Energy and Resource Mapping of MSMEs in India

Steel Re-Rolling Sector Report

GOVERNMENT OF INDIA
MINISTRY OF POWER

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ICF Consulting India Pvt. Ltd.
New Delhi

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Abbreviation

BEE	Bureau of Energy Efficiency
NISST	National Institute of Secondary Steel Technology
MRAI	Material Recycling Association of India
CEA	Central Electricity Authority
KPI	Key Performance Indicators
MSME	Micro, Small and Medium Enterprises
PNG	Piped Natural Gas
Fo	Furnace Oil
SCM	Standard Cubic Meter
SCR	Silicon Controlled Rectifier
GHG	Green House Gas
EU	European Union
TCR	Thermo Chemical Recuperation
NOx	Nitrogen Oxide
CO2	Carbon di-oxide
RPD	Roll Pass Design
PV	Photo Voltaic
EMS	Energy Monitoring System
CFM	Cubic Feet per Minute
EEM	Energy Efficient Motor
FAD	Free Air Delivery
JPC	Joint Plant Committee
VFD	Variable Frequency Drive
CCM	Continuous Casting Machine
IGBT	Insulated-Gate Bipolar Transistor
CO	Carbon Monoxide
IR	Infrared
CAGR	Compound Annual Growth Rate
BF-BOF	Blast Furnace – Basic Oxygen Furnace
ISO	International Organization for Standards
GCal	Giga Calorie
EAF	Electric Arc Furnace
IF	Induction Furnace
DRI	Direct reduced Iron
TPH	Tonne Per hour
DC	Direct Current
AC	Alternate Current
GIDC	Gujarat Industrial Development Corporation
MTOE	Million Tonne Oil Equivalent
MTPA	Million Tonne Per Annum
TPH	Tonne Per Hour
TPD	Tonne Per Day
MEDA	Maharashtra Energy Development Agency
CREDA	Chhattisgarh Renewable Energy Development Agency
SRMA	Steel Rolling Mill Association

NSP	National Steel Policy
BAU	Business As Usual
ETS	Emission Trading Scheme
INR	Indian National rupee
IRDEA	Indian Renewable Energy Development Agency Limited
PAT	Perform Achieve & Trade
ESCOs	Energy Service Company
AICTE	All India Council for Technical Education
MoHRD	Ministry of Human Resource Development
NGO	Non-Governmental Organizations
CGTMSE	Credit Guarantee Fund Trust for Micro and Small Enterprises
WCTL	Working Capital Term Loan
ZED	Zero Defect and Zero Defect
SPC	Specific Power Consumption
SEC	Specific Energy Consumption
SIDBI	Small Industries Development Bank of India
GDP	Gross domestic product
GOI	Government of India
SME	Small and Medium Enterprises
SME	Small and Medium Enterprises
BAT	Best Available Technologies
DIC	District Industries Centre
EE	Energy Efficiency
GCV	Gross Calorific Value
GDP	Gross Domestic Product
MSME	Micro, Small and Medium Enterprises
MSME-DI	Micro, Small and Medium Enterprises – Development Institute
SEC	Specific Energy Consumption
TOE	Tons of Oil Equivalent
UNIDO	United Nations Industrial Development Organization

1. Introduction

India is the world's second-largest producer of crude steel, producing 99.6 million Tons (MT) crude steel in FY2020-21 with a growth rate of 2% over 2018. The Indian Steel Sector contributes to over 2% of the country's GDP and employs around 25 lakhs of employees in steel/allied sectors.[1]

Steel has contributed immensely to Indian economic growth. This is evident from the similar growth patterns of India's GDP and steel production in the country, which also highlights the economy's dependence on steel. National production of crude steel rose from 18.11 MT in 1992 to 109.27 MT in 2018, while GDP (at constant price, 2010) grew from USD 0.28 trillion in 1992 to USD 2.72 trillion in 2018.[2]

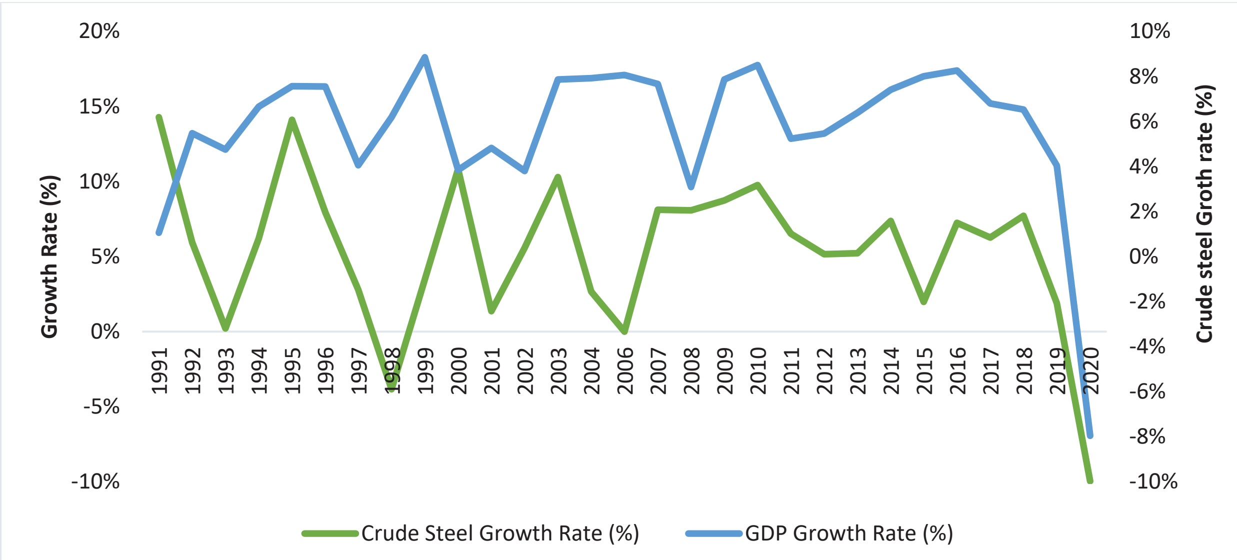


Figure 1: Crude Steel Growth Rate (%) Vs GDP Growth Rate (%)

This MSME sub-sector is energy-intensive in their operations and generally use a mix of both modern as well as conventional technologies for their day-to-day functioning, but at the same time, it holds immense potential for energy efficiency measures and up-gradation of technologies in routine processes.

BEE has developed various comprehensive programs to address the various challenges confronting MSMEs in India. Still, at a national level, the energy mapping across different energy-intensive MSME sub-sectors is missing. Energy mapping provides data on various parameters like production, type and quantity of fuel consumption, energy-saving potential, details on energy-efficient technologies, and future growth scenarios. These data points are not readily available and, in a way, hampers the process of designing sector-specific policies.

Given the need for energy mapping within Indian steel re-rolling clusters, ICF Consulting India Pvt. Ltd., with support from BEE, has executed the project "Energy efficiency and Resource Mapping of the

1 Annual Report 2019-20, Ministry of Steel

2 Source: GDP data: World Bank,

MSME Sector" for the steel re-rolling clusters in India. This exercise focused on estimating the energy consumption, production, technical aspects and conducting detailed techno-economic assessments for the selected cluster. This report provides a complete energy mapping along with benchmarking of various processes. Policy recommendations with a road map for implementation measures are also covered under this report to make the steel re-rolling sector energy & resource-efficient, and environmentally friendly.

1.1 Project Objectives

The objectives of the study include the following:

1. Mapping of energy-intensive Steel Re-rolling clusters
2. Conducting an in-depth study of existing scenarios on energy consumption and identifying opportunities for energy and resource-saving
3. Identifying energy-efficient technologies relevant to the sector and developing a technology roadmap
4. Mapping the readiness of the sector in adopting EE solutions
5. Preparing an energy-efficient roadmap along with timelines to make the sector energy and resource-efficient as well as environment friendly

1.2 Project Methodology

The project team adopted a five-step approach to meet the objective of the project as provided below:

1. Project Inception
2. Research and sensitization workshop
3. Energy Audits and post-activity workshop
4. Sectoral Benchmarking
5. Policy Recommendation/Implementation Roadmap

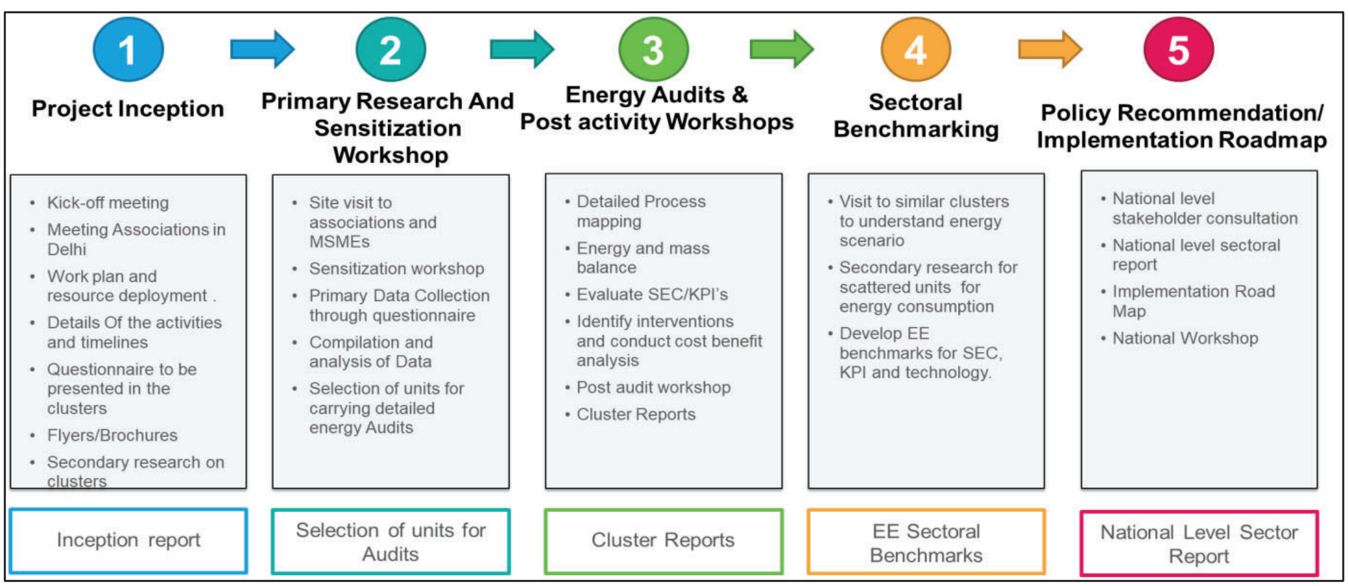


Figure 2: Approach and Methodology

1.2.1 Project Inception

The project started with a kick-off meeting with the BEE team to discuss the overall approach, specific task areas, lines of communication, and the project schedule. The project team has provided the preliminary project plan encompassing the following:

- The work plan for completing each of the identified tasks
- Deliverables and interim work products and project timelines
- Secondary and primary research about the cluster
- Contacts of industry associations and MSME units available
- Finalization of the questionnaire (Sample attached in Annexure E1)
- Flyer of the project (Sample attached in Annexure E2)

The project team started preparing for the primary and secondary research along with the sensitization workshops for the five clusters.

1.2.2 Research and Sensitization Workshop

Research: This step includes secondary research including review of existing MSME cluster and gathering number of units available in each cluster, units in operation, production capacity, energy efficiency/audit reports of the cluster/ sector (whichever available), energy directory (wherever available), technology needs assessment documents and international best practices in the sector, and current practices in India.

For primary research, the project team have conducted meetings with the industrial associations in all the identified clusters based on the points mentioned in Figure 3. The primary objective of the research was to build a database (or inventory) for developing the baseline.

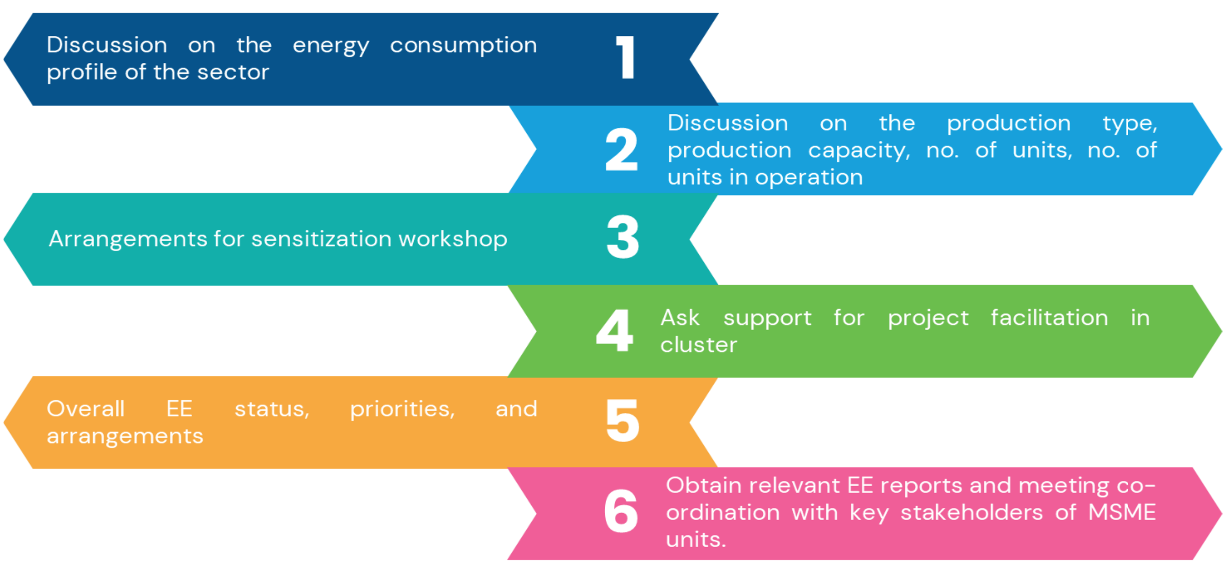


Figure 3: Discussion points with industrial association

Data Collection Templates (Questionnaire): The project team prepared the Questionnaire for data collection from MSMEs, which is divided into two parts, the first is basic information and the second is the energy consumption detail section. The detailed questionnaire is attached in **Annexure E1**.

Sensitization Workshops

The project inception workshops were conducted in selected clusters to sensitize the stakeholders about various project activities and their benefits for the sustainable development of the MSME sector.

Targeted participants for the workshops:

1. MSME units - represented by plant manager or factory owner
2. Cluster/Industry associations or Local Chamber of Commerce and Industries
3. BEE officials, etc.
4. Local MSME Development Institutes

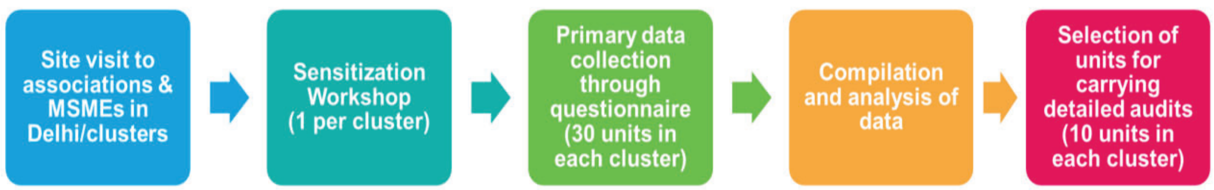


Figure 4: Workshop Methodology

Sample Agenda for the inception workshops is attached in Annexure E3 and the feedback form is attached in Annexure E4.

1.2.3 Energy Audits, Process Mapping and KPI Development

Onsite visits & Energy Audits: Before starting the process mapping, it was pertinent to identify the units for which detailed energy assessment can be conducted. The selection process was guided by the following key parameters:

1. Depending on the size and energy consumption profile
2. Covering the complete product segment of the sector

The project team conducted an onsite industry assessment to assess the various parameters for the identification of KPIs. The detailed energy assessments were conducted for at least 10 units to arrive at KPIs. To find answers to the above-mentioned questions, the project team had included four components in the investment-grade audits. They are shown in the graphic below:

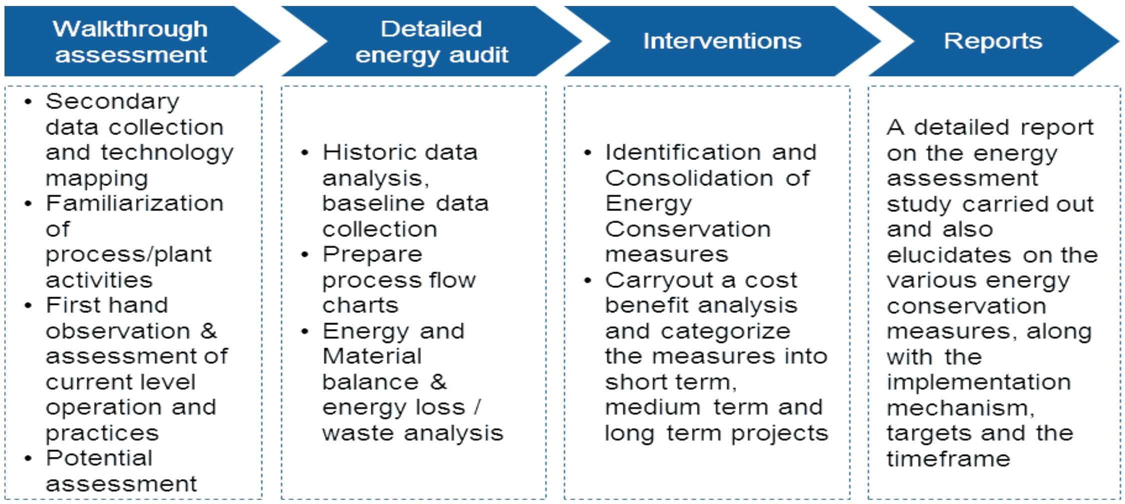


Figure 5: Detailed energy audit methodology

Interventions: The Identified list of improvement options that apply to an MSME unit is based on cost and ease of implementation. A database of improvement options was available to the auditor while conducting the audits. During the detailed audit process, the auditors based on their experience and knowledge (based on site conditions) explored the suitability of deploying an option listed in the database and shortlist the most attractive option. The project team compiled a library of energy conservation options based on the following:

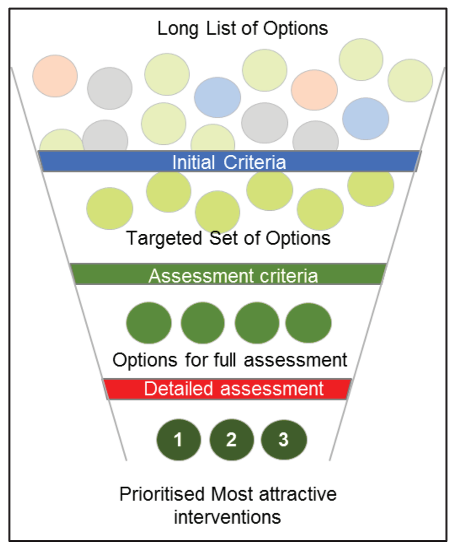


Figure 6: Funnel diagram for interventions

- The project team's existing database developed over the years working on energy and resource efficiency
- Collation of Case studies published by organizations such as IEA, UNIDO's National Cleaner Production Centre.
- Post identification of different technologies, the project team have categorized the technologies based on different criteria as highlighted above.
- The existing database was also be improved based on the energy audit reports that are available with BEE through various Energy Efficiency (EE) programs.
- The database also included renewable energy-based options.

