministry of MSME – 12 nodal banks including SIDBI	• Implemented through 12 nodal agencies such as SIDBI & other Primary Lending Institutions. • Facilitation of technology upgradation - an upfront subsidy of 15% on institutional credit up to ₹ 1 crore for MSMEs in various sub-sectors.
SRIJAN Scheme (TIFAC-SIDBI Revolving Technology Innovation Fund)	2010	SIDBI	• Financing for development, demonstration, and commercialization of innovative technology projects by MSMEs. • Maximum loan amount of up to INR 2 Crores at 5% interest rate.

Annexure – 3

Integrating Best Available Technologies and Input-based Solutions in the DRI process (Ghosh et al., 2021)

Best Available Technologies (Short & Medium term)	Technology Description	Estimated Investment required (USD million)	Estimated Savings (USD million)	Energy saving (Gcal/ year)	GHG reduction (tCO_2/ year)	Payback (Year)	Plant Capacity
Coal gasification for partial substitution	The producer gas is supplied instead of coal in the rotary kiln. The process consists of pyrolysis and gasification. The producer gas (CO and H2) is partially substituted instead of coal for combustion	1.3167	0.3148	21840	7500	NA	100 TPD (the plant will have to invest in setting up a producer gas system of corresponding capacity)
Use of iron ore pellets in DRI	To reduce the thermal load and increase the load of Iron ore pellets.		0.3947	27300	9400	NA	100 TPD
Thermostatic controller for cooling tower	The cooling tower is equipped with an automatic control system to regulate fan operation instead of manual controls. It reduces the temperature of incoming water based on wet bulb temperature and relative humidity of ambient conditions.	0.0002	0.0005	12	11	0.5	For a motor with a 10 Kw capacity for 100 TPD
FRP blades for cooling tower fans	The metal blades in cooling tower fan can be replaced with lighter fibre-reinforced plastic (FRP) blades, which would reduce the power consumption of the cooling tower system.	0.0008	0.0003	9	8	2.4	For a motor with a capacity of 7.3 kW
Energy-efficient pumps	Energy-efficient centrifugal pumps can be used in place of inefficient pumps, which provide advantages such as high-flow rates, smooth and non-pulsating delivery, and regulation of flow rate over a wide range.	0.0024	0.0029	72	69	0.8	The motor rating of an energy-efficient system will be 18.5 kW, replacing 30-kW inefficient pumps
Decentralized VFDs for shell air fans	VFD for each fan can be used to attain precise control of temperature. The main advantage of the use of decentralized VFDs is that it eliminates the manual intervention in controlling airflow across the kiln, leading to close control over the temperature in each zone.	0.0036	0.0006	16	16	5.2	Decentralized VFD systems for shell air fans for 100 tpd capacity rotary kiln

Best Available Technologies (Short & Medium term)	Technology Description	Estimated Investment required (USD million)	Estimated Savings (USD million)	Energy saving (Gcal/ year)	GHG reduction (tCO_2/ year)	Payback (Year)	Plant Capacity
Energy-efficient motors	The motive loads are the major consumers of electricity, which includes equipments like kiln drive, ID fan, shell air fans, crushers, cooling tower pumps, material handling system, and air compressor. For a 100-tpd coal-based DRI plant, the motor capacity is in the range of 7.5 kW to 75 kW. Most of the motors used are of standard type.	0.0036	0.0008	19	18	4.8	A typical example of electrical motor application is ID fan in rotary kiln, which uses 75 kW standard motor in a 100-tpd plant. This standard motor can be replaced with an IE3 (4-pole) motor
VFDs for air compressors	The VFD is used to minimize electricity consumption during unloading in the rotary screw compressor. VFD-enabled air compressors can deliver variable airflow to maintain set pressure based on end-use points.	0.0036	0.0028	71	67	1.3	VFD with a rated power of 22 Kw and with a full time load of 3,110 h/year
Mullite-based kiln lining	The high-alumina low-cement castable refractory material can be replaced with mullite-based high alumina castable refractory for reducing the outer-shell temperature and heat loss through the klin shell by 30 per cent.	0.0605	0.0436	3033	1050	4.1	Mullite-based lining of rotary kiln of 100 tpd capacity
WHR - Vapour Absorption Chiller	A vapour absorption machine (VAM) can be utilised to replace existing cooling arrangements. The existing standalone air conditing system can be replaced with WHR based VAM.	0.0085	0.0035	36	34	2	Energy saving that can be achieved by replacing conventional chillers with a VAM-based system of 10 TR (cooling load) capacity
WHR – Coal moisture reduction	The WHR-based rotary drum dryer can be installed for moisture removal in coal using the off-gases generated from the rotary klin during the process for iron production.	0.1211	0.0799	5539	1900	1.5	100 TPD
WHR– Iron ore preheating	The off-gases generated from the rotary kiln during the process can be recovered using the WHR boiler to generate a high-pressure system for preheating of iron ore, resulting in lower coal consumption.	0.4238	0.3935	22360	7726	1.1	200 TPD

