FINANCING DECARBONIZATION OF THE SECONDARY STEEL SECTOR IN INDIA
Towards an Enabling Environment
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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 Prosanta Pal, and Mr Sabhanbabu 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.

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# Abbreviations

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<th>Abbreviation</th>
<th>Full Form</th>
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<tr>
<td>ADB</td>
<td>Asian Development Bank</td>
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<tr>
<td>BAT</td>
<td>Best Available Technologies</td>
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<td>BEE</td>
<td>Bureau of Energy Efficiency</td>
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<td>BEE-SME</td>
<td>National Program on Energy Efficiency and Technology Upgradation of SMEs</td>
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<td>BF/BOF</td>
<td>Blast Furnace/ Blast Oxygen Furnace</td>
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<td>CIF</td>
<td>Climate Investment Fund</td>
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<tr>
<td>CGTMSE</td>
<td>Credit Guarantee Fund Trust for Micro and Small Enterprises</td>
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<td>CLCSS</td>
<td>Credit Linked Capital Subsidy Scheme for Technology Upgradation</td>
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<td>CTF</td>
<td>Clean Technology Fund</td>
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<td>DRI</td>
<td>Direct Reduction Iron</td>
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<td>EAF</td>
<td>Electric-Arc Furnace</td>
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<tr>
<td>EE</td>
<td>Energy Efficiency or Energy-efficient</td>
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<td>EAFP</td>
<td>Energy Efficiency Financing Platform</td>
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<td>EERF</td>
<td>Energy Efficiency Revolving Fund</td>
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<tr>
<td>GCal</td>
<td>Giga Calories</td>
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<tr>
<td>GCF</td>
<td>Green Climate Fund</td>
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<tr>
<td>GEF</td>
<td>Global Environment Facility</td>
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<tr>
<td>GIZ</td>
<td>Deutsche Gesellschaft für Internationale Zusammenarbeit</td>
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<tr>
<td>IF</td>
<td>Induction Furnace</td>
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<tr>
<td>ICF</td>
<td>International Climate Finance</td>
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<td>JICA</td>
<td>Japan International Cooperation Agency</td>
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<td>KfW</td>
<td>Kreditanstalt für Wiederaufbau Development Bank</td>
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<td>LCT</td>
<td>Low-Carbon Transition</td>
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<td>MDB</td>
<td>Multilateral Development Bank</td>
</tr>
<tr>
<td>MoEFCC</td>
<td>Ministry of Environment, Forest and Climate Change</td>
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<tr>
<td>MSME</td>
<td>Micro, Small, and Medium Enterprises</td>
</tr>
<tr>
<td>MT</td>
<td>Million Tonnes</td>
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<tr>
<td>MTOE</td>
<td>Million Tonnes of Oil Equivalent</td>
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<tr>
<td>MTPA</td>
<td>Million Tonnes Per Annum</td>
</tr>
<tr>
<td>NAPCC</td>
<td>National Action Plan on Climate Change</td>
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<tr>
<td>NBFI</td>
<td>Non-Banking Financial Institution</td>
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<td>NMEEE</td>
<td>National Mission for Enhanced Energy Efficiency</td>
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<td>PAT</td>
<td>Perform, Achieve, and Trade</td>
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<td>PRGFEE</td>
<td>Partial Risk Guarantee Fund for Energy Efficiency</td>
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<tr>
<td>RAMP</td>
<td>Raising and Accelerating MSME Performance</td>
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<td>SAPCC</td>
<td>State Action Plan on Climate Change</td>
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<td>SBI</td>
<td>State Bank of India</td>
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<td>SEC</td>
<td>Specific Energy Consumption</td>
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<td>SECF</td>
<td>State Energy Conversation Funds</td>
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<td>SIDBI</td>
<td>Small Industries Development Bank of India</td>
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<td>SSRM</td>
<td>Secondary Steel Re-rolling Mills</td>
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<td>TADF</td>
<td>Technology Acquisition &amp; Development Fund</td>
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<tr>
<td>TEQUP</td>
<td>Technology and Quality Upgradation (TEQUP) Support to MSMEs</td>
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<tr>
<td>UNFCCC</td>
<td>United Nations Framework Convention on Climate Change</td>
</tr>
<tr>
<td>UNIDO</td>
<td>United Nations Industrial Development Organization</td>
</tr>
<tr>
<td>UNDP</td>
<td>United Nations Development Programme</td>
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<tr>
<td>VCFEE</td>
<td>Venture Capital Fund for Energy Efficiency</td>
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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 MTCO2 emissions annually, while the IFs and EAFs emit 13.4 MTCO2 and 0.1 MTCO2, respectively. Additionally, the re-rolling mills are responsible for 6 MTCO2 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