Details of Process Flow: Basic process flow diagram for audited steel re-rolling sector MSME units includes details of all the process/combinations available in that sector. Based on the data collected, the project team have performed a trend line analysis of product output and energy consumption of a few MSME units. If the unit produces multiple products, then the energy consumption and KPIs are estimated for each product separately.

Identification of key performance indicators (KPIs): Based on the processes and parameters as identified in the previous task, a few key parameters which reflect the electrical, as well as thermal energy consumption of the units, are selected. These parameters are acting as the key results in the benchmarking section. These processes are related to critical parameters, which if, monitored on regular basis, will help the MSME units in establishing their existing performance and improve it gradually. The project team has developed KPI for process and sub-process level KPIs. In the case of the non-availability of data, the use of assumptions/estimations/expert opinion was considered to arrive at KPIs.

Post Cluster Workshops: Post cluster workshops covered findings based on energy audits from inter-cluster studies and comparisons of energy efficiency among clusters. Interventions for the sector was determined based on the energy audits.

1.2.4 Sectoral Benchmarking

Energy efficiency benchmarking is regarded as the technique to compare the industry with international best practices and technologies for implementation. The project team also visited similar clusters to understand their energy scenario and compare the results of the five clusters with similar clusters and international benchmarks. The project team identified a list of improvement options that apply to these MSME units based on cost and ease of implementation. A database of improvement options was made available to MSME units for reference. This database is available in an integrated Excel-based sheet that can easily be updated as changes occur or as customization is needed.

The project team compared the baseline technologies employed in each of the audited MSME steel re-rolling sectors with Best Available Technologies (BAT) along with assessing the readiness for technology adoption. This was carried out through a comprehensive review of technologies available / deployed/demonstrated in comparable regions/geographies.

1.2.5 Policy Recommendation & Implementation Roadmap

End-stage of the project includes a national level stakeholder consultation, sectoral report, policy implementation and roadmaps.

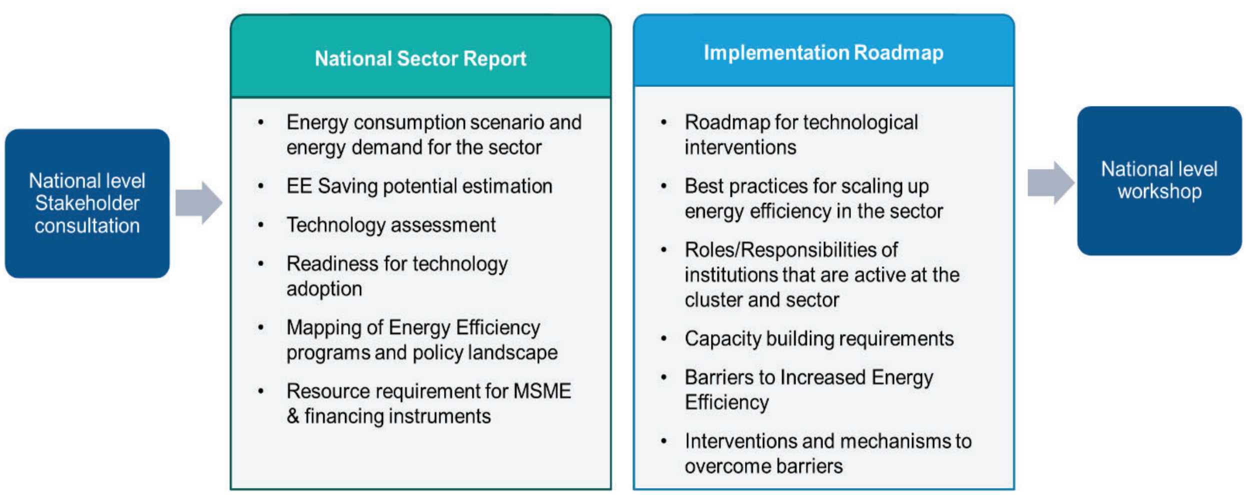


Figure 7: National level stakeholder and dissemination workshop structure

2. Steel Re-Rolling (SRRM) Sector Overview

Steel Sector

The global steel production volume is estimated to reach 2,175 MT in 2024, growing at a CAGR of 4.5% from 2020 to 2024. China and India have consistently grown their production to become the top two steel producing nations. India is the fastest-growing market for steel with increasing urbanization, industrialization and infrastructure investments. China has dominated the industry, accounting for more than half of global steel output; India is in second place, accounting for 5.3% of global steel production.[3]

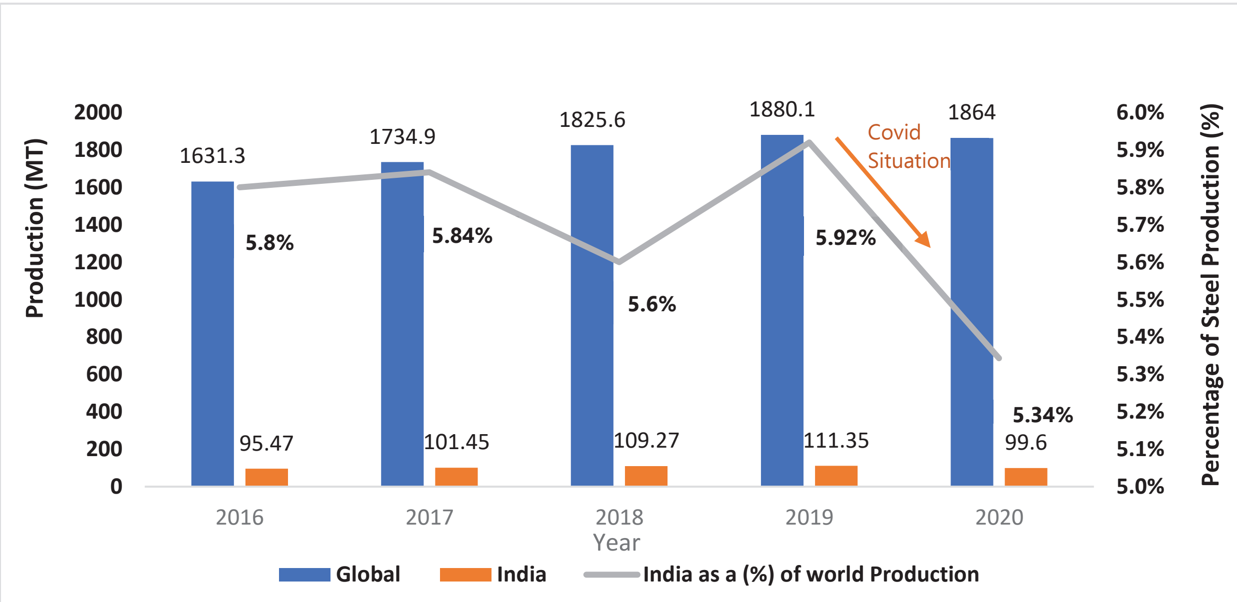


Figure 8: Global steel production vs India steel production

Covid had a negative impact on the overall world economy and due to the lockdowns and restrictions, the share of India's steel production fell 9.7% in 2020 compared to the previous year.

Steel Re-rolling Sector

Steel re-rolling[4] is the process of transforming raw/unprocessed steel into finished steel products by rolling and re-rolling it into desired forms including bars, TMT (thermo-mechanically treated) rods, sectional products, and wires while it is still hot. The bulk of these finished products are used in the construction sector.

Due to a lack of aggregated statistics on the global SRRM sector, determining their value to the global steel industry is challenging. Data on the Indian SRRM sector, on the other hand, is far more readily available. On the basis of evidence from India, it is reasonable to conclude that the SRRM sector is the

[3] Global Steel Context: World Steel Association
[4] https://in.one.un.org/wp-content/uploads/2016/09/STEEL_BOOK_Low_res_for_upload.pdf

primary source of finished steel products for individual consumers, particularly in the developing world, whose demand for steel is for small quantities at lower prices, as opposed to institutional consumers.

2.1 Indian Steel Re-rolling Mill Sector

The steel re-rolling mill (SRRM) sector is one of the most important segments of the steel industry in India and is a key link in the supply chain of iron and steel production in the country. The sector produces majorly long products mills with the facility of the re-heating furnace and rolling mills. Few units have completed backward integration by installing induction furnaces to melt scrap and DRI cast by ingot or continuous casting. The direct energy cost in the MSME mills is estimated at 25-30 percent of the overall conversion cost[5]

There are an estimated 1200 working small and medium steel re-rolling mills in India, scattered across the country, and producing 33 MT of steel. It is also reported that 80% of India's total exports of bars are sourced from the secondary steel sector. It is estimated that the sector employs, directly and indirectly, about 400,000 people. These employees are a mix of skilled engineers/operators, semi-skilled foremen and technicians, and unskilled shop-floor workers.

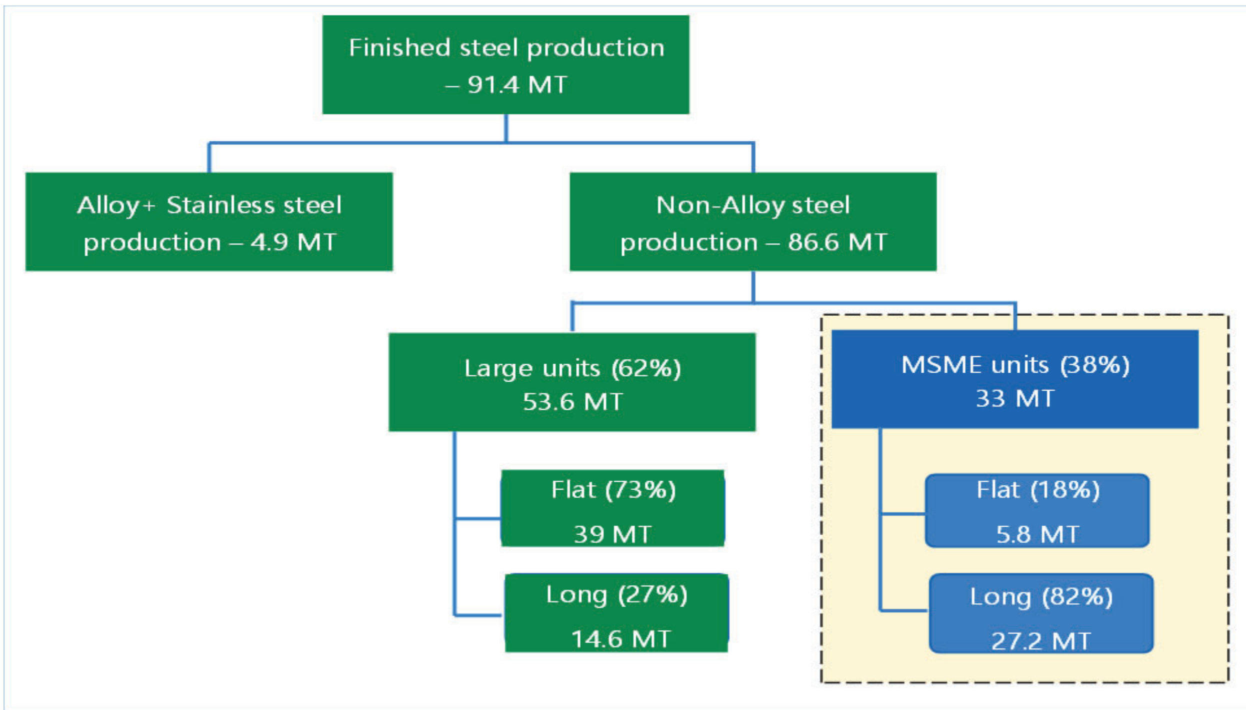


Figure 9: Classification of Steel Production in India (source: Ministry of Steel Annual Report and ICF analysis)

Micro Small and Medium Enterprises (MSMEs) contributes to 38% of the Non-Alloy Steel production in India. As per ISO 6929 Steel products are classified into flat and non-flat products or long products. Mostly the large units produce flat products mainly sheets, about 73% of their total production and the units in the MSME category produces long products mainly Thermo Mechanically Treated Bars

[5] UNDP Report: Energy Efficient Steel Re-rolling

(TMT), angles, channels, beam, pipe, tubes and others, about 82% of the production. [6]

2.1.1 Steel Re-rolling Mill Classification

The Steel rerolling units can be classified in 3 ways viz. based on the category (Small, Medium, Large), based on the raw material, and based on the products. The classification of the steel rerolling units is depicted below:

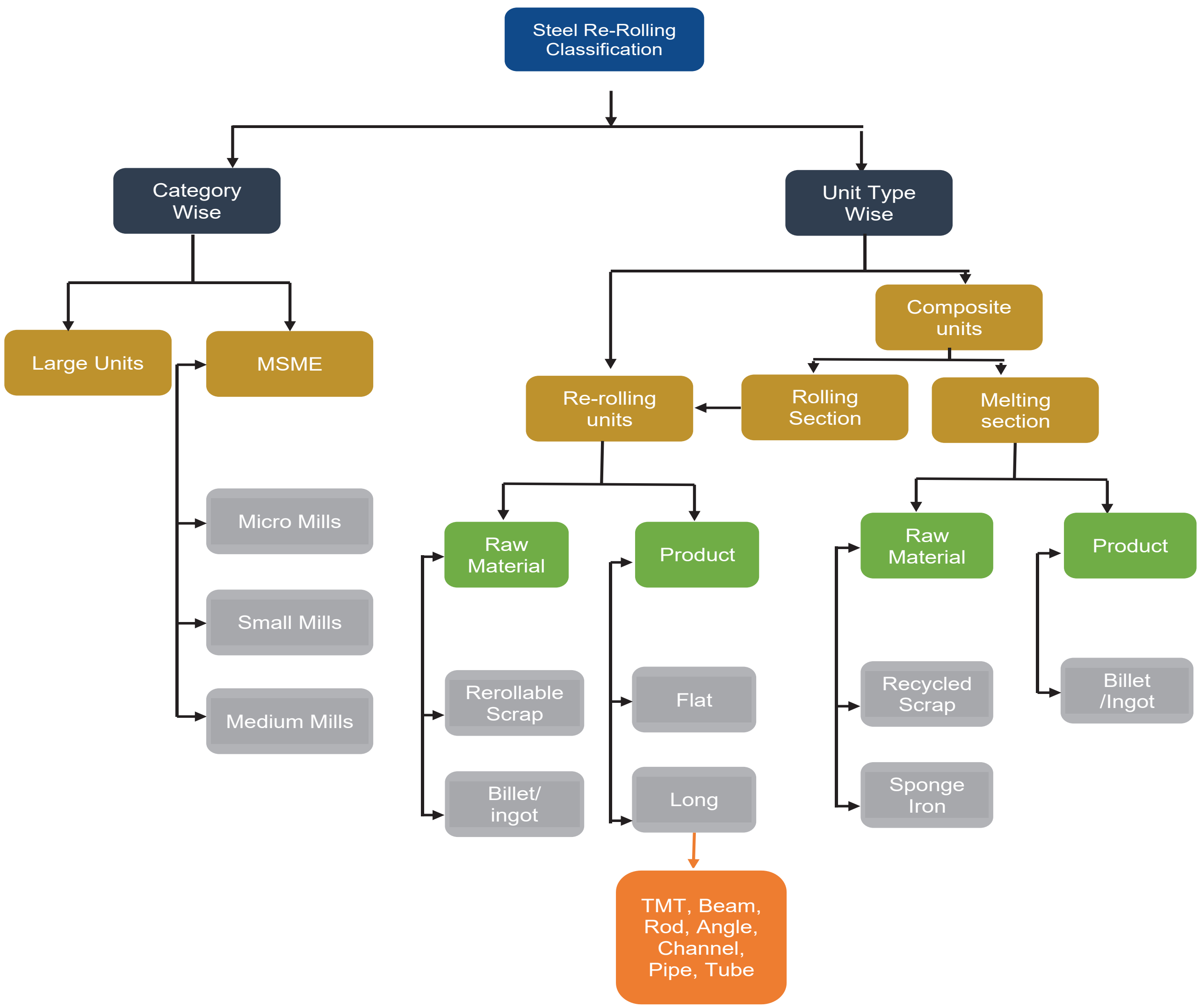


Figure 10: Steel Re-rolling mills classification

2.2 Key Growth Drivers of the Market – End-User Segmentation

While large integrated steel plants contribute the bulk of India's steel products, Steel re-rolling sector

[6] Joint Plant committee Survey of Indian Re-Rolling Industry

is an equally important player with 82% of Long products. Its long-term stability is vital for India's steel sector. The advantages that India has in terms of easy availability of raw material and quality workforce makes it one of the most competitive players in the steel Re-rolling sector.

Robust Demand

- The government is working on several infrastructural projects, such as the Mumbai-Delhi Industrial Corridors, which is driving up demand.
- India's present steel intensity is around 37 tonnes per million dollars, and it is likely to rise in the next 3-5 years as the country's economic activity grows.

Increasing Investments

- Increasing investment from the financial institutions/ ESCOs in providing the Energy Efficient technologies at low cost to the units which are driving investment in the secondary steel sector.

Policy/ Institutional Support

- There are various programs/ policies run by Government bodies and Financial institutions/ Banks to support uptake of energy efficienct technologies. A list of programs and policies is provided in Annexure D
- BEE has recently launched a program of grading of EE technologies to help units to easily get loan on certain EE technologies

Competitive Advantage

- India is the world's second largest producer of steel.
- Easy availability of low-cost manpower and presence of abundant iron ore reserves makes India competitive in the global set up.
- India is home to the fifth-highest reserves of iron ore in the world

Figure 11: Key Growth Drivers of the Market

Construction, capital goods, automobiles, intermediate products, consumer durables, and railways are among the end-use industries in India that drive steel demand. The pandemic's impact and prospects differ for each end-use sector, and the overall impact on steel demand could vary depending on the share of demand for individual sectors. The below table provides an overview of major steel-consuming industries.