Best Available Technologies (Short & Medium term)	Technology Description	Estimated Investment required (USD million)	Estimated Savings (USD million)	Energy saving (Gcal/ year)	GHG reduction (tCO_2/ year)	Payback (Year)	Plant Capacity
WHR - Power generation	The off-gases generated from the rotary klin during the process can be recovered using the WHR boiler to generate a high-pressure system for power generation	3.3902	1.0582	20227	19300	3.2	A kiln with 200 TPD production capacity has a WHR power generation facilty of 4 MW. A kiln with 100 TPD production capacity would have a power generation potential of 1.5-2.5 MW

Annexure – 4

Integrating Best Available Technologies in EAF and IF processes (TERI, 2017)

Best Available Technologies (Short and Medium term)	Technology Description	Estimated Investment required USD million	Estimated Savings/ year (USD million)	Energy saving	GHG reduction (tCO_2 /year)	Payback (Year)	Plant Capacity
FRP blades in cooling tower	The metal blades in the cooling tower fan can be replaced with 'fibre reinforced plastic' (FRP), lighter blades. Using FRP blades would reduce the power consumption of the cooling tower system.	0.0024	0.0024	Reduction in electricity consumption of cooling tower fan by 15-25%	40	0.8	Values based on cooling tower of 1.5 lakh kCal capacity
Installation of EE pumps	Generally, the pumps' efficiency in the cooling water circuit is in the range of 40-60 %. The installation of EE pumps for pumping water for cooling could increase energy savings.	0.0061	0.0097	energy savings with use of EE pumps in cooling water system is about 15–25%.	90	0.5-1	Values based on a 100 hp pump
Variable frequency drives in ID fans	The off gases generated from various reactions inside EAF are removed from the EAF using a fumes extraction system, which is typically equipped with a high-power ID fan.	0.0091	0.0091	Reduction in electricity consumption by 15 to 20%	120	1	50 tonne furance

Best Available Technologies (Short and Medium term)	Technology Description	Estimated Investment required USD million	Estimated Savings/ year (USD million)	Energy saving	GHG reduction (tCO_2 /year)	Payback (Year)	Plant Capacity
Waste heat recovery for boiler feed water	To reduce the overall energy consumption, the waste heat gases (900-1200°C) can be recovered and reused for pre-heating.	0.0121	0.0484	Furnace oil saving by 22 kg/hr	1510	0.2-0.5	NA
Scrap preheating (bucket System)	To reduce the overall energy consumption, the waste heat gases (900-1200°C) can be recovered and reused for a pre-heating scrap charging bucket.	0.2422	0.3245	41 kWh/t	5900	0.5-1	50 tonne furnace
Scrap preheating (Continuous System)	To reduce the overall energy consumption, the waste heat gases (900-1200°C) can be recovered and reused for a continuous pre-heating scrap charging system.	0.4843	0	NA	8860	1	50 Tonne furance
Ladle Pre-heating (BEE)	To reduce the overall energy consumption, the waste heat gases (900-1200°C) can be recovered and reused for pre-heating ladle used to transport molten liquid.	0.0121	0.0121	10-15 ToE/yr	150	1	steel IF with 5 tonnes capacity with 8 heats per day and 12,000 tonnes of annual production

Annexure – 5

Integrating Best Available Technologies and Input-based Solutions in the Steel Re-rolling Process (Unido, 2020)