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The steel sector would also hinge on the development of a 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.

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 CO₂ emissions from the re-rolling segment.

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

Source: TERI & GIZ, 2022
Steel Re-Rolling Mills in India

Legend

Steel re-rolling mills in India
no(SRRM)

- 1
- 5
- 10
- 50
- 100

Source: TERI & GIZ, 2022

FIGURE 2: Distribution of Steel Re-rolling Mills in India
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](image)

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 Nm³ 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 tCO₂/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.
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 tCO₂/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 CO₂ emission by 1510 tCO₂/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 CO₂ emissions by 8,860 tCO₂/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).

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 tCO₂/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 tCO₂/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.
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 tCO2/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. 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 tCO2, per
Financing Decarbonization of the Secondary Steel Sector in India Towards an Enabling Environment

The emissions from the natural gas-based DRI-EAF route are only about 1.0 tCO2/t of steel produced. However, in India, only 3 plants produce sponge iron through the natural gas-based DRI route as of yet.1 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>
<thead>
<tr>
<th>Capacity</th>
<th>Estimated Investment required USD million</th>
<th>Estimated Savings/ year</th>
<th>Energy saving (Gcal/year)</th>
<th>Emissions tCO2/t</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 Mt</td>
<td>219.512</td>
<td>NA</td>
<td>NA</td>
<td>0.415</td>
</tr>
</tbody>
</table>

Source: Stakeholder consultation with sectoral experts

3.2.2 Coal-based DRI to Hydrogen-based DRI

In the DRI process, hydrogen (H2) 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 H2 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 tCO2/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>
<thead>
<tr>
<th>Green H2 blend in process</th>
<th>Estimated Investment required (USD million)</th>
<th>Production Cost in USD per ton of crude steel</th>
<th>Emissions tCO2/t</th>
</tr>
</thead>
<tbody>
<tr>
<td>9%</td>
<td>18.163</td>
<td>443</td>
<td>0.74</td>
</tr>
<tr>
<td>60%</td>
<td>17.384</td>
<td>424</td>
<td>0.41</td>
</tr>
<tr>
<td>100%</td>
<td>15.826</td>
<td>386</td>
<td>0.25</td>
</tr>
</tbody>
</table>

(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 tCO2/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 the 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.

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

<table>
<thead>
<tr>
<th>Estimated Investment (USD million)</th>
<th>Estimated Savings/Year (USD million)</th>
<th>Energy Saving (Gcal/year)</th>
<th>GHG Reduction (tCO2/year)</th>
<th>Payback (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.12</td>
<td>0.61</td>
<td>39,196</td>
<td>15,015</td>
<td>Less than 1 Year</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Potential pathways for decarbonization</th>
<th>No. of Plants</th>
<th>Current Production Capacity (MTPA)</th>
<th>Mitigation Potential MTCO2/yr</th>
<th>Estimated Capital Cost USD Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incremental Pathways</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrating BATs – DRI</td>
<td>223</td>
<td>52.30</td>
<td>0.66</td>
<td>9,309.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Based on the existing production capacity, the cost of technology is for 100 TPD, assuming 300 production days</td>
</tr>
<tr>
<td>Integrating BATs – EAF and IF</td>
<td>1,037</td>
<td>93.00</td>
<td>0.42</td>
<td>2,380.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Based on the existing production capacity, the cost of technology is for 100 TPD, assuming 300 production days</td>
</tr>
<tr>
<td>Integrating BATs – Re-rolling</td>
<td>1,257</td>
<td>91.00</td>
<td>1.49</td>
<td>3,124.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Based on the existing production capacity, the cost of technology is for 150 TPD, assuming 300 production days</td>
</tr>
</tbody>
</table>
### TABLE 4: Summary of Overall Financial Requirements for the Potential Pathways