Table 1: Key Growth Driver - End-User Industry (World Steel Association, Kearney)

End-User Industry	Description	Product types	Share of demand	Prospects & Key Growth Drivers
Construction	▪ Residential, Commercial and Industrial ▪ Transport Networks ▪ Utilities	Commodity items such as TMT, Hi beam, pipe, sheet pile and coated sheet	**62%**	**Strong** Logistics infrastructure (highway construction, industrial corridors, freight corridors), affordable housing and power transmission
Capital Goods	▪ Rotating equipment ▪ Static equipment ▪ Electrical equipment such as transformers ▪ Electric motors and cables ▪ High dependence on imports for technology	Steel Plates, sheets, pipes, bars and speciality and highly functional steel	**15%**	**Strong** Dependent on economic growth and secondary sectors such as construction, heavy and light industries, and government spending
Automobiles	▪ Primarily driven by automotive sales of cars, trucks, buses, and two-wheelers	Surface treated sheets Steel plates, sheets, pipes and bars	**9%**	**Weak** Short term issues around regulations, affordability, financing, industrial activity, and covid **Moderate to Strong** Over the next three to seven years
Intermediate products		Gear boxes, bearings, pipes, drums and barrels	**6%**	**Weak** Closely linked to the auto and oil and gas sector and packaging (drums and barrels)
Consumer durables	▪ White goods ▪ Yellow goods	Sheets, strips plates and stainless steel	**5%**	**Moderate** Linked to GDP and consumers' spending power
Railways	▪ Wagons and Coaches ▪ Track infrastructure	Sheet metals, special steel	**3%**	**Strong** Large planned investments, dedicated freight corridors

2.3 Key Challenges

Most of the steel rerolling units fall under MSME and they cannot use advanced technological equipment or automation due to high capital costs. The market is dominated by large players which inhibit the growth of MSME enterprises. Besides this, the sector faces various challenges related to energy pricing, financial and workforce skill-related challenges.

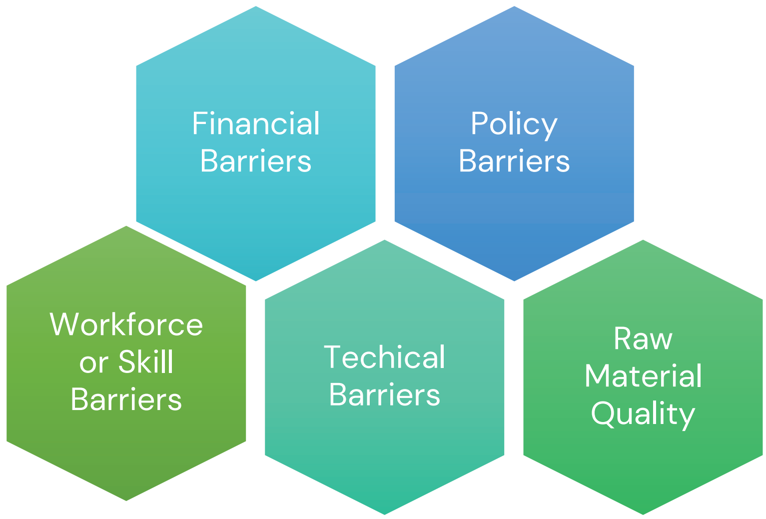


Figure 12: Key Challenges faced by the Steel Re-rolling sector

2.3.1 Financial barriers

The higher cost of energy-efficient technologies is a major reason for MSMEs' inability to adopt them. Difficulty in accessing loans and higher cost of finance - which can make repayments difficult, acts as a big impediment for adopting energy-efficient technologies. MSMEs are also wary of the documentation formalities involved and are hence not often considering applying for a loan. Some of the MSMEs who have availed the loan have experienced non-transparent or hidden charges in the loan. Further, from the business perspective for any industry owner, it is more viable, and convenient to invest in project expansion for improving the production capacity, rather than make a piecemeal investment in retrofit and replace options for energy savings. Lack of interest in investing in the new technologies, as these industries getting profits with the existing technologies.

2.3.2 Policy barriers

The general policies at the national and state levels send a strong signal in favour of EE uptake, there are still barriers related to policy that have been identified which inhibit the effective functioning of the market. Some of the policy barriers which have been identified –

i. Lack of access to cleaner affordable fuels like natural gas

Fuel switching away from coal in the reheating furnace process to cleaner affordable natural gas has significant potential to reduce ambient air pollution, mitigate CO_2 emissions and increase the yield by reducing the scale/burning loss in the reheating furnace. **Only the Mandi Gobindgarh steel rerolling cluster has limited access to piped natural gas**. The emission intensity of coal is about 55% higher than that of natural gas. Shifting to affordable natural gas-based cleaner fuels will not only reduce emissions but will also enhance productivity and improve the working environment.

ii. Lack of availability of scrap, scrap processing centres and deregistration of scrap vehicles facilities

The use of steel scrap in India is quite low (~23%) due to the lack of an effective collection mechanism. Out of the total scrap usage, India imported almost 7 MT of scrap in 2019 – 2020. The scrap route of steel production can reduce the emission intensity and energy intensity by 63% and 68% respectively. To alleviate this significant challenge there is an urgent requirement of the policy to enhance the scrap usage in the melting units by having scrap processing centres at major steel rerolling cluster locations. Also, there is a requirement of providing deregistration authorization of scrapped vehicles to the units which will enhance the availability of scrap in the cluster.

iii. Lack of market-driven policies to reduce the emissions from the sector

There is a requirement of some market-driven policies like – Emission trading scheme and carbon pricing initially at the voluntary phase to reduce the emissions from the sector.

Emission Trading Scheme (ETS): The ETS scheme requires a cap set for maximum emissions to be emitted by the units. The surplus entities (achievers) who have reduced the emissions (from the target) can trade with the non-achievers, who have surpassed the targeted emissions (non-achievers). This policy will push the units for cleaner and more energy-efficient technologies and the adoption of renewable energy. It can be initially started as a voluntary program and could be mandated with higher caps and trading. **The Gujarat government has piloted the cap-and-trade program in 158 industries and achieved around a 29% reduction in emission from the units that participated in the pilot project.**

Carbon pricing (Polluters pay principle): The emissions produced by industries are a negative externality for the environment and the economy since their true social cost is not reflected by the market price of carbon-intensive goods and services. Instituting a price that reflects the true cost of these emissions seems like an intuitive solution to address these climate change issues. This will drive the industry to push for alternative energy sources, cleaner fuel & renewables. The **UK has introduced the Carbon tax of $25 per ton in 2013 which has reduced coal usage sharply.**

2.3.3 Workforce or Skill set barriers

Successful implementation of energy-efficient technologies depends to a large extent on the technical knowledge available to the entrepreneurs, managers and operators. This is because many of these technologies have a substantial component of best-operating practices**. For example, the operators and maintenance technicians need training on good practices of the induction furnace (like – feeding of properly sized scraps to increase the bulk density, use of proper grade and**

quality of furnace lining (ramming mass) material), temperature monitoring of the stocks in reheating furnace and energy monitoring of different sections of the plant. Lack of trained manpower is a serious issue for the implementation and operation of energy-efficient technologies.

2.3.4 Technical barriers

The SME steel re-rolling mills have conventional and inefficient technologies. The reason attributable to this is the lack of awareness of efficient technologies that can be used to save energy. In addition to it, the lack of reliable technology providers coupled with the poor quality of local service providers has resulted in a high degree of skepticism towards the adoption of new technologies and processes. Since new efficient technologies (like – direct rolling, regenerative burners, Oxy-fuel combustion) are capital intensive, the MSMEs want to be certain before they invest in such technologies.

2.3.5 Raw material quality barriers

Most of the steel mills in India uses Scrap as a raw material to produce different steel products however the **quality of scarp is not consistent**. Bhavnagar cluster for example majorly uses steel scrap as a raw material to produce different types of steel products. A large part of this comes from “Alang Ship Breaking Yard” which is 50 km away from the cluster. However, the quality of scrap is not uniform, and a substantial portion of the good quality scrap is directly sold to the large steel players. Small unit owners are left with poorly sorted scrap from which they are unable to produce high-quality steel products. The quality of the scrap being processed at Alang needs to be regulated.

In addition to it, the poor quality of domestic coal (high ash content in Indian Coal) and high electricity prices also hinders the growth of the SRRM industry.

2.4 Geographical Coverage

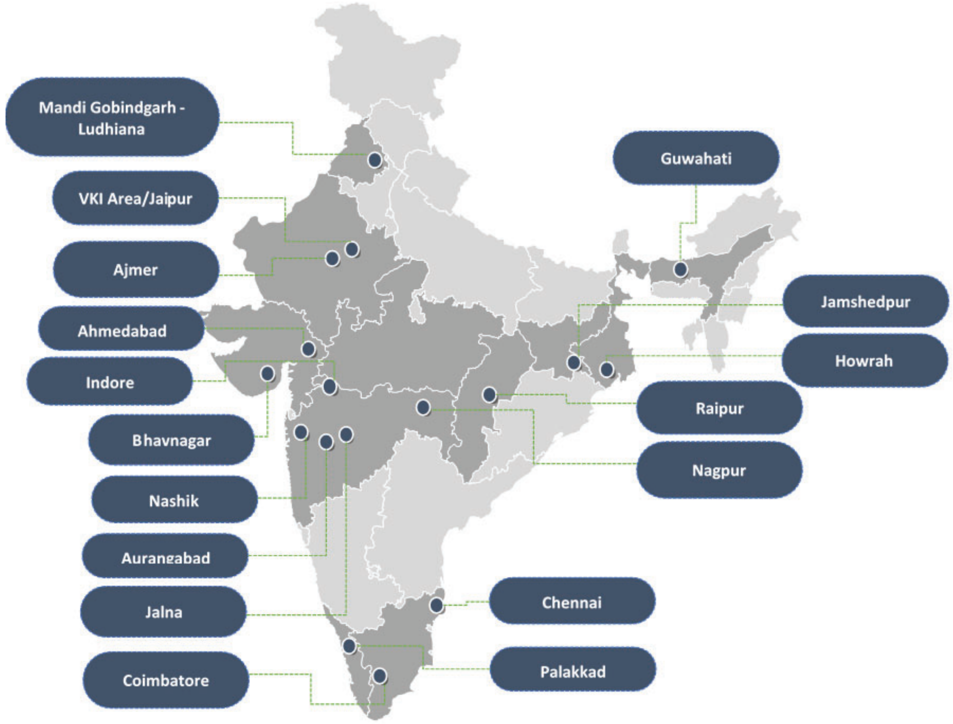


Figure 13: Steel Re-rolling clusters in India

To have an Energy and Resource outlook of the steel re-rolling sector, a detailed and holistic study was conducted in five steel clusters across the country. These 5 clusters were selected through secondary research, field visits, and stakeholder consultations. In addition to the selected 5 clusters, 2 additional steel clusters were also selected for the walkthrough surveys.

The cluster selection was governed keeping in view different matrices such as:

- No of units in the cluster
- Production capacity of the units on the cluster
- Raw material mix
- Product mix
- Presence of local association

Five clusters selected for detailed study include:

- Punjab – Mandi Gobindgarh & Ludhiana
- Rajasthan – Jaipur
- Chhattisgarh – Raipur
- Gujarat – Bhavnagar
- Maharashtra – Jalna

In each of the selected five clusters, 10 units were selected for conducting detailed energy audits. Three clusters selected for the additional survey include:

- Rajasthan – Jodhpur
- West Bengal – Howrah
- West Bengal – Durgapur

The selected clusters are shown in the map below:

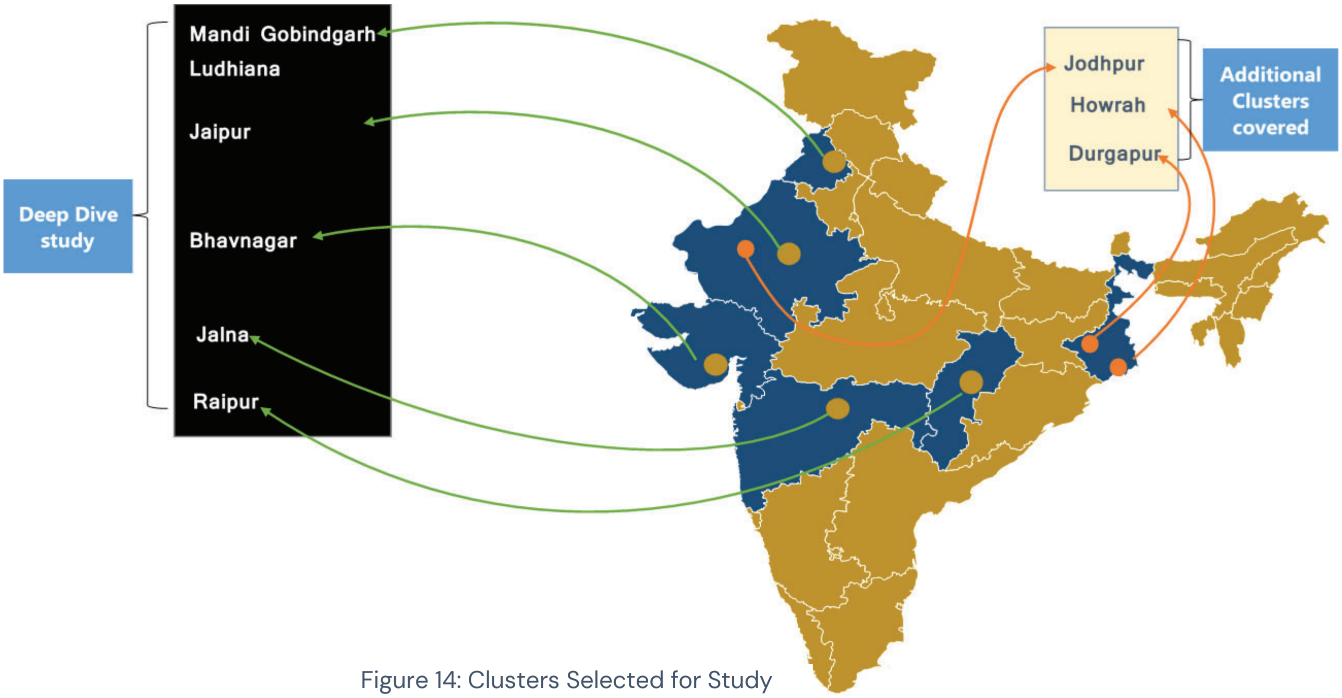


Figure 14: Clusters Selected for Study

2.4.1 Cluster Selection Matrix

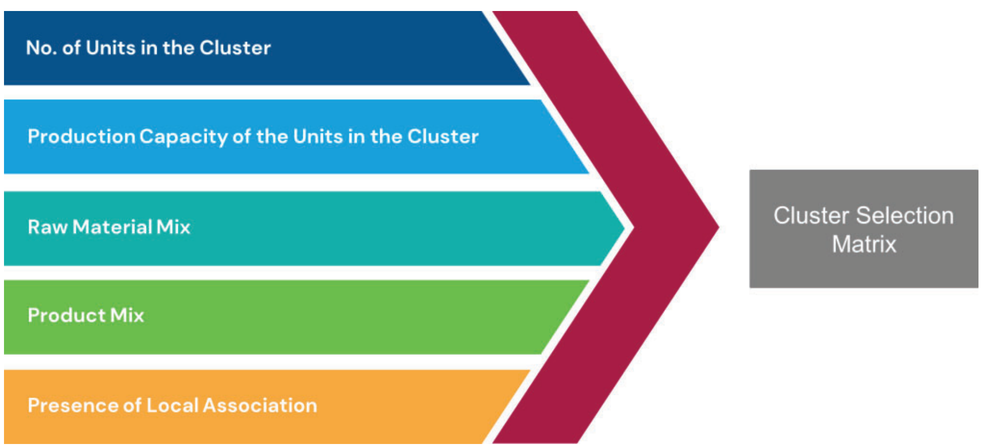


Figure 15: Cluster Selection Matrix

Information for different steel re-rolling clusters is given in the table below:

Table 2:Cluster selection matrix

S.L. No.	State	Cluster	No. of Mills	Technology – Steel Mill classification		Products Manufactured
				With input as Scrap (Induction + Reheating Furnace)	*With input as Billet (Only Reheating Furnace)*	
1	Punjab	Mandi Gobindgarh & Ludhiana	275	✓	✓	Rounds, Squares, TMT Bars, Ingot, steel wire, Billets, Tubes, M.S flat, rounds, square, TMT bars, Strips
2	Rajasthan	Jaipur	33	✓	✓	Bars, Angles, Channels, Beams, Flats, Squares, Rounds, Billets
3	Chhattisgarh	Raipur	135	✓	✓	Angle, Channel, Rods, Flats, Ingots, Billets, Rounds, Angles
4	Gujarat	Bhavnagar	70	✓	✓	M.S flat, rounds, square, TMT bars, Strips, channels, Beams, Billets
5	Maharashtra	Jalna	30	✓	✓	Angles, Channels, Beams, Flats, Squares, Rounds, Billets, Bar
6	Maharashtra	Nagpur	7	✓	✓	Bars, Angles, Channels, Beams, Flats, Squares, Rounds, Billets
7	Maharashtra	Aurangabad	7	✓	✓	Flats, Squares, Rounds, Bars
8	Rajasthan	Jodhpur	100			S.S. Sheets
9	West Bengal	Howrah	100	✓	✓	Rounds, Squares, TMT, Bars, Ingot, steel wire, Angles, Channels, Beams, Flats
9	West Bengal	Durgapur	50	✓	✓	Rounds, Squares, TMT, Bars, Ingot, steel wire, Angles, Channels, Beams, Flats

S.L. No.	State	Cluster	No. of Mills	Technology - Steel Mill classification		Products Manufactured
				With input as Scrap (Induction + Reheating Furnace)	*With input as Billet (Only Reheating Furnace)*	
10	Kerala	Palakkad	7	✓	✓	Squares, TMT, Bars, steel wire, Angles, Channels
11	Tamil Nadu	Chennai	60	✓	✓	Channels, Beams, Flats, Squares, Rounds, Billets, Bar, Billet
12	Gujarat	Ahmedabad	163	✓	✓	Wire, Tubes, M.S flat, rounds, square, TMT bars, Strips
13	Jharkhand	Jamshedpur	20	✓	✓	Flats, Squares, Rounds, Bars
14	Tamil Nadu	Coimbatore	60	✓	✓	Billet, Ingot, TMT bars, Wire rod, coils, Rounds, angles, channels, rails, flats.
15	Maharashtra	Nasik	60	✓	✓	Channels, Beams, Flats, Squares, Rounds, Billets, Bar, Billet
16	Assam	Guwahati	25	✓	✓	Squares, TMT, Bars, steel wire, Angles, Channels
17	Madhya Pradesh	Indore	40	✓	✓	Billet, Ingot, TMT bars, Wire rod, coils, Rounds, angles

2.4.2 Brief Overview of the clusters selected for the study

About Mandi Gobindgarh & Ludhiana

Mandi Gobindgarh is known as 'Steel Town or Loha Mandi' for its largest cluster of steel re-rolling mills in the country. In 1928, Mandi Gobindgarh became a free trade zone for steel, since then as a centre of steel, the city has experienced tremendous growth and has housed numerous steel re-rolling mills. Ludhiana city is known as the industrial capital of Punjab and is quite often referred to as Manchester

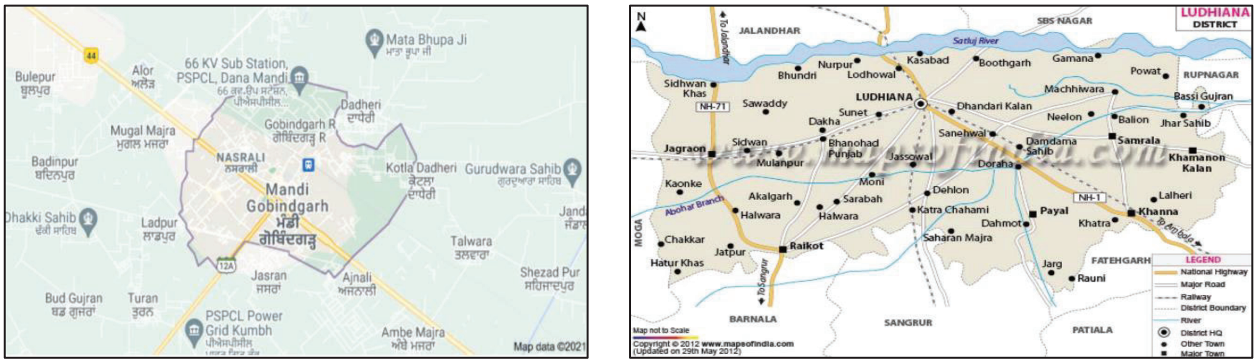


Figure 16: Map – Mandi Gobindgarh & Ludhiana

of India. Post-independence, a number of industries started booming in the city to support the agriculturally rich area. Initial development was of agricultural implements, tractor industries; slowly growth was seen in allied industries such as forging, foundry, sheet metal and auto-parts as well. The Mandi Gobindgarh and Ludhiana cluster has about 275 micro, small and medium-scale steel re-rolling units. The total production from the cluster is about 5 MTPA. The steel re-rolling industry is supported by around 500 traders and allied industries like induction furnaces, foundries, and pipe plants.