Best Available Technologies (Short and Medium term)	Technology Description	Estimated Investment required USD Million	Estimated Savings/year (USD million)	Energy saving (Gcal/ year)	GHG reduction (tCO_2 /year)	Payback (Year)	Plant Capacity
Modified pulverized coal feeding system	Conventionally, the pulveriser is inefficient due to no proper control over air and fuel leading to improper combustion. In an efficient system, coal is pre-crushed and dried to remove the moisture and then coal is fed into the pulveriser.	0.02	0.031	1811	718	0.9	Considering a 10 t/h SRRM plant
Conversion of fossil fuel to Natural gas based reheating furnace	Natural gas is used instead of coal for better combustion and to reduce burning losses.	0.05	0.052	31391	14800	0.11	Considering a 15 t/h furnace

Best Available Technologies (Short and Medium term)	Technology Description	Estimated Investment required USD Million	Estimated Savings/year (USD million)	Energy saving (Gcal/ year)	GHG reduction (tCO_2 /year)	Payback (Year)	Plant Capacity
Energy Efficient Re-heating Furnace	Typically, all conventional furnaces have various losses due to inefficient design. The energy-efficient design of the re-heating furnace consumes less fuel and heat losses by increasing productivity.	0.18	0.199	8526	94.6	1.5	15 t/h furnace fired by pulverized coal
Conversion of fossil fuel to Coal-Based Methane (CBM) based reheating furnace	Coal-based methane is a carbon-neutral fuel extracted from coal beds. It's a form of natural gas used in re-rolling instead of solid fuel.	0.18	0.289	6354	9365	0.8	Considering a 15 t/h furnace
Conversion of fossil fuel to biomass-based producer gas re-heating furnace	Biogas is a carbon-neutral fuel generated from agricultural waste that can be used in re-rolling instead of solid fuel.	0.18	0.605	4543	11915	0.2	Considering a 15 t/h SRRM unit
Installation of high efficiency metallic recuperator in re-heating furnace	The waste heat generated from the re-heating furnace is recovered by the installation of recuperator.	0.03	0.099	5724	2,262	0.4	15 tph furnace capacity
Installation of automation & control system in re-heating furnace	Installation of automatic and control system basic monitoring instruments like thermocouples can increase the furnace efficiency at optimal level.	0.03	0.061	1331	526	0.5	15 tph furnace capacity
Installation of Energy Efficient Pulveriser	The critical components of energy-efficient pulverisers such as a Hammer, a mild steel liner (Use grooved EN-31 hardened steel plates or cast high manganese), a classifier, and an in-built blower. This can enhance the efficiency of the furnace by reducing energy consumption.	0.02	0.010	911	359	0.7	Considering a 10 t/h SRRM plant
Installation of Coal Drying system	The flue gases from the re-heating furnace are passed through a cyclone dyer for removing the moisture from the coal.	0.02	0.052	3032	1198	0.5	Considering a 15 t/h SRRM plant
Swirl Burner Used for Pulverized Coal Firing	Swirl burners are used for proper control of air fuel-mixture in re-heating furnaces	0.02	0.009	1001	395	0.6	Considering a 15 t/h SRRM plant
Installation of Anti-friction Roller Bearing in Rolling Mill Strands	Anti-friction roller bearing is used instead of conventional metal bearing for improving transmission efficiency and reducing energy consumption.	0.06	0.138	730	763	0.5	Considering a 15 t/h SRRM plant

Best Available Technologies (Short and Medium term)	Technology Description	Estimated Investment required USD Million	Estimated Savings/year (USD million)	Energy saving (Gcal/ year)	GHG reduction (tCO_2 /year)	Payback (Year)	Plant Capacity
Installation of Universal Couplings/ Spindles in Rolling Mill	Universal spindles and couplings are used instead of conventional wobbler couplings and spindles.	0.06	0.062	350	371	1	considering a 15 t/h SRRM unit
Installation of Y-table / Tilting Table / Repeaters in Rolling Mill	To reduce the temperature and energy consumption the Automatic Material handling system is installed.	0.06	0.166	2221	1025	0.4	considering a 15 t/h SRRM unit
Replacement of Existing Motors with IE3 Class Efficiency Energy Efficient Motors	Replacement of energy efficient motors instead of conventional motors improves process efficiency.	0.0005	0.001	7	7.6	8	Considering a 20 hp motor
Revamping of rolling mill	Conventionally, the re-rolling mills are built without proper layout design. The revamping of the rolling mill significantly determines the mill's productivity, energy consumption and efficiency.	0.12	0.27	4373	1972	0.5	Considering a 15 t/h SRRM unit