<table>
<thead>
<tr>
<th>Potential pathways for decarbonization</th>
<th>No. of Plants</th>
<th>Current Production Capacity (MTPA)</th>
<th>Mitigation Potential MTCO₂/yr</th>
<th>Estimated Capital Cost USD Million</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Substitution - Increasing Scrap Input</td>
<td>30.00</td>
<td>114.00</td>
<td>114.00</td>
<td>For installing scrap processing units with additional capacity of 30MTPA</td>
<td></td>
</tr>
<tr>
<td>Integrating Renewable Energy in EAF and IF</td>
<td>1037</td>
<td>93</td>
<td>200.5</td>
<td>Based on actual production 60MTPA,</td>
<td></td>
</tr>
<tr>
<td><strong>Transitional Pathways</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal to natural gas based DRI</td>
<td>223</td>
<td>52.30</td>
<td>20,000</td>
<td>Not suitable for SSP MSMEs as min. capacity needed is 1 MT.</td>
<td></td>
</tr>
<tr>
<td>Coal to hydrogen based DRI</td>
<td>223</td>
<td>52.30</td>
<td>130,750</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct-Rerolling - Integrating with DRI-EAF</td>
<td>999</td>
<td>91.00</td>
<td>0.51</td>
<td>3,699.19</td>
<td>Converting standalone units to composite.</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>169,583.2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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
Financing Decarbonization of the Secondary Steel Sector in India
Towards an Enabling Environment
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.

**International Sources**
1. **International Institutions**
   - Multilateral Development Banks, World Bank, ADB, GIZ, JICA, OPIC, UNIDO, etc.
2. **International Funds**
   - GCF, GIF, Clean Technology Funds, Climate Investment Funds
3. **Bilateral and Multilateral Agencies**

**National & State Government Policies and Funds**
1. **National and State Action Plans For Climate Change (NAPCC & SAPCC).**
2. **National Schemes and Policies**
   - (NMEEE, RAMP, CLCSS, TEQUP, TADF, 4E Financing Scheme, TIFAC-SRIJAN Scheme)
3. **National Funds**
   - (CGTMSE, VCFEE, PRGFEF, BEE-SME, EEFP)

**National Institutions**
1. **BEE** (implementing entity for The World Bank, GIZ, UNIDO, UNDP)
2. **SIDBI** (implementing entity for GCF, the World Bank, KfW, and JICA)
3. **Ministry of Environment, Forest and Climate Change**

**Self-Financing Or Informal Sources**

**Private Institutions**
1. **Domestic Public and Private Sector Banks** such as SBI, HDFC, ICICI, Canara Bank, Axis Bank, etc.
2. **Non-Banking Financial Institutions** (e.g., TATA Capital)

**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
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

Commercial 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 disincentivize 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

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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

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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