Table 3: Mandi Gobindgarh and Ludhiana Details

Mandi-Gobindgarh and Ludhiana Cluster details	Values		
Total Number of units	275		
Units Classification	Category	No of units	Average production capacity (TPD)
	Micro	15%	17
	Small	60%	60
	Medium	25%	105
Total Production (MTPA)	5 MTPA		
Total energy consumption (MTOE)	0.25 MTOE		
Major Products	Semi-finished steel (Ingot, billet, blooms), HR (Hot rolled) Coils, ERW pipes (Electronic Resistance Welded pipe), Channel, Angle, TMT (Thermo Mechanical Treatment) bar, Flats, CR (Cold rolled) Strips.		
Fuel used	Piped Natural Gas (PNG), Furnace Oil (FO), Coal		

Active Association	1. All India Steel Re-Rollers Association (AISRA) 2. Ludhiana Steel Re-Rollers Association
National Level Institutions	National Institute of Secondary Steel Technology
State Designated Agency	Punjab Energy Development Agency (PEDA), State Designated Agency

About Jaipur Cluster

Jaipur city is the capital of Rajasthan and is universally known as the Pink City. Jaipur means "city of victory" was founded in 1726 by Maharaja Jai Singh II. The city is a major hub for arts and crafts. Jaipur is an economically vibrant city. Tourism, trade and commerce and local handicrafts industries are the key strengths of the city.

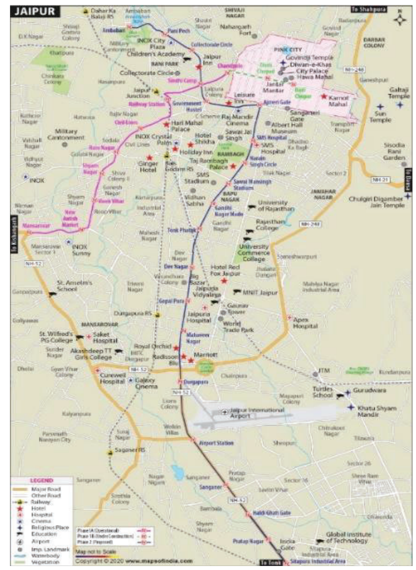


Figure 17: Map – Jaipur

Industrial development in Jaipur began in 1943 with the establishment of the Jaipur Metal and Electrical Industry, Limited. In 1979, the Rajasthan State Industries Development and Investment Corporation (RIICO) was formed to assume responsibility for the proper and controlled planning and development of industry in Rajasthan. To encourage industrial development in the city, several initiatives have been undertaken by the state government. The Industrial policy was declared by the state in 1994. The Jaipur cluster has about 33 micro, small and medium-scale steel re-rolling units. The total production from the cluster is about 1.2 MTPA. The steel re-rolling units are mainly located in Vishwakarma, Jhotwara, Reengus, Jaitpura, Sarna Dungar and Jetpura industrial areas.

Table 4: Jaipur Cluster Details

Jaipur Cluster details	Values		
Total Number of units	33		
Units Classification	Category	No of units	Average production capacity (TPD)
	Micro	10%	57
	Small	40%	85
	Medium	50%	148
Total Production (MTPA)	1.2 MTPA		
Total energy consumption (MTOE)	0.08 MTOE		
Major Products	Semi-finished steel (Ingot, billet, blooms), MS Flat, Steel angles, Steel round bars, TMT (Thermo Mechanical Treatment) bar.		
Fuel used	Coal		

Active Association	1. Rajasthan Steel Chambers 2. Viswakarma Industries Association 3. Bagru Industrial Association
State Designated Agency	Rajasthan Renewable Energy Corporation Limited (RRECL)

About Bhavnagar Cluster

Figure 18: Map – Bhavnagar

Bhavnagar District is a district of southeastern Gujarat, India, on the Saurashtra peninsula. The proximity of Bhavnagar with commercial districts of Ahmedabad, Rajkot, Surendranagar, and Amreli has made the district an important industrial location. Bhavnagar district is divided into 11 strata called Blocks or Talukas. It has always been an important district for trade with many large- and small-scale industries along with Asia's largest ship-breaking yard, Alang which is located 50 kilometres away. The Shipbreaking industry aided the growth of businesses such as steel re-rolling mills and steel melting factories. Approximately 90% of the recovered steel in recycling operations is sent to the re-rolling mills where it is rerolled and covered into steel bars. The raw material for steel re-rolling industries located in the Bhavnagar district (mainly in Sihor taluka) is sourced from ship breaking industries in the form of sheets. The steel melting units also procure scrap raw material to produce billets and ingots, which is the further input material for steel rolling mills. Ship recycling in India contributes around 1-2% of domestic steel demand and most dismantled ship scraps are recycled and reused.

There were about 120 re-rolling mills in the Bhavnagar district of these, only 70 mills are estimated to be in operation with an estimated installed capacity of 3 million tonnes (mt) per year. Most of the units are located in GIDC (Sihor). The production from the operational unit is estimated to be 1.8 million tonnes (60% of the installed capacity). The capacities of associated reheating furnaces in the cluster vary in the range of 3.5–10 tonne per hour (TPH). The production and energy consumption details of the operational units are tabulated below.

Table 5: Bhavnagar Cluster Details

Bhavnagar Cluster details	Values		
Total Number of units	70		
Units Classification	**Category**	**No of units**	**Average production capacity (TPD)**
	Micro	20%	43
	Small	50%	86
	Medium	30%	114
Total Installed Capacity (MTPA)	3 MTPA		

Total Production (MTPA)	1.8 MTPA
Total energy consumption (MTOE)	0.130 MTOE
Major Products	Semi-finished steel (Ingot, billet, blooms), MS Flat, Steel angles, Steel round bars, TMT bar.
Fuel used	Coal
Active Association	Bhavnagar (Sihor) Steel Re-Rolling Association
State Designated Agency	Gujarat Energy Development Agency (GEDA)

About Jalna Cluster

Jalna district is an administrative district in the state of Maharashtra in Western India. Jalna town is the districts headquarter. The district is part of the Aurangabad division. At present, there are eight tehsils in the Jalna district i.e. Jalna, Badnapur, Bhokardan, Jafrabad, Partur, Ambad, Ghansawangi and Mantha. The Jalna city is situated on the banks of the Kundalika river is the premier commercial centre of the Marathwada region. The most significant part of the Jalna district is that about 85% of the Geographical area is under agricultural use.

Figure 19: Map – Jalna

Jalna district is well known for its hybrid seed industries, steel re-rolling mills, bidi industry & agro-based industries like dal mill. The district is also known for the highest production of Sweet Lemon (Mosambi) in the state. There were about 30 re-rolling mills in the Jalna district. It provides employment to about 1000 workers. The production from the operational unit is estimated to be 3.9 million tonnes. The capacities of associated reheating furnaces in the cluster vary in the range of 3 – 35 tonne per hour (TPH). The production and energy consumption details of the operational units are tabulated below.

Table 6: Jalna Cluster Details

Bhavnagar Cluster details	Values		
Total Number of units	30		
Units Classification	**Category**	**No. of units**	**Average production capacity (TPD)**
	Micro	10%	217
	Small	50%	433
	Medium	40%	578
Total Production (MTPA)	3.9 MTPA		
Total energy consumption (MTOE)	0.25 MTOE		
Major Products	Semi-finished steel (Ingot, billet, blooms), MS Flat, Steel angles, Steel round bars, TMT (Thermo Mechanical Treatment) bar.		

Fuel used	Coal
Active Association	Steel Manufacturers Association Of Maharashtra;
State Designated Agency	Maharashtra Energy Development Agency (MEDA)

About Raipur Cluster

Raipur district is one of the oldest districts and is important from in historical and archaeological point of view. 'Chhattisgarhi' is the local language that most of the people in this area love to converse in. The district is surrounded by District Bilaspur in North, District Bastar and part of Orissa state in South, District Raigarh and part of Orissa state in East and district Durg in West. Mahanadi is the principal river of this district.

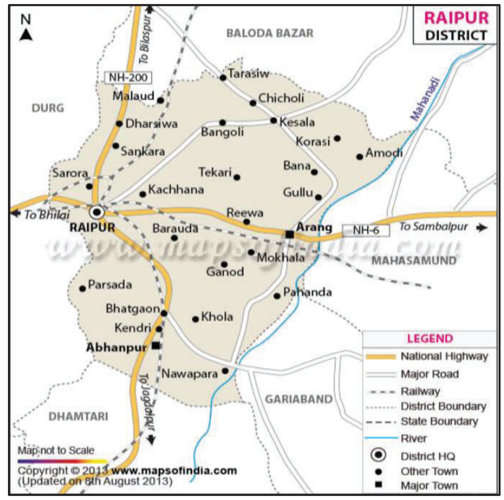


Figure 20: Map – Raipur

Raipur is located in the state of Chhattisgarh which has a large deposit of coal, iron ore, Limestone and various other mineral ores which fosters the establishment of various industrial units in the state. The availability of the excess amount of cement, industrial raw material, the cheap labour force has contributed to the substantial growth of industrial sectors in the state.

The district is famous for its various grades of limestones deposits. Rolling Mill Industries, Ferro Alloys, Steel Casting, Non-ferrous casting, cement etc. are the main industries of the district. The Raipur cluster has about 135 micro, small and medium-scale steel re-rolling units. The total production from the cluster is about 3.3 MTPA. The steel re-rolling units are mainly located in Ultra, Siltara and Rawa Bhata industrial areas.

Table 7: Raipur Cluster Details

Bhavnagar Cluster details	Values		
Total Number of units	135		
Units Classification	**Category**	**No of units**	**Average production capacity (TPD)**
	Micro	20%	61
	Small	60%	81
	Medium	20%	102
Total Production (MTPA)	3.3 MTPA		
Total energy consumption (MTOE)	0.241 MTOE		
Major Products	Semi-finished steel (Ingot, billet, blooms), MS Flat, Steel angles, Steel round bars, TMT (Thermo Mechanical Treatment) bar.		
Fuel used	Coal		
Active Association	Chhattisgarh Steel Re-Rollers Association		
State Designated Agency	Chhattisgarh State Renewable Energy Development Agency		

	(CREDA)

2.5 Sector Level Stakeholders

The clusters included in the study have several key stakeholders which support the functioning and provide a range of services to the Steel Re-rolling mills. The key stakeholders include industry associations, government agencies including regulatory bodies, research and academic institutions, and testing facilities and training institutes. A detailed list of stakeholders is shared in Annexure E6:

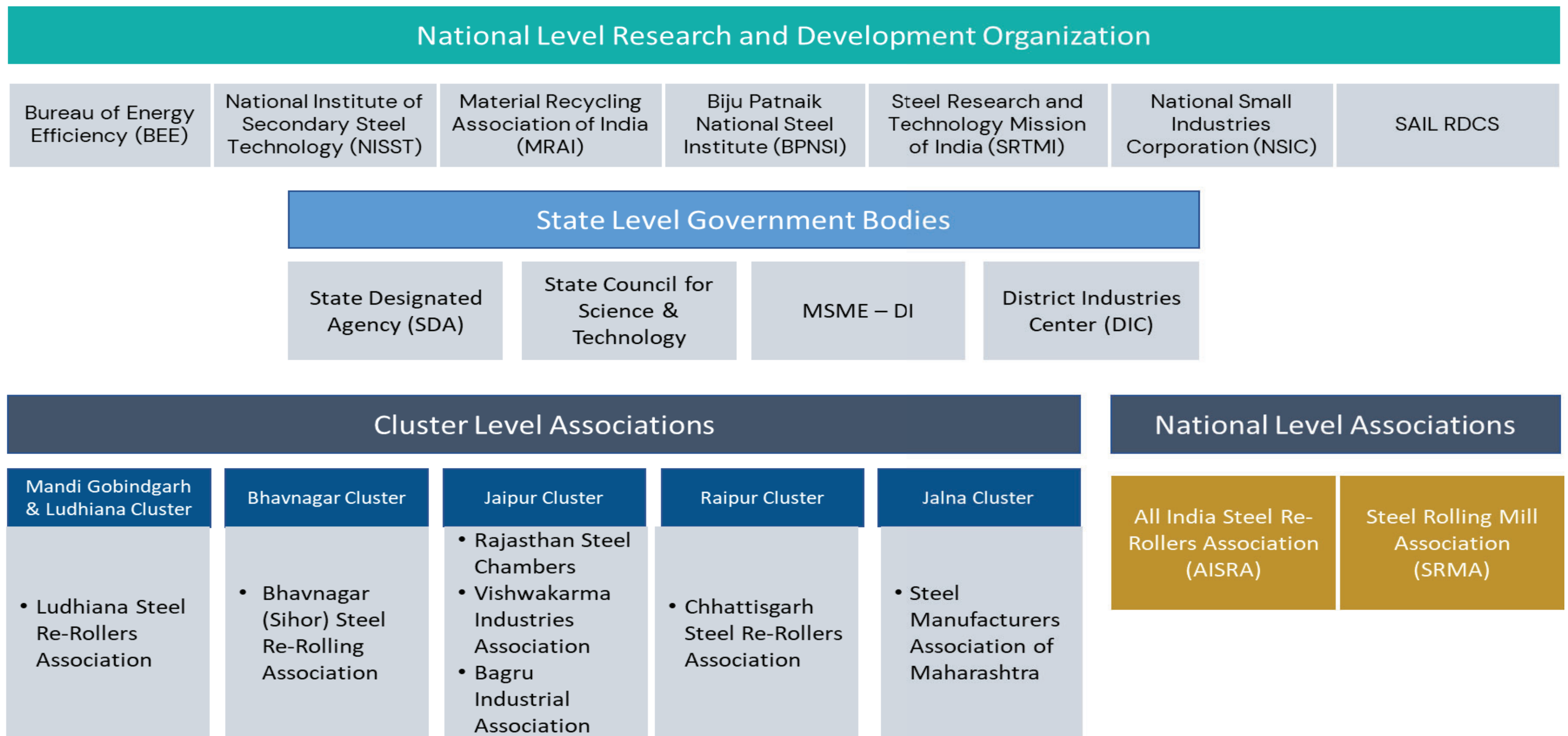


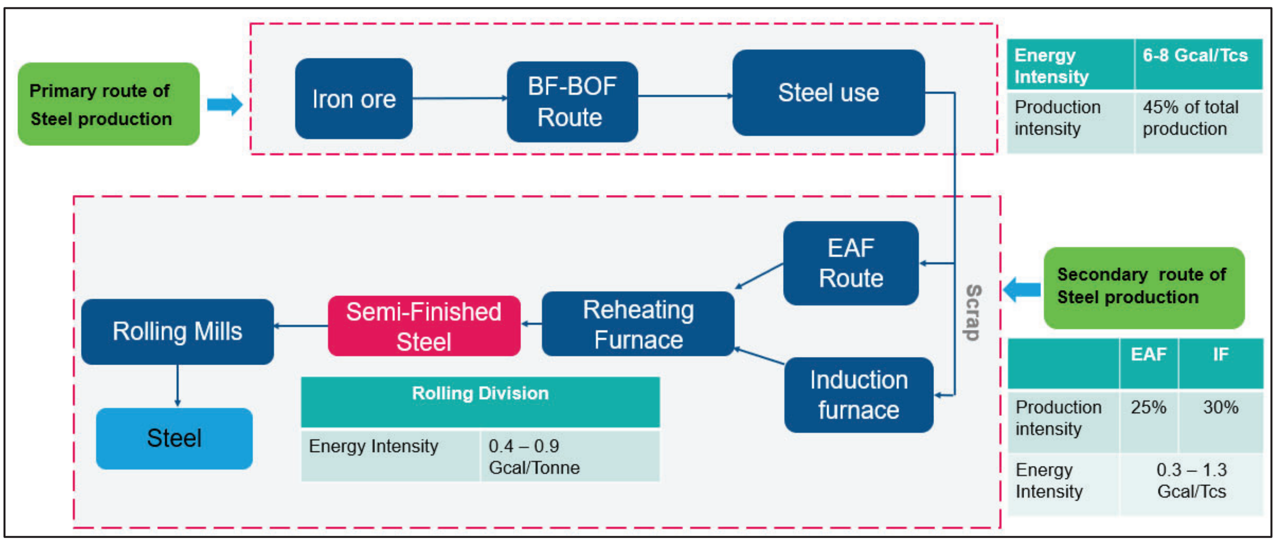
Figure 21: Major Stakeholders

3. Energy Consumption and Benchmarking

There are two production routes of steel– primary route and secondary route. In the primary route, the steel is produced from iron ore (as the raw material) in the BF-BOF (Blast Furnace – Basic Oxygen Furnace) process. The primary route accounts for 45% of the total steel production and is very energy-intensive, requiring 6-8 GCal (Giga Calorie) of energy per tonne of crude steel production.

The secondary route processes the used steel (i.e. scrap) to produce the crude steel. There are two production routes in the secondary steelmaking process – EAF (Electric Arc Furnace) and IF (Induction Furnace). The energy requirement varies between 0.3 – 1.3 GCal per tonne of crude steel, depending upon the charge mix (ratio of pig iron, sponge iron and scrap) of the furnace. EAF and IF process contributes to 25% and 30% of the steel production respectively.

The semi-finished steel (i.e. Ingot/Billet/Blooms) produced are further processed in the steel rerolling mills to produce different end-use flat and long products which are used in various sectors like construction, transport, appliances, oil and Gas, Power etc. The energy intensity of the rolling division varies between 0.4 – 0.9 GCal per tonne of product.