Annexure 6

Assumptions for the Calculation of Overall Investments

Production Route	Production Route	Plant Capacity	Cost - USD Million	Comments	Source
DRI	Natural Gas Based Plant	1.0 Mt	225-400	The minimum capacity of gas based DRI plant should be 1.50 Mt.	As per stakeholder consultation the cost of a 1 MT natural gas based DRI plant is about USD 400 million
	Hydrogen Based Plant	1.0 Mt	2300-2500		As per stakeholder consultations the cost of a 1 MT greenfield hydrogen based DRI plant is about USD 2.3 - 2.5 billion
	BATs for DRI	100TPD	5.34	Total value of all BATs for DRI - Check Sheet - DRI_BATs	Gosh et al, TERI 2021
EAF and IF	BATs for EAF and IF	100 TPD	0.77	Total value of all BATs for EAF/IF	TERI, 2017
Steel Re-rolling mills	BATs for Re-rolling Mills		1.03	Total value of all BATs for Re-rolling	UNIDO, 2020
Scrap Input	Processing Plant	1 MT	3.80		David. M., 2021

Production Route	Production Route	Plant Capacity	Cost - USD Million	Comments	Source
Renewable energy	Energy required per tonne of liquid steel	KWH	420-755		TERI, 2017
	Cost of 1 MW Solar Plant	1 MW	5		Amplus Solar, 2023
		KW energy produced in 1 MW per day	4000		
Currency Conversion	Conversion rate – USD to INR – 82 INR = 1 USD				

Annexure – 7

Guide to Technological Readiness Level (TRL) (Source: IEA, 2021)

Stage	TRL	Description	
Concept	1	Initial Idea	Basic principles have been defined
	2	Application Formulated	Concept & application of solution have been formulated
	3	Concept needs Validation	Solution needs to be prototyped and applied
Small Prototype	4	Early Prototype	Prototype proven in test conditions
Large Prototype	5	Large Prototype	Components proven in conditions to be deployed
	6	Full Prototype at Scale	Prototype proven at scale in conditions to be deployed
Demonstration	7	Pre-Commercial Demonstration	Solution working in expected conditions
	8	First of a Kind Commercial	Commercial demonstration, full scale deployment in final form
Early Adoption	9	Commercial Operation in Relevant Environment	Solution is commercially viable, needs evolutionary improvements to stay competitive
	10	**Integration Needed at Scale**	The solution is commercial & competitive, but needs further integration efforts
Mature	11	Proof of Stability Reached	Predictable growth

We are an independent, multi-dimensional organization, with capabilities in research, policy, consultancy and implementation. We are innovators and agents of change in the energy, environment, climate change and sustainability space, having pioneered conversations and action in these areas for over four decades. We believe that resource efficiency and waste management are the keys to smart, sustainable and inclusive development. Our work across sectors is focused on (a) promoting efficient use of resources; (b) increasing access and uptake of sustainable inputs and practices; and (c) reducing the impact on environment and climate. Headquartered in New Delhi, we have regional centers and campuses in Gurugram, Bengaluru, Guwahati, Mumbai, Panaji, and Nainital. Our 1,000-plus team of scientists, sociologists, economists and engineers delivers insightful, high quality action-oriented research and transformative solutions supported by state- of-the-art infrastructure.

teri THE ENERGY AND RESOURCES INSTITUTE
Creating Innovative Solutions for a Sustainable Future

TERI, Darbari Seth Block, IHC Complex, Lodhi Road, New Delhi 110 003, India
Tel.: +91 11 2468 2100 or 2468 2111 | Fax: +91 11 2468 2144 or 2468 2145
Email: pmc@teri.res.in | Web: www.teriin.org