<table>
<thead>
<tr>
<th>Program</th>
<th>Time Period</th>
<th>Target Areas</th>
<th>Funding</th>
<th>Objectives / Achievements</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEF-UNDP-MOS EE in Steel-Rolling Mills (Phase-1)</td>
<td>2004-13</td>
<td>14 states; 38 Model MSME units</td>
<td>USD 14.03 million (GEF – USD 6.75 million &amp; Steel Development Fund – USD 7.28 million)</td>
<td><strong>Aim:</strong> To improve the level of adoption of EE technologies and reduce emissions. <strong>Achievements</strong>&lt;br&gt;a. Establishing low as well as high investment benchmarks for eco-tech packages, effective knowledge dissemination, and capacity-building of units.&lt;br&gt;b. Reduction of specific electrical energy consumption by 10-20% &amp; Specific Thermal Energy Consumption by 20-50% &amp; reduction of GHG by 1000-2500 tCO2 /per unit per year.</td>
</tr>
<tr>
<td>UNDP, AusAID-MoS (Phase - 2)</td>
<td>2013-16</td>
<td>PAN India; 285 MSME units</td>
<td>USD 2.44 million</td>
<td><strong>Aim:</strong> To improve EE, mitigate GHG emissions, and enhance technical capacity and productivity. <strong>Achievements</strong>&lt;br&gt;a. Technical assistance to enable energy audits, implementation of energy efficiency measures, cost-benefit interventions, &amp; knowledge development.&lt;br&gt;b. 24% energy savings and 28% reduction in GHG emission per ton of mill output.</td>
</tr>
</tbody>
</table>

### 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.

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. 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.

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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.\textsuperscript{15} It could also help broaden the

\textbf{TABLE 7: Financial Instruments & their Suitability against Barriers to Finance}

<table>
<thead>
<tr>
<th>Bottlenecks/Challenges Covered</th>
<th>Financial Instruments and Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Asset-based Finance</td>
</tr>
<tr>
<td>Examples</td>
<td>CGTMSE</td>
</tr>
<tr>
<td>Lengthy Documentation &amp; Processing Time</td>
<td></td>
</tr>
<tr>
<td>Inadequate Collateral Holdings</td>
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<tr>
<td>High Rate of Interest</td>
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<tr>
<td>Low Credit Scores</td>
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<tr>
<td>High Transaction Costs</td>
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</tr>
<tr>
<td>Technical/Financial Capacity Building</td>
<td></td>
</tr>
<tr>
<td>High Technological Upgradation/Capital Costs</td>
<td></td>
</tr>
<tr>
<td>Investor Risk Protection</td>
<td></td>
</tr>
<tr>
<td>Large-scale Coverage</td>
<td></td>
</tr>
</tbody>
</table>

(Source: Author’s Analysis)

(Note: ■ High efficacy against the barrier ■ Moderate efficacy against the barrier ■ Low efficacy against the barrier.)

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
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 environment 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 CO2 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 ecosyssstem 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


## Annexures

### Annexure – 1

**List of Stakeholders for Consultation**

<table>
<thead>
<tr>
<th>Financing Institutions - International</th>
</tr>
</thead>
<tbody>
<tr>
<td>United Nations Industrial Development Organization (UNIDO)</td>
</tr>
<tr>
<td>Asian Development Bank</td>
</tr>
<tr>
<td>GEF Capital Partners</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Financing Institutions - Domestic</th>
</tr>
</thead>
<tbody>
<tr>
<td>YES Bank</td>
</tr>
<tr>
<td>Small Industries Development Bank of India (SIDBI)</td>
</tr>
<tr>
<td>Energy Efficiency Services Limited (ESSL)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confederation of Indian Industry (CII)</td>
</tr>
<tr>
<td>Minmet Consultants</td>
</tr>
<tr>
<td>Sponge Iron Manufacturers Association (SIMA)</td>
</tr>
<tr>
<td>All India Induction Furnaces Association (AlIFA)</td>
</tr>
<tr>
<td>All India Steel Re-Rollers Association (AISRA)</td>
</tr>
<tr>
<td>Alloy Steel Producers Association of India</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Think Tank/Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>German Corporation for International Cooperation (GIZ)</td>
</tr>
<tr>
<td>The Energy and Resources Institute (TERI)</td>
</tr>
<tr>
<td>Shakti Sustainable Energy Foundation</td>
</tr>
<tr>
<td>Climate Policy Initiative (CPI)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Government Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministry of Steel Task Force on Financing Steel Sector</td>
</tr>
<tr>
<td>Bureau of Energy Efficiency (BEE)</td>
</tr>
</tbody>
</table>
# Annexure – 2