The secondary route (using scrap) of steel production is low energy intensive and resource intensive as compared to primary route. The use of every ton of scrap will save 1.1 ton of iron ore, 630 kg of coking coal and 55 kg of limestone and will reduce the energy consumption by 70%.

Figure 22: Energy intensity of different production routes

Secondary steel (combining EAF and IF route) accounts for 55 per cent of overall steel industry production in India and comprises over 1200 small and medium steel re-rolling mills (SRRMs) units spread across the country. The SRRM sector generates employment of about 400,000 people directly or indirectly. They are usually found in clusters, with each cluster having about 20 to 300 units closely located. This sector produces about 33 million tonnes of steel which contributes to about 68% of the total production of non-flat steel products in the country.

The Project team has done a holistic study in the steel re-rolling sector. After doing the secondary research on all the different steel re-rolling clusters of the country, the project team has selected 5 steel re-rolling clusters for the detailed study and 2 additional clusters for the walkthrough surveys. These 5 clusters are chosen in such a way that they can be used as the representative sample of the whole steel re-rolling clusters of India. The outline of the Indian steel re-rolling sector which will be discussed in the following sections is based on the audits and the surveys in the selected clusters.

Categorization of units

Mostly the Steel Rerolling units belong to the "Small" category which is estimated to be varying between 40 percent to 60 percent of the total number of units in the cluster. About 10 to 20 percent of the units belong to the Micro category. In the Jaipur cluster, most of the units (about 50%) belong to the "Medium" category.

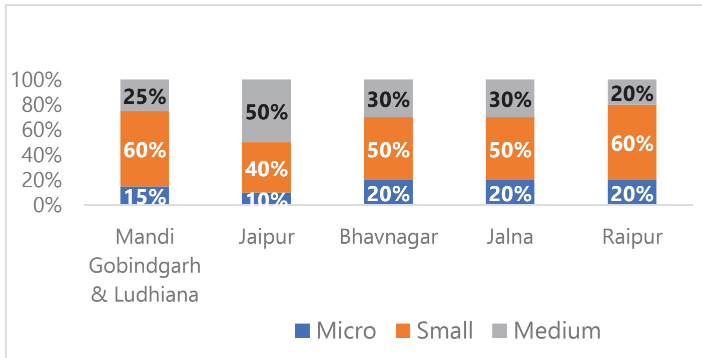


Figure 23: Number of MSME

Production and No of units

Mandi Gobindgarh is the largest steel rerolling cluster and has around 275 units. The total production of the cluster is estimated to be around 5 MTPA. On contrary, the Jalna cluster has around 30 units and the total production from the cluster is estimated to be 3.9 MTPA. The units of the Jalna cluster are of larger capacity as compared to the Mandi Gobindgarh cluster. The rolling mills in the Jalna cluster operate for 24 hours a day, resulting in a large scale of production, whereas most mills in the other clusters operate 10-12 hours a day. The average production of different categories of units of five clusters is depicted in the graph below.

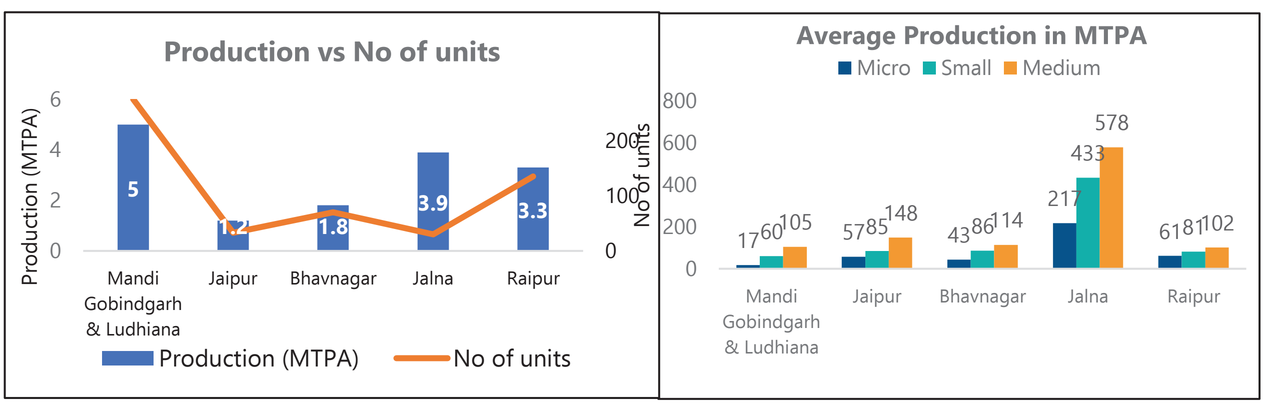


Figure 24: Production and No of Units

Jaipur, Bhavnagar and Raipur clusters have 33, 70 and 135 no of units respectively which amount to the production of 1.2 MTPA, 1.8 MTPA and 3.3 MTPA respectively.

Raw material & Product Mix

The raw materials used in the rolling section include semi-finished steel (Billet/Blooms/Ingot) and the re-rollable scrap. The melting section (predominant technology Induction furnace) uses raw materials like – Scrap/Pig iron/DRI which are charged in different charge mixes depending upon the ease of availability to produce the liquid metal. These raw materials are generally procured locally through traders & commission agents. The raw material contributes to 90% of the total production cost.

Table 8: Raw material and production

Type of Unit	Melting units	Re-rolling units
Raw material produced	Scrap, Sponge Iron, Pig iron	Billets, Ingots, Blooms, Re-rollable scrap

The semi-finished steel (i.e., Ingot/Billet/Blooms) produced in the melting section is further processed in the steel rerolling mills to produce different end-use flat and long products. The long product includes – Angle, Channel, Bar, TMT, Beam, Pipe Tube, and Rod, etc. Flat products are majorly categorized into strips, sheets. Among the different product portfolios of the rerolling mills, TMT bars are majorly produced (~29%).

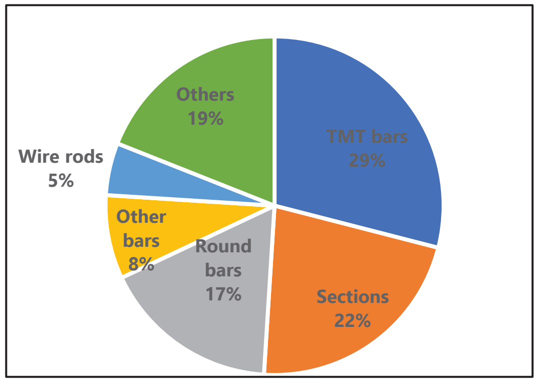


Figure 25: Finished Steel Production Mix

3.1 Energy Benchmarking

Benchmarking comprises the analysis and reporting of key energy performance Indicators to foster continual energy performance improvements in the industry through comparison with internal and external norms and standards. An energy benchmarking analysis generates two important perspectives; it provides an overview of how well a particular industry sector or sub-sector is doing in managing energy performance. Secondly, it enables company participants in a benchmarking exercise to compare the performance of their plant(s) with the overall industry indicators. The intention behind the benchmarking study is to facilitate the knowledge transfer and enable performance comparison with peers, identifying the aspects of their performance that were good, bad, or indifferent.

Figure 26: Energy Benchmarking Benefits

3.1.1 Benchmarking Methodology

The first step towards improving energy efficiency would be to define the baseline of the key KPIs for the sector. Benchmarking becomes a key priority in this context and for the following reasons:

- To benchmark sector's performances in terms of energy efficiency achievements for different KPIs
- Comparison of energy performance for different countries
- Identifying gaps and areas of improvement
- Develop improvement programs with a view of successful adoption

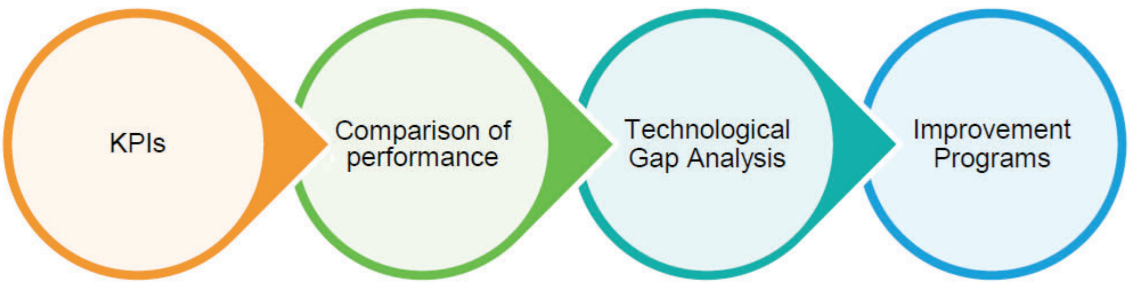


Figure 27: Benchmarking Methodology

The national benchmarks presented in the subsequent sections were prepared by both primary and secondary research while the international benchmarks were based on the secondary research. The benchmarking as a tool act as a guide for manufacturing plants to focus on reducing the manufacturing cost and improving efficiency towards maximum limits for sustaining the benefits amid volatile market, increase in raw material and energy cost, demand for highest quality and competition from international market players. The figure below shows the benchmarking cycle:

3.1.2 Energy Consumption Profile

The steel re-rolling sector has around 1200 units scattered across the various clusters with a total production of about 33 MT. The energy consumption of the units depends on the type of the unit – composite unit (unit with both melting and re-rolling facility) or the re-rolling unit.

Energy use details: Thermal and electrical energy used in various sections of the units for different operations. The thermal energy is used in the reheating furnace to increase the temperature of the stock to the re-rollable temperature. Electrical energy is used in the Induction furnace for the smelting operation and to drive various motive loads. Energy accounts for a significant 25 – 30% of the total energy cost.

Energy balance: The share of thermal energy in the Re-rolling units is in the range of 70% to 80%, whereas in the composite units the thermal energy share varies between 20% to 40%. Thermal energy is only used in the reheating furnaces to increase the temperature of the stock materials to be rolled. The higher share of electrical energy in the composite units is because of the melting operation of energy-intensive Induction furnaces.

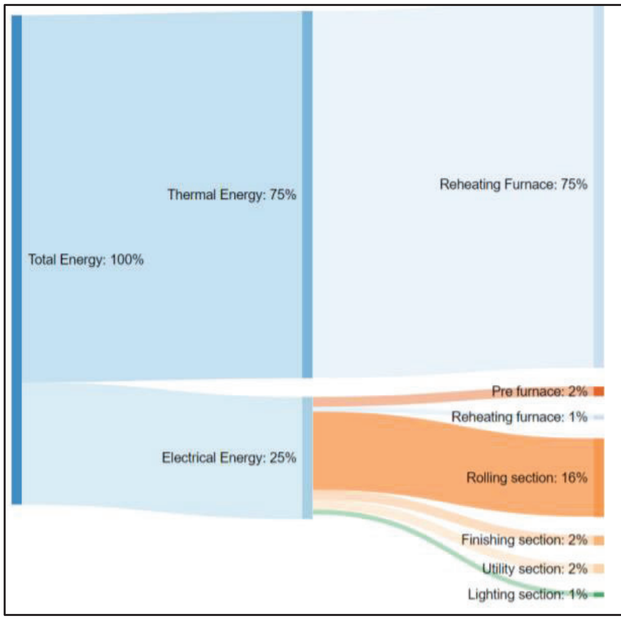


Figure 29 Energy Balance of Re-rolling units

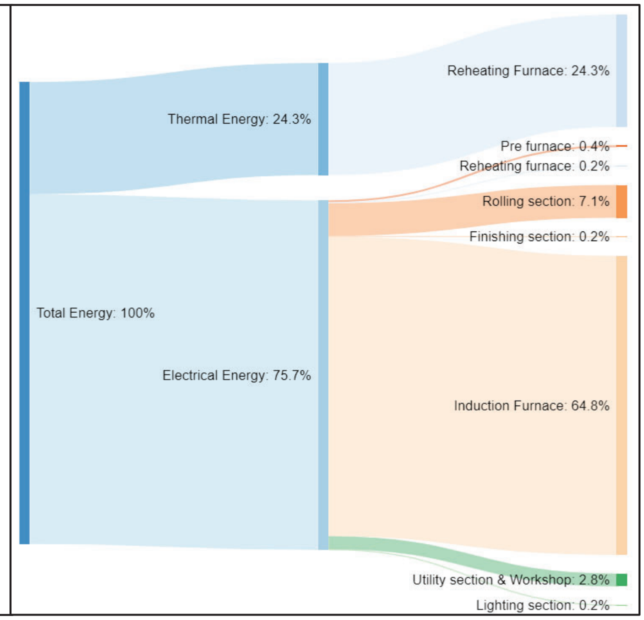


Figure 28: Energy Balance of Composite units

The electricity energy consumption of the units depends on the type of the unit – composite unit (unit with both melting and re-rolling facility) or the re-rolling unit. The thermal energy is only consumed in the reheating furnace to increase the temperature of the raw material charged in the reheating furnace to the re-rollable temperature, which is subsequently rolled in the rolling mills to the desired product dimensions.

Electricity is primarily used to drive various rolling mills motors and auxiliaries. Rolling mill drives consume about 10% of the total electrical energy in the rolling mill units. In the composite units, the electricity is also used for melting the scraps in the induction furnaces which accounts for 70% of the total electricity consumption. Typical electrical energy distribution in the various section for Re-rolling units and Composite units is represented below:

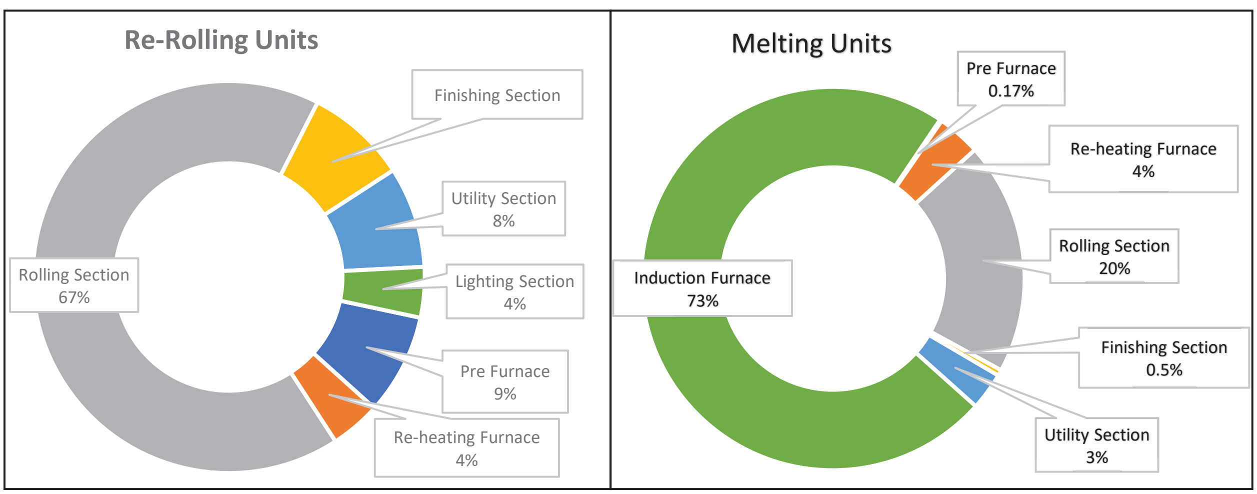


Figure 30: Electrical Energy Distribution

3.1.3 Cluster Level Thermal and Electrical Energy Consumption

Mandi Gobindgarh is the "Loha Mandi of India" and has around 275 units. Around 80% of the units in the cluster uses Coal and a few of the units around 15% have shifted to greener fuel Natural gas to reheat the billet/ingot in reheating furnace and 5% of the units uses furnace Oil.

Table 9: Cluster Level Thermal and Electrical Energy Consumption

Fuel Mix	No of Units	Production	Thermal Energy Consumption			Total Thermal Energy Consumption	Electrical Grid (Mtoe)
			Coal (Mtoe)	PNG (Mtoe)	FO (Mtoe)		
Mandi Gobindgarh & Ludhiana	275	5	0.156	0.029	0.009	0.195	0.055
Jaipur	33	1.2	0.062	-	-	0.062	0.020
Bhavnagar	70	1.8	0.110	-	-	0.110	0.020
Jalna	30	3.9	0.044	-	-	0.044	0.209
Raipur	135	3.3	0.104	-	-	0.170	0.071
Total		**15.2**	**0.476**	**0.029**	**0.009**	**0.581**	**0.375**

Thermal energy contributes to the major share of energy consumption varying between 66% to 84% of the total energy consumption in different clusters. Whereas in the Jalna cluster, most of the units belong to the composite category (having both rolling and melting facility) and have employed direct rolling technology (which eliminate the need for a reheating furnace) due to which the electrical energy contributes to 83% of the total cluster energy consumption

Below pie chart represents a more graphical presentation of the share of Thermal and Electrical energy consumption:

The Fuel mix for different clusters are as follows:

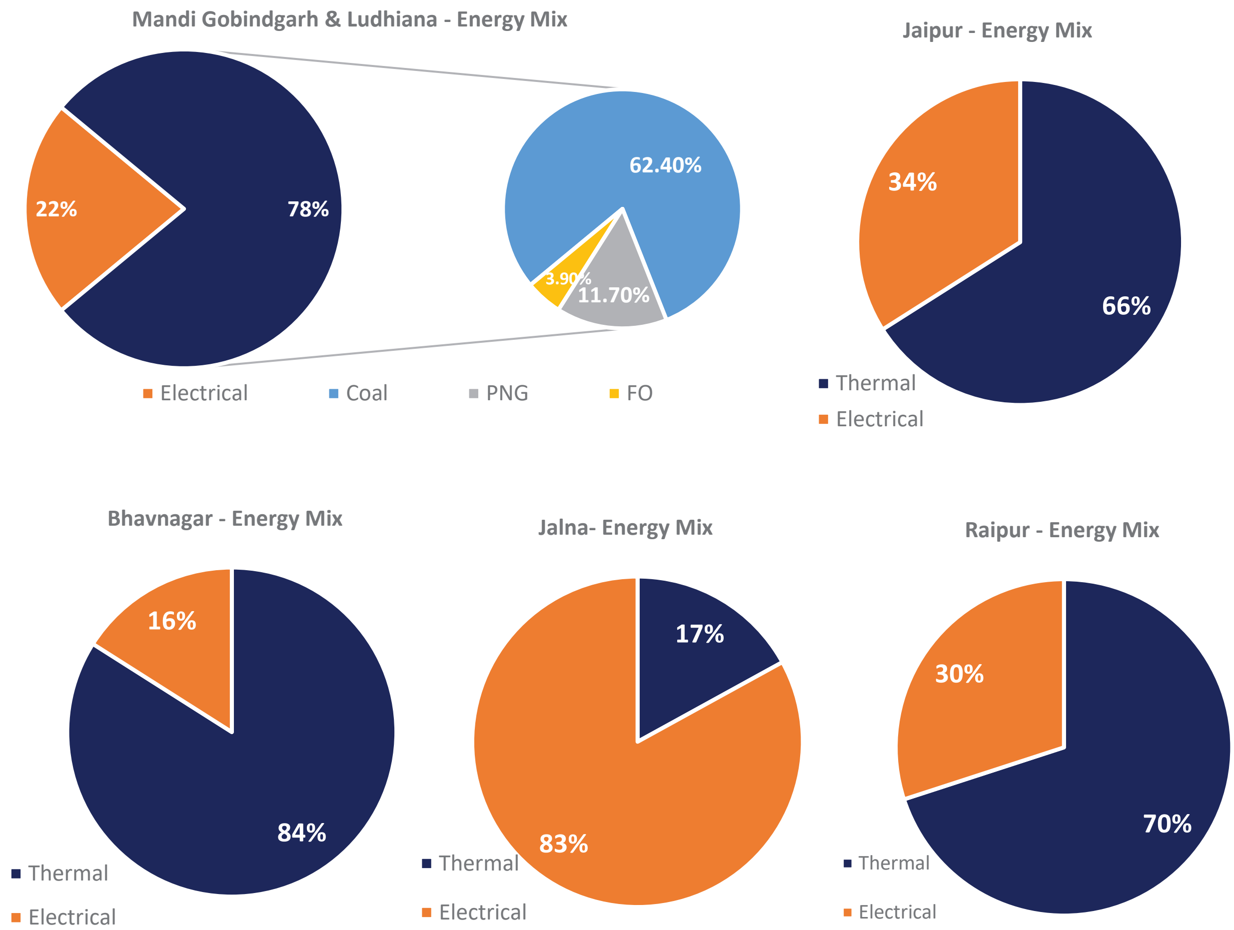


Figure 31: Fuel Mix

3.1.4 Sector level Thermal and Electrical energy consumption

The sector level annual energy consumption of the steel rolling units is estimated to be 2.1 MTOE to produce 33 million tons of products with an average specific energy of 0.06 Toe/tonne. Thermal energy accounts for the major share of 61% of the total energy consumption.

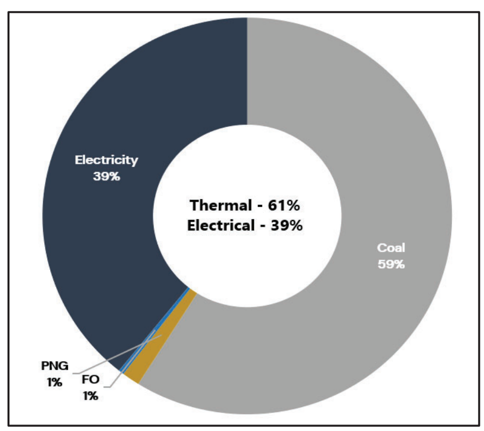


Figure 32: Sector Level Energy Consumption

The sector level annual energy consumption of the steel rolling units is estimated to be 2.1 MTOE to produce 33 million tons of products with an average specific energy of 0.06 Toe/tonne. Thermal energy accounts for the major share of 61% of the total energy consumption covering coal, PNG and Furnace Oil (FO) as fuels. The major source of thermal energy is coal and only 5% of the units in the Mandi Gobindgarh region are using FO and 15% of the units have shifted to cleaner PNG (Piped Natural Gas) fuels.

Table 10: Sectoral Energy Consumption

Particular	Unit	Value
Total Production	(MTPA)	33
Total Energy Consumption	(MTOE)	2.074
Thermal Energy Consumption	(MTPA)	1.261
Coal Consumption	(MT)	2.04
PNG Consumption	(Million SCM)	30.79
FO Consumption	(Million Litre)	10.6
Electrical Energy Consumption	(MTOE)	0.814
Electricity consumption	(GWh)	9467
GHG emission	(MtCO$_2$e)	11.55

Electricity Tariff – General Tariff structure

The general electricity tariff structure of clusters selected for study is provided below -

Table 11: Electricity Tariff structure

Clusters	Type of Industry	Details (HT Industry having contracted load above 88kVA/75 kW)	Energy Charges (Rs/unit)	Demand Charges (Rs/kVA/month)
Mandi Gobindgarh & Ludhiana	General Industry	Above 100 kVA and upto1000 kVA	5.89 Rs./kVAh	165
		Above 1000 KVA and up to 2500 kVA	5.93 Rs./kVAh	225
		Above 2500 KVA	5.98 Rs./kVAh	260
	Arc Furnaces & Power Intensive Units including Induction furnaces	Above 100 kVA and upto1000 kVA	5.93 Rs./kVAh	170
		Above 1000 KVA and up to 2500 kVA	6.18 Rs./kVAh	260
		Above 2500 KVA	6.19 Rs./kVAh	295
Jaipur	LP/HT - 5	Sanctioned Load above 150HP &/or Contract/Maximum Demand above 125KVA	7.3 Rs./kVAh	270
		Billing demand of 1MVA or more & having load factor 50% or more	6.3 Rs./kVAh	270

Clusters	Type of Industry	Details (HT Industry having contracted load above 88kVA/75 kW)	Energy Charges (Rs/unit)	Demand Charges (Rs/kVA/month)
Bhavnagar	HTP – I	Upto 500kVA	4.0 Rs./kWh	150
		From 500kVA to 1000kVA	4.2 Rs./kWh	260
		Above 1000kVA	4.2 Rs./kWh	475
		Above 2500 kVA	4.3 Rs./kWh	475
		In excess over contract demand	4.3 Rs./kWh	555
Jalna	Industry – General	For all supply voltage levels	6.96 Rs./kWh	432
	Industry - Seasonal	For all supply voltage levels	7.22 Rs./kWh	432
Raipur	HV-4: Steel Industries	220 kV supply	6.35 Rs./kWh	375
		132 kV supply	5.40 Rs./kWh	375
		33 kV supply (Load factor >15%)*	5.55 Rs./kWh	375
		33 kV supply (Load factor <=15%)*	5.95 Rs./kWh	190
		11 kV supply (Load Factor >15%) *	6.45 Rs./unit	375
		11 kV supply (Load Factor <=15%)*	6.05 Rs./unit	190

Fuel Tariff

Thermal energy is used to increase the temperature of the stock (Billet/Ingots) in the reheating furnace up to the re-rollable temperature, which is subsequently rolled in the rolling division for a different dimensional product. Coal is the predominant fuel that is fired in the reheating furnace to increase the temperature of the stock. However, some units of the Mandi Gobindgarh & Ludhiana cluster are also using Piped Natural Gas (PNG) and Furnace Oil (FO) in the reheating furnace.

Table 12: Fuel Tariff structure

Types of Thermal Energy	Calorific value	Price per unit	Source
Coal	5,500 - 6,000 kCal/kg	Rs. 6,000/tonne	Imported coal
FO	9,200 kCal/Ltr	Rs. 32/Ltr	Local Dealer
PNG	9,500 kCal/SCM	Rs. 21 – 39/SCM	City Gas Distributor

3.2 SEC Comparison across Clusters selected for Study

3.2.1 Unit Level Specific Electricity and Fuel consumption analysis of clusters

The electricity energy consumption of the units depends on the type of the unit – composite unit (unit with both melting and re-rolling facility) or the re-rolling unit. The thermal energy is only consumed in the reheating furnace to increase the temperature of the raw material charged in the reheating furnace to the re-rollable temperature, which is subsequently rolled in the rolling mills to the desired product dimensions.

The unit-level energy consumption in the cluster widely varies from cluster to cluster.

The specific energy consumption variance for different clusters is tabulated below:

Table 13: Unit level Fuel and electricity consumption analysis

Fuel type	Unit Type		Mandi Gobindgarh & Ludhiana	Bhavnagar	Jalna	Raipur	Jaipur
Electrical consumption	**Rolling units**	**(KWh/ tonne)**	70 – 170	79 – 144	84 – 130	85 – 132	72 – 186
		(toe/ tonne)	0.007 – 0.015	0.007 – 0.012	0.007 – 0.011	0.007-0.011	0.006-0.015
	Composite units	**(KWh/tonne)**	588 – 700	800 – 1040	580 – 696	665 – 820	746 – 1013
		(toe/tonne)	0.051 – 0.06	0.069 – 0.089	0.050 – 0.060	0.057 – 0.071	0.064 – 0.087
Thermal Energy Consumption[7]	**Coal**	**(Kg/tonne)**	62 – 200	88 – 123	74 – 145	78 – 134	84 – 170
		(toe/tonne)	0.035 – 0.12	0.053 – 0.074	0.044 – 0.087	0.047-0.080	0.05-0.102
	PNG	**(SCM/tonne)**	50	-	-	-	-
		(toe/tonne)	0.045	-	-	-	-
	FO	**(litre/tonne)**	23 – 40	-	-	-	-
		(Toe/tonne)	0.023 – 0.04	-	-	-	-
Total Energy	**Rolling units**	**(Toe/tonne)**	0.035 – 0.125	0.061 – 0.086	0.049 – 0.091	0.060 – 0.088	0.062 – 0.117
	Composite units	**(Toe/tonne)**	0.08 – 0.14	0.079 – 0.138	0.079 – 0.112	0.079 – 0.116	0.081 – 0.129

*The variation in SEC is attributed to product category, and its dimensions and type of furnace & fuel

[7] Thermal energy is only used in the reheating furnace which is a part of Rolling section

Re-rolling units

The specific energy consumption of the re-rolling units widely varies among different units. In the Mandi Gobindgarh region, some of the units were consuming coal as high as 200 Kg per tonne of production and some of the units were found to be energy efficient and use 62 Kg of coal per tonne of production. The handling and burning loss are very high in coal as compared to PNG, hence the PNG consumption is found to be varied in a narrow range of 45 SCM to 50 SCM per tonne of production. The specific electricity consumption was estimated to be varying between 70 kWh to 186 kWh per tonne of production.

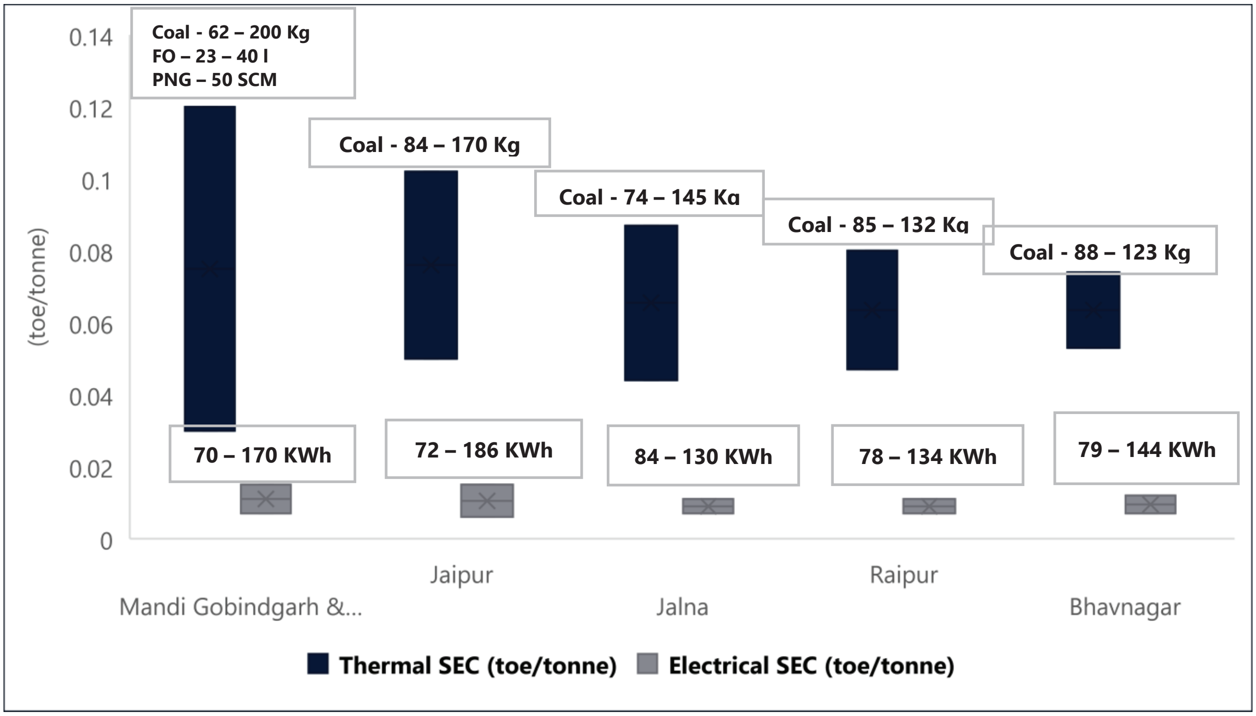


Figure 33: Thermal and electrical specific energy consumption - Re-rolling units

Composite Units

The composite units have both a melting and re-rolling facility. The melting section uses purely electrical energy in Induction Furnace to melt the iron. The specific energy consumption of the Melting section is provided below:

Melting section

The melting section has an energy guzzler induction furnace to melt the charge to the liquid metal. The density and type of charge mix (DRI/Pig Iron/Scrap) determine the electricity consumption in the melting units. The Specific electricity consumption of the melting section is found to be varying between 588 kWh to 1040 kWh per tonne of semi-finished steel (Billet/Ingot/Blooms) production.

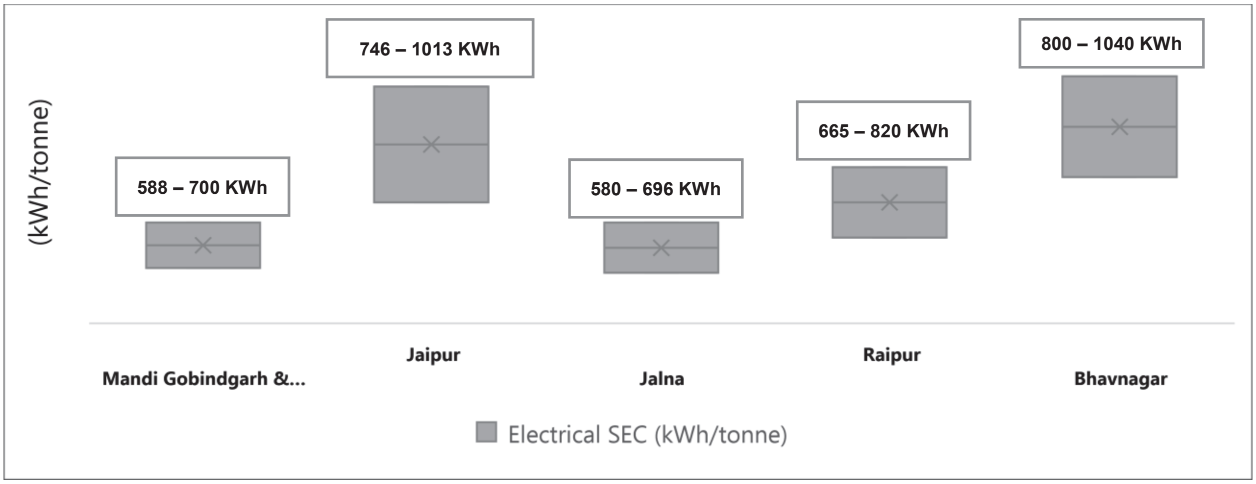


Figure 34: Electrical Specific Energy Consumption – Melting units

Overall Specific Energy Consumption

Re-Rolling Units

The overall specific energy consumption of Re-rolling units of the clusters varies widely between 0.037 – 0.125 toe per tonne of steel. Mandi Gobindgarh cluster has the highest number of units which falls under the micro and small category and the wide variation of SEC is also observed in the cluster. The average Specific energy consumption for the rerolling mills is estimated to be 0.0629 tonnes of oil equivalent (toe) per tonne of steel.

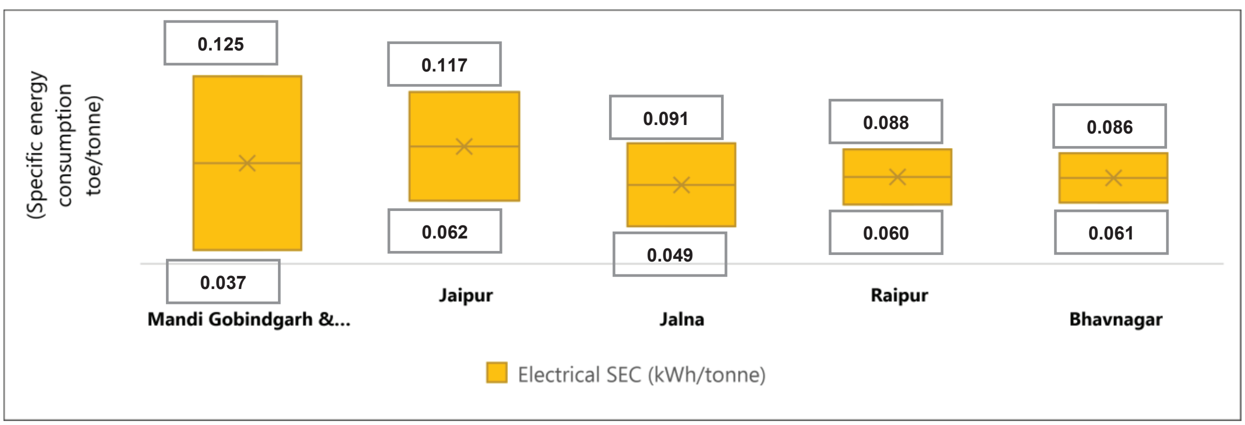


Figure 35: Overall Specific Energy Consumption – Re-rolling units

Composite Units

The composite units have generally higher specific energy consumption due to the high electricity consumption in Induction Furnace (IF) to melt the charge in the furnace. The specific energy consumption varies between 0.079 to 0.14 tonnes of oil equivalent per tonne of steel production. The composite units with direct rolling technology have low specific energy consumption. Direct rolling eliminates the use of reheating furnace from the units and the billets produced from the Induction Furnace is directly charged to the rolling section The majority of the units in the Jalna cluster has adopted direct rolling technology which has resulted in low energy consumption.