## Selected List of Active Funding Schemes for the Secondary Steel Sector

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Year of Introduction</th>
<th>Implementing body</th>
<th>Features / Provisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMEEE (National Mission for Enhanced Energy Efficiency)</td>
<td>2011</td>
<td>Ministry of Power &amp; BEE</td>
<td>• 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.</td>
</tr>
</tbody>
</table>
| 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 50-95% 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)

<table>
<thead>
<tr>
<th>Best Available Technologies (Short &amp; Medium term)</th>
<th>Technology Description</th>
<th>Estimated Investment required (USD million)</th>
<th>Estimated Savings (USD million)</th>
<th>Energy saving (Gcal/year)</th>
<th>GHG reduction (tCO2/year)</th>
<th>Payback (Year)</th>
<th>Plant Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal gasification for partial substitution</td>
<td>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</td>
<td>1.3167</td>
<td>0.3148</td>
<td>21840</td>
<td>7500</td>
<td>NA</td>
<td>100 TPD</td>
</tr>
<tr>
<td>Use of iron ore pellets in DRI</td>
<td>To reduce the thermal load and increase the load of iron ore pellets.</td>
<td>0.3947</td>
<td>27300</td>
<td>9400</td>
<td>NA</td>
<td>100 TPD</td>
<td></td>
</tr>
<tr>
<td>Thermostatic controller for cooling tower</td>
<td>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.</td>
<td>0.0002</td>
<td>0.0005</td>
<td>12</td>
<td>11</td>
<td>0.5</td>
<td>For a motor with a 10 Kw capacity for 100 TPD</td>
</tr>
<tr>
<td>FRP blades for cooling tower fans</td>
<td>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.</td>
<td>0.0009</td>
<td>0.0003</td>
<td>9</td>
<td>8</td>
<td>2.4</td>
<td>For a motor with a capacity of 7.3 kW</td>
</tr>
<tr>
<td>Energy-efficient pumps</td>
<td>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.</td>
<td>0.0024</td>
<td>0.0029</td>
<td>72</td>
<td>69</td>
<td>0.8</td>
<td>The motor rating of an energy-efficient system will be 18.5 kW, replacing 30-kW inefficient pumps</td>
</tr>
<tr>
<td>Decentralized VFDs for shell air fans</td>
<td>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.</td>
<td>0.0036</td>
<td>0.0006</td>
<td>16</td>
<td>16</td>
<td>5.2</td>
<td>Decentralized VFD systems for shell air fans for 100 tpd capacity rotary kiln</td>
</tr>
</tbody>
</table>
### Best Available Technologies (Short & Medium term)

<table>
<thead>
<tr>
<th>Technology Description</th>
<th>Estimated Investment required (USD million)</th>
<th>Estimated Savings (USD million)</th>
<th>Energy saving (Gcal/year)</th>
<th>GHG reduction (tCO₂/year)</th>
<th>Payback (Year)</th>
<th>Plant Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy-efficient motors</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>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.</td>
<td>0.0036</td>
<td>0.0008</td>
<td>19</td>
<td>18</td>
<td>4.8</td>
<td>100 TPD</td>
</tr>
<tr>
<td><strong>VFDs for air compressors</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>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.</td>
<td>0.0036</td>
<td>0.0028</td>
<td>71</td>
<td>67</td>
<td>1.3</td>
<td>100 TPD</td>
</tr>
<tr>
<td><strong>Mullite-based kiln lining</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>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 kiln shell by 30 per cent.</td>
<td>0.0605</td>
<td>0.0436</td>
<td>3033</td>
<td>1050</td>
<td>4.1</td>
<td>100 TPD</td>
</tr>
<tr>
<td><strong>WHR – Vapour Absorption Chiller</strong></td>
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<td></td>
</tr>
<tr>
<td>A vapour absorption machine (VAM) can be utilised to replace existing cooling arrangements. The existing standalone air conditioning system can be replaced with WHR based VAM.</td>
<td>0.0085</td>
<td>0.0035</td>
<td>36</td>
<td>34</td>
<td>2</td>
<td>100 TPD</td>
</tr>
<tr>
<td><strong>WHR – Coal moisture reduction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The WHR-based rotary drum dryer can be installed for moisture removal in coal using the off-gases generated from the rotary kiln during the process for iron production.</td>
<td>0.1211</td>
<td>0.0799</td>
<td>5539</td>
<td>1900</td>
<td>1.5</td>
<td>100 TPD</td>
</tr>
<tr>
<td><strong>WHR– Iron ore preheating</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td>0.4238</td>
<td>0.3935</td>
<td>22360</td>
<td>7726</td>
<td>1.1</td>
<td>200 TPD</td>
</tr>
</tbody>
</table>