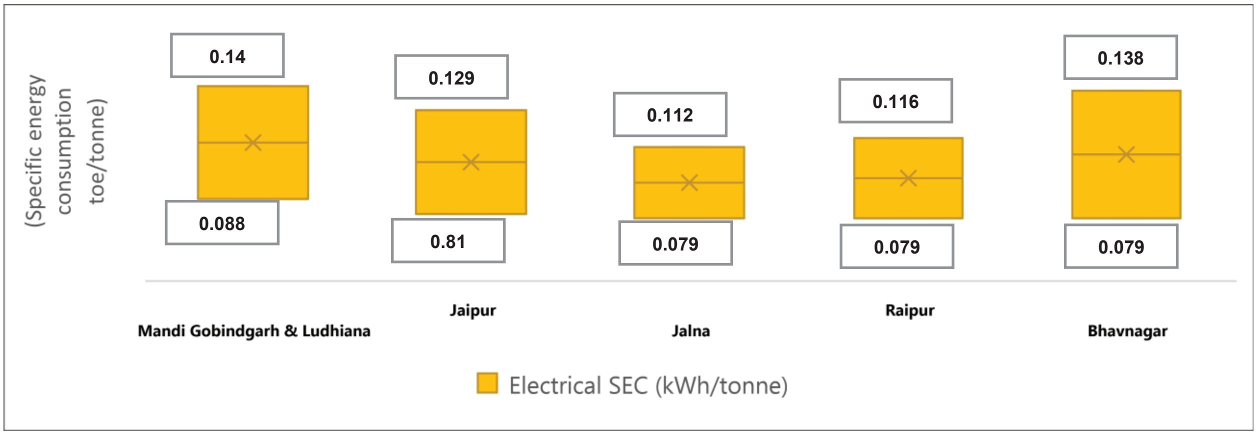


Figure 36: Overall Specific Energy Consumption – Composite units

3.3 Comparison with International benchmark

The worldwide steel sector has grown exponentially by 21% in the last 10 years, from 1518 in the year 2011 million tonnes to 1864 million tonnes in the year 2020. China has dominated the industry, accounting for more than half of global steel output; India is in second place, accounting for 5.3% of global steel production.

The Per capita consumption of steel is the benchmark of a country's social status and yardstick of its economic development. The leading economies of the world use over 800 kg of steel per person. India the per capita consumption is about 74 kgs, which is lower than that of the rest of Asia which stands at 362 kgs and also lower when compared to the World average which stands at 261 kgs. This illustrates that there is tremendous headroom for the growth of the Steel sector in India when compared with the Asian as well as the world average.

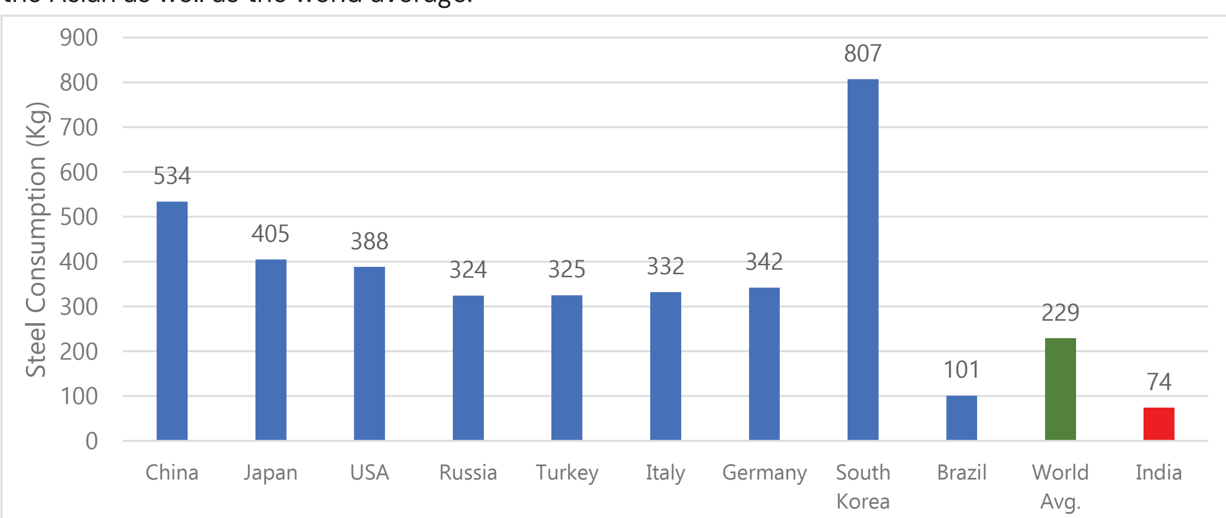


Figure 37: Steel Per Capita Consumption *(Source: World Steel Association)*

International benchmarking[8]

Comparison of Specific Energy Consumption (SEC) between India and the World

Re-Rolling Section – The energy intensity varies among steel rolling mills in different clusters in India, and the energy intensity of small rolling mills is generally higher than that of large steel rerolling mills. The average SEC of Indian MSME steel rerolling mills is estimated to be 0.0629 toe/tonne which is 30% higher compared to large rerolling mills. The large rolling mills are equipped with updated technology and automation controls and has adopted best operating practices.

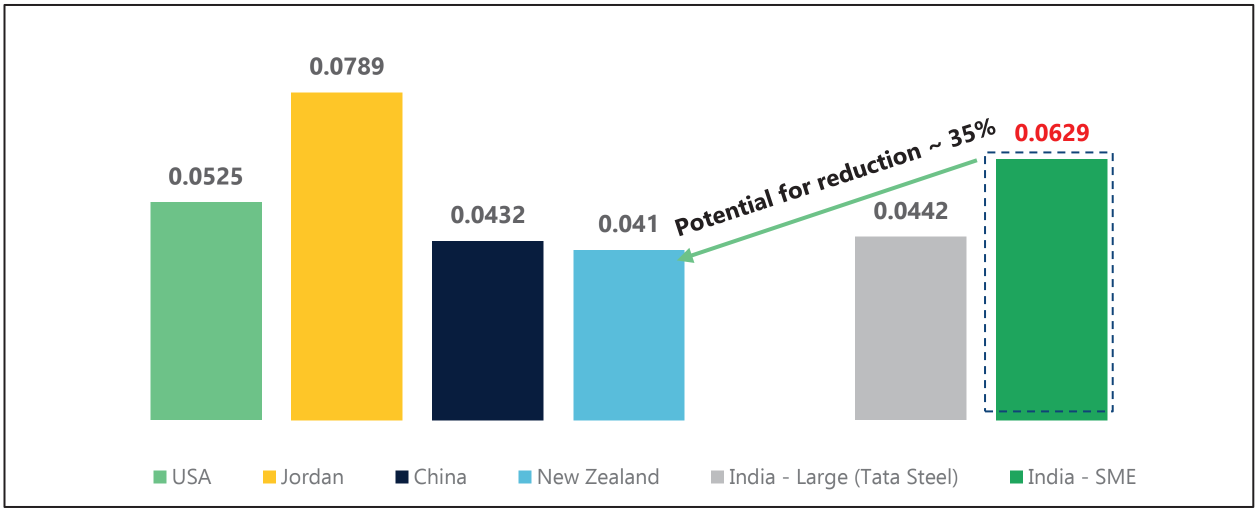


Figure 38: Benchmarking Specific Energy Consumption of Indian SME with International – Re-rolling section

New Zealand has the lowest energy consumption because the mills generally use cleaner and more efficient natural gas in the reheating furnaces. Natural gas provides the advantages of better combustion, no handling loss of the fuel and lower emissions and a better work environment as compared to coal. The emission intensity of coal is about 55% higher than that of natural gas.

Melting Section – The average specific energy consumption of the melting section is estimated to be 0.0645 toe/tonne. Which is 40% higher compared to the melting units in New Zealand. In India, the melting units in SME steel rerolling units has predominantly Induction Furnace (IF) technology, whereas in New Zealand the melting units have Electric Arc Furnace (EAF). The electric arc furnace is of higher capacity with greater refining capability and uses low energy compared to Induction Furnaces. The only hurdle of the SME units in adopting the electric arc furnace technology is the capital requirement in the installation of the EAF.

[8] https://www.mdpi.com/2075-4701/10/3/302/htm
https://aurak.ac.ae/publications/Energy-analysis-of-the-steel-making-industry.pdf
https://www.mbie.govt.nz/assets/3345bf98e5/heavy-industry-energy-demand-update-report.pdf
http://www.greenbusinesscentre.com/energyawards/enepresent/Metals_164_Tata_Steel__Jamshedpur_0.pdf
http://large.stanford.edu/courses/2016/ph240/martelaro1/
https://www.researchgate.net/publication/324552398_EnergySaving_Potential_of_China's_Steel_Industry_According_to_Its_Development_Plan

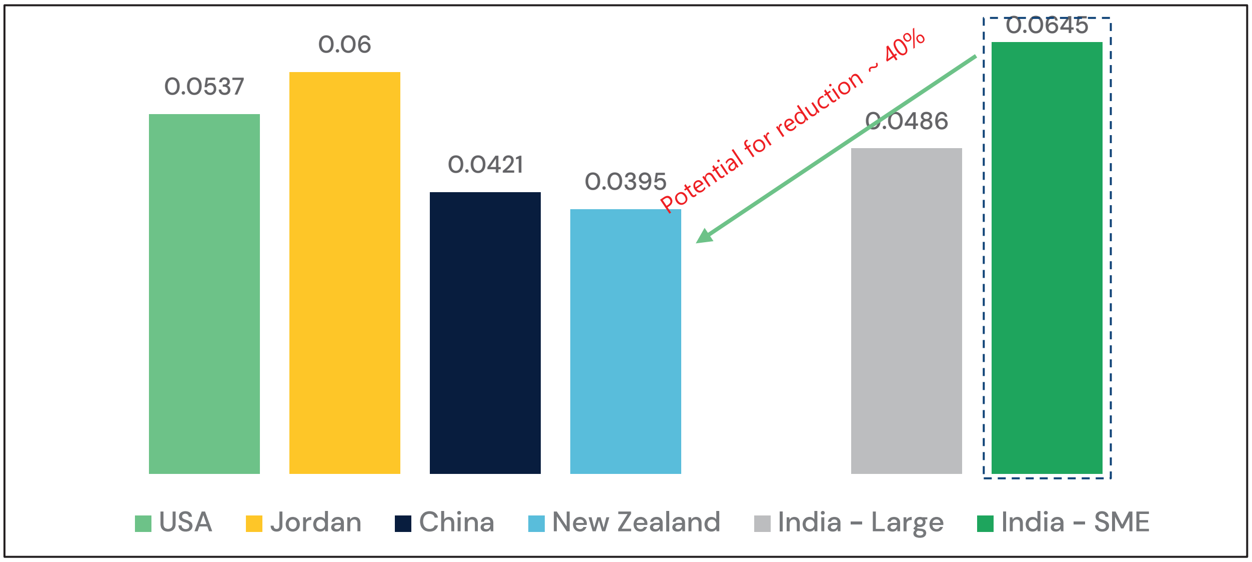


Figure 39: Benchmarking Specific Energy Consumption of Indian SME with International – Melting section

The different melting furnace technologies employed, and the type of fuel used in the reheating furnace in different countries is tabulated below:

Table 14: Melting technologies and fuel in Reheating furnace used in different countries

Country	Melting Furnace type	Fuel Used in Reheating Furnace
U.S.A.	EAF	Not Available
Jordan	EAF	Fuel Oil
China	EAF	Natural Gas
New Zealand	EAF	Natural Gas (small amount of diesel)
India (SME)	EIF	Coal (a small number of units also use Natural Gas/Fuel Oil)

Use of Scrap in Steel Production – India & Global

Scrap-based production (also referred to as secondary or recycled production) can be valuable in reducing energy demand and CO_2 emissions. The scrap route of steel production can reduce the emission intensity and energy intensity by 63% and 68% respectively. Apart from the low energy route, the secondary route (using scrap) of steel production is also low resource-intensive as compared to the primary route. The use of every ton of scrap will save 1.1 tons of iron ore, 630 kg of coking coal and 55 kg of limestone and will reduce the energy consumption by 70%. Scrap is used as the main ferrous feed-in electric arc furnaces (EAFs), as well as in induction furnaces. As per International Energy Agency (IEA), Scrap-based production in EAFs and induction furnaces accounted for about 20% of production in 2018 globally.

Scrap ratio is defined as the percentage of scrap consumption in the total steel production.

$$\text{Scrap Ratio} = \frac{\text{Scrap Consumption}}{\text{Steel Production}}$$

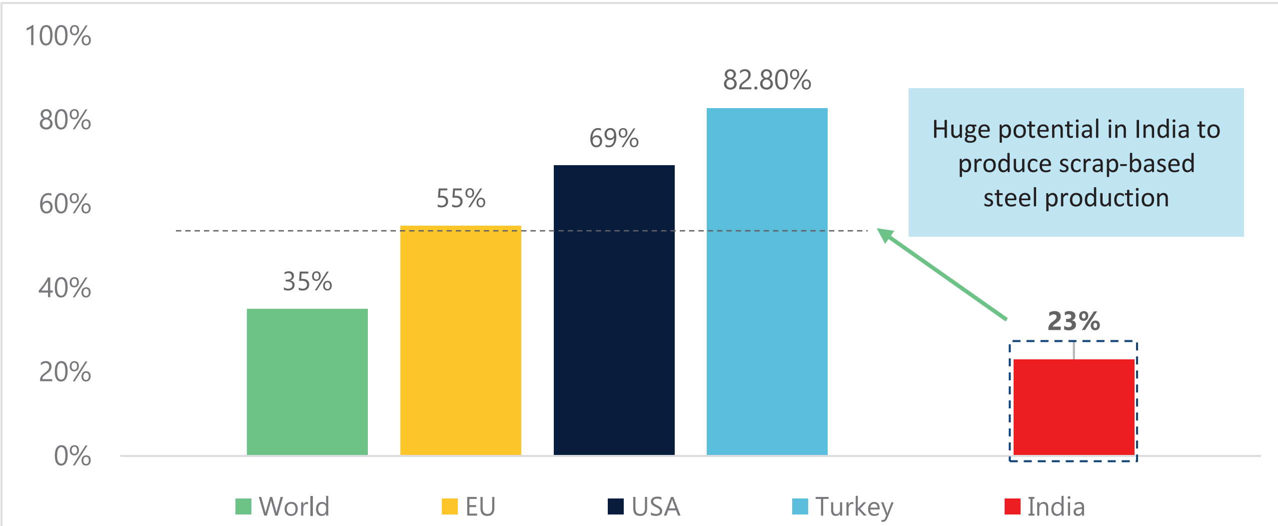


Figure 40: Scrap based steel production - comparing India with Global (Source: BIR global facts and figures)

Over the past few years, the scrap ratio of the global steel industry remained at around 35%. Among the world's major steel-producing countries, The United States and Turkey have the highest scrap ratio of 70%. Japan and EU's scrap ratio are also high at around 54%. The scrap ratio of India is at around 23%, which indicates the huge potential to mainstay the scrap in steel production.

Case Study – China Steel Scrap Usage[9]

China largest steel-producing and developing country has dramatically doubled its steel scrap usage in the last 5 years and has plans to increase its use of steel scrap by 23% to 320 million tonnes by 2025. According to China's 13th five-year plan (2016-2020), in addition to scrap vehicles, many bridges, houses and military equipment have reached the scrap period. This will further increase China's scrap ratio in the coming years.

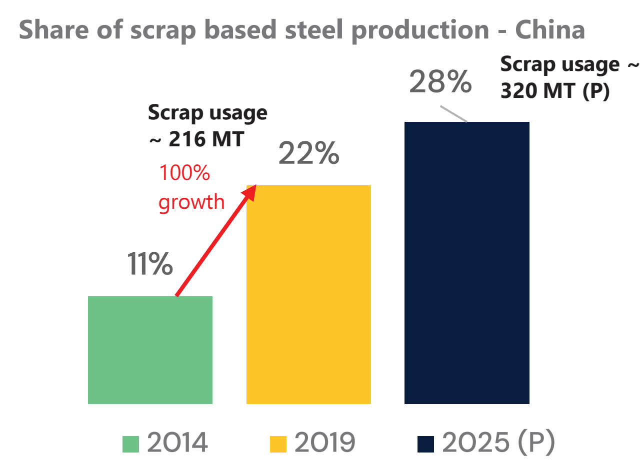


Figure 41: Case Study – China Steel Scrap Usage

India which has currently a scrap ratio of around 23% will also see a rise in scrap usage due to the government intervention and

[9] https://www.researchgate.net/publication/324552398_Energy-Saving_Potential_of_China's_Steel_Industry_According_to_Its_Development_Plan

policies around making steel from the secondary route. India is the world's second-largest steel scrap importer of about 7 million tonnes in 2019-20.

There is potential to increase scrap usage in India with the help of policies like Vehicle Scrappage policy 2021 and doubling the capacity of Alang Ship Breaking yard by 2024. However, India's Scrap Industry demands attention in the below four main areas:

1. The capacity of scrap processing is much lower than the social scrap volume.
2. The quality of equipment for scrap processing is low and dismantling lines for automobiles has not yet been extensively established.
3. Reliable statistical data for the classification of scrap resources and technical standards for the scrap processing products industry are lacking
4. The taxation of scrap import and distribution enterprises should be conducive to scrap recycling.

Therefore, management of the scrap steel industry should be improved, and specific processing and classified sales should be implemented to meet the needs of various users.

4. Energy Efficiency Potential in Steel Re-rolling Sector

4.1 The penetration level of technologies in the cluster selected for study

The below table provides an overview of the penetration level of Energy Efficient technologies in the clusters selected for the study. The five clusters represent the overall Steel Rolling sector of the country. Each of the criteria is scored and the priority of the interventions is assigned in three categories – Low, Medium, High

	0-20%	Low
	20-50%	Medium
	>50%	High

Table 15: Penetration level of technologies in the cluster

S. No	Section	Recommendation	Mandi Gobindgarh & Ludhiana	Bhavnagar	Jalna	Jaipur	Raipur
1	Melting Section/ Induction Furnace	Replacement of SCR based induction furnace with energy-efficient IGBT based induction furnace	Low	Low	Medium	Low	Medium
2		Installation of Sintering panel to preheat the ramming mass	Low	Low	Low	Low	Low
3		Installation of Scrap processing unit to reduce melting cycle time and energy consumption in the induction furnace	Low	Low	Medium	Low	Low
4		Installation of VFD on CCM (Continuous Casting Machine) pump to optimize the pressure and flow	Low	Low	Medium	Low	Medium
5		Improvement in the efficiency of Induction Furnace by using proper grade and quality ramming mass	Low	Low	Low	Low	Low
6		Implementation of continuous casting and direct rolling to eliminate the requirement of reheating furnace	Low	Low	High	Low	High
7	Reheating Furnace	Installation of Oxygen and CO sensor to optimize the excess air of the furnace	Low	Low	Medium	Low	Low
8		Installation of automation and temperature control system in the reheating furnace	Low	Low	Medium	Medium	Medium

S. No	Section	Recommendation	Mandi Gobindgarh & Ludhiana	Bhavnagar	Jalna	Jaipur	Raipur
9		Overhauling of the furnace with proper insulation lining	Low	Low	Medium	Medium	Low
10		Installation/ Overhauling of the recuperator to reduce the flue gas heat loss	Medium	Low	Medium	Medium	Medium
11		Fuel shifting from coal to PNG	Low	PNG is Not Available			
12		Installation of regenerative burners in the PNG fired reheating furnace	Low	PNG is Not Available			
13		Installation of the energy-efficient furnace with top and bottom firing	Low	Low	Low	Low	Low
14		Installation of membrane-based oxygen-enriched combustion	Low	Low	Low	Low	Low
15	Rolling Mill Division	Installation of energy-efficient roller motor for each rolling strand	Low	Low	Medium	Medium	Medium
16		Installation of Y- roller table/tilting table in 3-Hi mill stands of rolling mills	Low	Low	Medium	Medium	Medium
17		Installation of Crop length optimization to enhance the yield	Low	Low	Low	Low	Low
18		Installation of Universal Spindles and Couplings	Medium	Medium	Medium	Medium	Medium
19		Installation of Anti-friction roller bearings	Medium	Medium	High	High	Medium
20	Electrical System	Installation of Energy Monitoring System (EMS) to optimize the power consumption in a different section of the Plant	Low	Low	Medium	Low	Low
21	Auxiliaries System	Replacement of the existing compressor with energy efficient (low specific power consumption) compressor	Medium	Medium	Medium	Medium	Medium
22		Installation of VFD in the compressor to eliminate the no-load power consumption	Low	Low	Medium	Low	Low
23		Replacement of the multiple cooling water pumps with single energy efficient pump with VFD	Low	Low	Low	Low	Low
24	Renewable Energy	Installation of Solar PV Panels	Low	Low	Low	Low	Low

4.2 Cluster Saving Potential

The model units in each of the clusters were selected based on a selection matrix, which was formulated considering different parameters such as – raw material, product mix, fuel, production level and category of the unit.