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.

VFD with a rated power of 22 Kw and with a full time load of 3,110 h/year.

Mullite-based lining of rotary kiln of 100 tpd capacity.

Energy saving that can be achieved by replacing conventional chillers with a VAM-based system of 10 TR (cooling load) capacity.

100 TPD

200 TPD
**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.

<table>
<thead>
<tr>
<th>Investment required (USD million)</th>
<th>Estimated Savings (USD million)</th>
<th>Energy saving (Gcal/year)</th>
<th>GHG reduction (tCO₂/year)</th>
<th>Payback (Year)</th>
<th>Plant Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3902</td>
<td>1.0582</td>
<td>20227</td>
<td>19300</td>
<td>3.2</td>
<td>A kiln with 200 TPD production capacity has a WHR power generation facility of 4 MW. A kiln with 100 TPD production capacity would have a power generation potential of 1.5-2.5 MW</td>
</tr>
</tbody>
</table>

**Annexure – 4**

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

<table>
<thead>
<tr>
<th>Best Available Technologies (Short and Medium term)</th>
<th>Technology Description</th>
<th>Estimated Investment required USD million</th>
<th>Estimated Savings/ year (USD million)</th>
<th>Energy saving</th>
<th>GHG reduction (tCO₂/year)</th>
<th>Payback (Year)</th>
<th>Plant Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRP blades in cooling tower</td>
<td>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.</td>
<td>0.0024</td>
<td>0.0024</td>
<td>Reduction in electricity consumption of cooling tower fan by 15-25%</td>
<td>40</td>
<td>0.8</td>
<td>Values based on cooling tower of 1.5 lakh kCal capacity</td>
</tr>
<tr>
<td>Installation of EE pumps</td>
<td>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.</td>
<td>0.0061</td>
<td>0.0097</td>
<td>Energy savings with use of EE pumps in cooling water system is about 15-25%.</td>
<td>90</td>
<td>0.5-1</td>
<td>Values based on a 100 hp pump</td>
</tr>
<tr>
<td>Variable frequency drives in ID fans</td>
<td>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.</td>
<td>0.0091</td>
<td>0.0091</td>
<td>Reduction in electricity consumption by 15 to 20%</td>
<td>120</td>
<td>1</td>
<td>50 tonne furance</td>
</tr>
</tbody>
</table>
Towards an Enabling Environment

### Annexeure – 5

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

<table>
<thead>
<tr>
<th>Best Available Technologies (Short and Medium term)</th>
<th>Technology Description</th>
<th>Estimated Investment required USD Million</th>
<th>Estimated Savings/year (USD million)</th>
<th>Energy saving (Gcal/year)</th>
<th>GHG reduction (tCO₂/year)</th>
<th>Payback (Year)</th>
<th>Plant Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modified pulverized coal feeding system</td>
<td>Conventional, the pulvriser 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 pulvriser.</td>
<td>0.02</td>
<td>0.031</td>
<td>1811</td>
<td>718</td>
<td>0.9</td>
<td>Considering a 10 t/h SRRM plant</td>
</tr>
<tr>
<td>Conversion of fossil fuel to Natural gas based reheating furnace</td>
<td>Natural gas is used instead of coal for better combustion and to reduce burning losses.</td>
<td>0.05</td>
<td>0.052</td>
<td>31391</td>
<td>14800</td>
<td>0.11</td>
<td>Considering a 15 t/h furnace</td>
</tr>
<tr>
<td>Waste heat recovery for boiler feed water</td>
<td>To reduce the overall energy consumption, the waste heat gases (900-1200°C) can be recovered and reused for pre-heating.</td>
<td>0.0121</td>
<td>0.0484</td>
<td>1510</td>
<td>0.2-0.5</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Scrap preheating (bucket System)</td>
<td>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.</td>
<td>0.2422</td>
<td>0.3245</td>
<td>5900</td>
<td>0.5-1</td>
<td>50 tonne furnace</td>
<td></td>
</tr>
<tr>
<td>Scrap preheating (Continuous System)</td>
<td>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.</td>
<td>0.4843</td>
<td>0</td>
<td>NA</td>
<td>8860</td>
<td>1</td>
<td>50 Tonne furnace</td>
</tr>
<tr>
<td>Ladle Preheating (BEE)</td>
<td>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.</td>
<td>0.0121</td>
<td>0.0121</td>
<td>10-15 ToE/yr</td>
<td>150</td>
<td>1</td>
<td>Steel IF with 5 tonnes capacity with 8 heats per day and 12,000 tonnes of annual production</td>
</tr>
<tr>
<td>Best Available Technologies (Short and Medium term)</td>
<td>Technology Description</td>
<td>Estimated Investment required USD Million</td>
<td>Estimated Savings/year (USD million)</td>
<td>Energy saving (Gcal/year)</td>
<td>GHG reduction (tCO2/year)</td>
<td>Payback (Year)</td>
<td>Plant Capacity</td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>------------------------</td>
<td>------------------------------------------</td>
<td>-------------------------------------</td>
<td>-------------------------</td>
<td>--------------------------</td>
<td>----------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Energy Efficient Re-heating Furnace</td>
<td>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.</td>
<td>0.18</td>
<td>0.199</td>
<td>8526</td>
<td>94.6</td>
<td>1.5</td>
<td>15 t/h furnace fired by pulverized coal</td>
</tr>
<tr>
<td>Conversion of fossil fuel to Coal-Based Methane (CBM) based re-heating furnace</td>
<td>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.</td>
<td>0.18</td>
<td>0.289</td>
<td>6354</td>
<td>9365</td>
<td>0.8</td>
<td>Considering a 15 t/h furnace</td>
</tr>
<tr>
<td>Conversion of fossil fuel to biomass-based producer gas re-heating furnace</td>
<td>Biogas is a carbon-neutral fuel generated from agricultural waste that can be used in re-rolling instead of solid fuel.</td>
<td>0.18</td>
<td>0.605</td>
<td>4543</td>
<td>11915</td>
<td>0.2</td>
<td>Considering a 15 t/h SRRM unit</td>
</tr>
<tr>
<td>Installation of high efficiency metallic recuperator in re-heating furnace</td>
<td>The waste heat generated from the re-heating furnace is recovered by the installation of recuperator.</td>
<td>0.03</td>
<td>0.099</td>
<td>5724</td>
<td>2,262</td>
<td>0.4</td>
<td>15 tph furnace capacity</td>
</tr>
<tr>
<td>Installation of automation &amp; control system in re-heating furnace</td>
<td>Installation of automatic and control system basic monitoring instruments like thermocouples can increase the furnace efficiency at optimal level.</td>
<td>0.03</td>
<td>0.061</td>
<td>1331</td>
<td>526</td>
<td>0.5</td>
<td>15 tph furnace capacity</td>
</tr>
<tr>
<td>Installation of Energy Efficient Pulveriser</td>
<td>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.</td>
<td>0.02</td>
<td>0.010</td>
<td>911</td>
<td>359</td>
<td>0.7</td>
<td>Considering a 10 t/h SRRM plant</td>
</tr>
<tr>
<td>Installation of Coal Drying system</td>
<td>The flue gases from the re-heating furnace are passed through a cyclone drier for removing the moisture from the coal.</td>
<td>0.02</td>
<td>0.052</td>
<td>3032</td>
<td>1198</td>
<td>0.5</td>
<td>Considering a 15 t/h SRRM plant</td>
</tr>
<tr>
<td>Swirl Burner Used for Pulverized Coal Firing</td>
<td>Swirl burners are used for proper control of air fuel-mixture in re-heating furnaces</td>
<td>0.02</td>
<td>0.009</td>
<td>1001</td>
<td>395</td>
<td>0.6</td>
<td>Considering a 15 t/h SRRM plant</td>
</tr>
<tr>
<td>Installation of Anti-friction Roller Bearing in Rolling Mill Strands</td>
<td>Anti-friction roller bearing is used instead of conventional metal bearing for improving transmission efficiency and reducing energy consumption.</td>
<td>0.06</td>
<td>0.138</td>
<td>730</td>
<td>763</td>
<td>0.5</td>
<td>Considering a 15 t/h SRRM plant</td>
</tr>
</tbody>
</table>
### Best Available Technologies (Short and Medium term)

<table>
<thead>
<tr>
<th>Technology Description</th>
<th>Estimated Investment required USD Million</th>
<th>Estimated Savings/year (USD million)</th>
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<th>Plant Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation of Universal Couplings/Spindles in Rolling Mill</td>
<td>0.06</td>
<td>0.062</td>
<td>350</td>
<td>371</td>
<td>1</td>
<td>considering a 15 t/h SRRM unit</td>
</tr>
<tr>
<td>Installation of Y-table/Repeater in Rolling Mill</td>
<td>0.06</td>
<td>0.166</td>
<td>2221</td>
<td>1025</td>
<td>0.4</td>
<td>considering a 15 t/h SRRM unit</td>
</tr>
<tr>
<td>Replacement of Existing Motors with IE3 Class Efficiency Energy Efficient Motors</td>
<td>0.0005</td>
<td>0.001</td>
<td>7</td>
<td>7.6</td>
<td>8</td>
<td>Considering a 20 hp motor</td>
</tr>
<tr>
<td>Revamping of rolling mill</td>
<td>0.12</td>
<td>0.27</td>
<td>4373</td>
<td>1972</td>
<td>0.5</td>
<td>Considering a 15 t/h SRRM unit</td>
</tr>
</tbody>
</table>

### Annexure 6

**Assumptions for the Calculation of Overall Investments**

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

<table>
<thead>
<tr>
<th>Production Route</th>
<th>Plant Capacity</th>
<th>Cost - USD Million</th>
<th>Comments</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable energy</td>
<td>Energy required per tonne of liquid steel</td>
<td>KWH 420-755</td>
<td>TERI, 2017</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost of 1 MW Solar Plant</th>
<th>1 MW</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>KW energy produced in 1 MW per day</td>
<td>4000</td>
<td></td>
</tr>
</tbody>
</table>

Amplus Solar, 2023

| Currency Conversion | Conversion rate – USD to INR – 82 INR = 1 USD |

### Annexure – 7

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

<table>
<thead>
<tr>
<th>Stage</th>
<th>TRL</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept</td>
<td>1</td>
<td>Initial Idea</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Application Formulated</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Concept needs Validation</td>
</tr>
<tr>
<td>Small Prototype</td>
<td>4</td>
<td>Early Prototype</td>
</tr>
<tr>
<td>Large Prototype</td>
<td>5</td>
<td>Large Prototype</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Full Prototype at Scale</td>
</tr>
<tr>
<td>Demonstration</td>
<td>7</td>
<td>Pre-Commercial Demonstration</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>First of a Kind Commercial</td>
</tr>
<tr>
<td>Early Adoption</td>
<td>9</td>
<td>Commercial Operation in Relevant Environment</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Integration Needed at Scale</td>
</tr>
<tr>
<td>Mature</td>
<td>11</td>
<td>Proof of Stability Reached</td>
</tr>
</tbody>
</table>
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