The detailed assessment of the model units shows the energy-saving potential varies between 12 percent to 22 percent

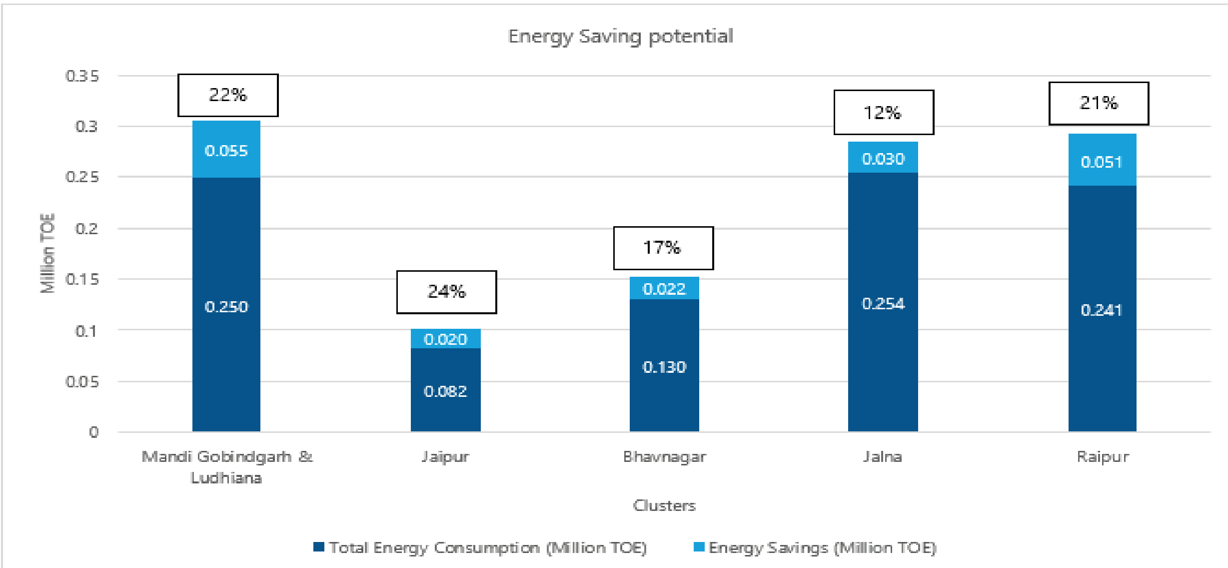


Figure 42: Energy Saving Potential

The emission saving potential varies between 9 percent to 31 percent. The Jalna being the progressive cluster have the least energy-saving potential among the five clusters.

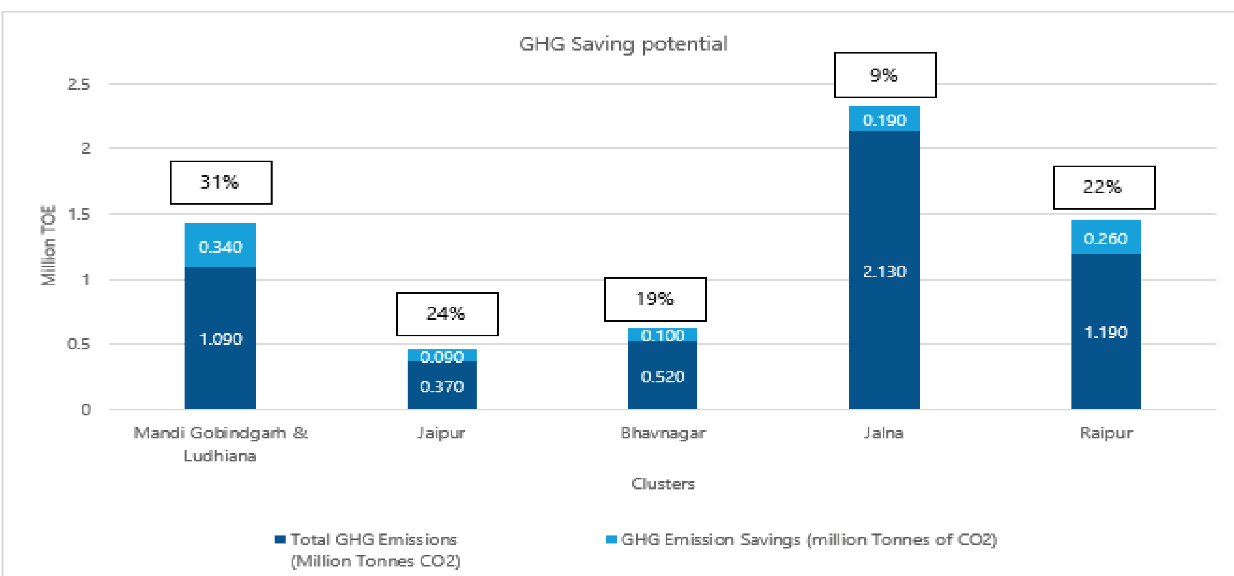


Figure 43: GHG saving potential

4.3 Sectoral Saving Potential

Based on the detailed assessment of the steel Re-rolling sector, the average energy saving potential of 38% is envisaged in the sector which will require an energy efficiency investment to the tune of 19,816 million rupees

Table 16: Steel Re-rolling Sectoral Information

Steel Re-rolling Sector Level		
Total Production	Million tonne	33
Total Energy Consumption	Million TOE	2.07
Total Energy Saving Potential	Million TOE	0.38
Total GHG Emission	Million tCO_2	11.55
Total GHG Reduction Potential	Million tCO_2	2.2
Total Investment Potential	Million rupees	19,816
Average payback Period	Years	1.2

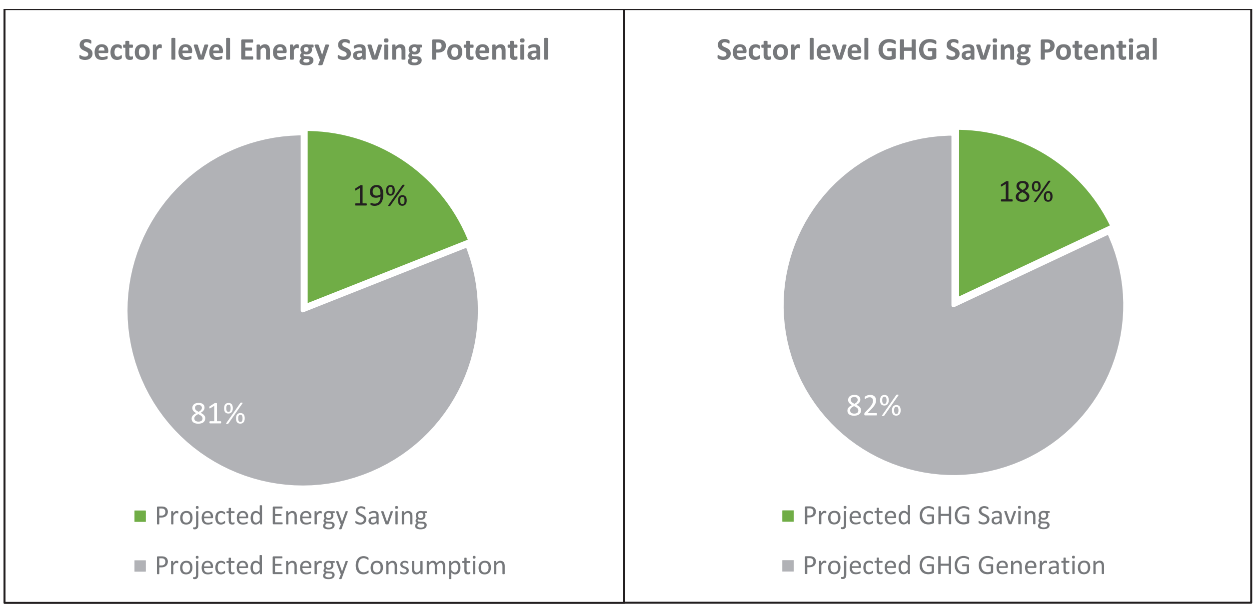


Figure 44: Sectoral Energy-saving and Emission reduction potential

4.4 Market Potential for Energy Efficient Technologies

The below table shows market potential including energy-saving opportunities, investment potential, GHG emission reduction potential for each energy-efficient technology. This section also covers a brief description of each technology intervention and its key benefits.

Table 17: Market Potential for Energy Efficient technologies

S. No	Section	Recommendation	Saving potential %	Payback period (Yrs)	Energy-saving (toe/year)	Sectoral Investment in Lakh Rupees (P)	GHG Emission reduction TCO2
1.	**Melting Section/ Induction Furnace**	Replacement of SCR based induction furnace with energy-efficient IGBT based induction furnace	Electrical = 8 – 10%	1.5-2	11,728	24,750	111,826
2.		Installation of Sintering panel to preheat the ramming mass	Electrical = 0.5 – 1%	<1	533	2,700	5,083
3.		Installation of Scrap processing unit to reduce melting cycle time and energy consumption in the induction furnace	Electricity = 5%	<1	2,962	6,750	28,239
4.		Installation of VFD on CCM (Continuous Casting Machine) pump to optimize the pressure and flow	Electricity = 20-25%	<1	925	960	8,819
5.		Improvement in the efficiency of Induction Furnace by using proper grade and quality ramming mass	Electricity = 2%	<1	1,895	1,440	18,073
6.		Implementation of continuous casting and direct rolling to eliminate the requirement of reheating furnace	Thermal = 100%	<1	357,459	37,500	1,082,000
7.	**Reheating Furnace**	Installation of Oxygen and CO sensor to optimize the excess air of furnace	Thermal = 10-15%	<1	105,092	3,600	318,078

S. No	Section	Recommendation	Saving potential %	Payback period (Yrs)	Energy-saving (toe/year)	Sectoral Investment in Lakh Rupees (P)	GHG Emission reduction TCO2
8.		Installation of automation and temperature control system in the reheating furnace	Thermal = 4%	2-4 months	33,629	2,000	101,785
9.		Overhauling of the furnace with proper insulation lining	Thermal = 5 – 7%	<1	54,648	800	165,401
10.		Installation/ Overhauling of the recuperator to reduce the flue gas heat loss	Thermal = 10 -15%	2.5-3	105,092	6,000	318,078
11.		Fuel shifting from coal to PNG	Thermal = 20%	2.5-3	30,266	7,200	91,606
12.		Installation of regenerative burners in the PNG fired reheating furnace	Thermal = 25%	10	25,222	9,600	76,339
13.		Installation of energy efficient furnace with top and bottom firing	Thermal - 20% Burning loss: 20-25% Productivity: 5 – 10%	<2	10,509	27,500	31,808
14.		Installation of membrane-based oxygen-enriched combustion	Thermal = 30%	<2	23,646	11,250	71,568
15.	**Rolling Mill Division**	Installation of energy efficient roller motor for each rolling strand	Electricity = 15%	<1	2,398	42,000	22,863

S. No	Section	Recommendation	Saving potential %	Payback period (Yrs)	Energy-saving (toe/year)	Sectoral Investment in Lakh Rupees (P)	GHG Emission reduction TCO2
16.		Installation of Y- roller table/tilting table in 3-Hi mill stands of rolling mills	Electrical 10% Higher mill utilization Increased productivity	<2	3,390	2,500	32,322
17.		Installation of Crop length optimization to enhance the yield	Yield – 0.5%	<1	-	300	-
18.		Installation of Universal Spindles and Couplings	Electrical – 2 to 10%	<2	1,627	1,800	15,514
19.		Installation of Anti friction roller bearings	Electrical 5%	<2	2,034	5,250	19,393
20.	**Electrical System**	Installation of Energy Monitoring System (EMS) to optimize the power consumption in different section of the Plant	Electricity = 3%	<1	16,352	1,600	155,919
21.	**Auxiliaries System**	Replacement of the existing compressor with energy efficient (low specific power consumption) compressor	Electricity = 30%	1-2	308	240	2,940
22.		Installation of VFD in the compressor to eliminate the no load power consumption	Electricity = 7-10%	<1	524	360	4,997
23.		Replacement of the multiple cooling water pumps with single energy efficient pump with VFD	Electricity = 5 - 10%	<2	1,657	2,064	15,800
24.	**Renewable Energy**	Installation of Solar PV Panels	Depends upon the capacity	4-6	-	-	-

4.5 Prioritization of Intervention

The project study examined the impact of different energy-efficient technologies. A novel approach was developed using various factors to evaluate the prioritization of technology and allow plant managers to make better-informed decisions, leading to financially and environmentally successful energy-efficient technology project implementations.

The factors considered for prioritization of the intervention are -

a) Performance improvement,
b) Environment improvement,
c) Reliability,
d) Investment,
e) Technical risk.

Table 18: Prioritization of Intervention Criteria

S. No	Parameter	Criteria of Scoring	Scoring
1	Performance improvement criteria (a)	**High** = significant gain in energy savings or quality of product produced *(Electrical = 10%+; Thermal = 10%+)* **Medium** = moderate gain in energy savings *(Electrical = 3-10%; Thermal = 5-10%)* **Low** = marginal gain in energy savings *(Electrical < 3%; Thermal < 5%)*	**High –** 3 marks **Medium –** 2 marks **Low –** 1 mark
2	Environment improvement criteria (b)	**High** = multiple and significant environmental benefits, **Medium** = some environmental benefits, **Low** = little or no environmental benefit Apart from energy, Promotion of 3R, circular economy	**High –** 3 marks **Medium –** 2 marks **Low –** 1 mark
3	Replicability (c)	**High** - Widely applicable **Medium** - Applicable to many industries **Low** - Applicable to few industries or unique process	**High –** 3 marks **Medium –** 2 marks **Low –** 1 mark

S. No	Parameter	Criteria of Scoring	Scoring
4	Investment & Savings Payback (d)	**High -** Implementation cost >20 Lakhs or payback > 3 years **Medium** – Implementation cost <20 Lakhs and >5 lakhs or payback < 3 years and > 1 year **Low** – Implementation cost < 5 lakhs or payback < 1 year	**High –** 1 mark **Medium –** 2 marks **Low –** 3 marks
5	Technical Risk (e)	**High** = low likelihood of success, multiple and significant risk factors **Medium** = sufficient evidence of technology success, some risk factors **Low** = high likelihood of technology success and deployment, minimal risk factors	**High –** 1 mark **Medium –** 2 marks **Low –** 3 marks
6	Priority Score (a+b+c+d+e+f)	High, Medium, and Low	

Each of the criteria is scored (as defined in the table above) and the priority of the interventions is assigned in three categories – High Priority, Medium Priority, Low Priority

Colour	Score	Level
	11-13	**High Priority**
	10	**Medium Priority**
	8-9	**Low Priority**

High Priority score technologies should be implemented on a priority basis for reaping maximum benefits and improving overall plant performance. As a second priority, Medium Priority score technologies should be implemented followed by Low Priority score technologies which require financial assistance. The push from the government along with adequate policy support and subsidy schemes for medium to low priority score technologies can motivate the Steel Re-rolling unit for adoption and scaling up of these technologies at the national level.

Table 19: Prioritization of Intervention

S. No	Energy Conservation Opportunities	Investment (Lakhs)	Saving potential (%)	Payback (Years)	Performance improvement	Resource Saving Potential	Environment improvement	Replicability	Investment	Technical Risk	Priority Score (TRL)
1	Installation of VFD on CCM (Continuous Casting Machine) auxiliary pump	5	Electricity – 20–25% (Motor)	<1	3	1	1	3	3	3	**14**
2	Installation of Oxygen and CO sensor to optimize the excess air of furnace	3-6	Thermal - 10-15%	<1	3	1	1	3	3	3	**14**
3	Installation/ Overhauling of the recuperator to reduce the flue gas heat loss	5-10	Thermal – 10 -15%	<1	3	1	2	2	3	3	**14**
4	Installation of VFD in the compressor	0.5-2	Electricity – 7-10% (Compressor)	<1	2	1	2	3	3	3	**14**
5	Installation of automation and temperature control system in the reheating furnace	2.5	Thermal – 6%	<1	2	2	1	3	3	3	**14**
6	Installation of Energy Monitoring System (EMS) to optimize the power consumption of the Plant	2	Electricity - 5%	<1	2	1	1	3	3	3	**13**
7	Replacement of the existing compressor with energy efficient compressor	5	Electricity - 30% (Compressor)	1-2	3	1	1	2	3	3	**13**
8	Replacement of the multiple cooling water pumps with single energy efficient pump with VFD	1-3	Electricity – 5-10% (pumps)	<2	2	1	2	1	3	3	**12**

S. No	Energy Conservation Opportunities	Investment (Lakhs)	Saving potential (%)	Payback (Years)	Performance improvement	Resource Saving Potential	Environment improvement	Replicability	Investment	Technical Risk	Priority Score (TRL)
9	Overhauling of the furnace with proper insulation lining	1	Thermal – 5-7%	2-4 months	2	1	1	2	3	3	**12**
10	Installation of Scrap processing unit	75	Electricity – 5% (Induction furnace)	<1	2	2	2	2	1	3	**12**
11	Implementation of continuous casting and direct rolling	250	Thermal – 100 %	<1	3	2	1	2	1	3	**12**
12	Installation of Solar PV Panels	Depend upon capacity	-	4	2	1	2	2	2	3	**11**
13	Improvement in the efficiency of Induction Furnace by using proper grade and quality ramming mass	10	Electricity – 2% (Induction Furnace)	<1	1	1	1	3	2	3	**11**
14	Installation of the energy-efficient furnace with top and bottom firing	500 - 600	Thermal - 20% Burning loss: 20-25% Productivity: 5 - 10%	<2	3	1	1	1	1	3	**10**
15	Replacement of SCR based induction furnace with energy-efficient IGBT based induction furnace	100-150	Electricity – 8-10% (Induction furnace)	1-1.5	2	1	1	2	1	3	**10**
16	Installation of Universal Spindles and Couplings	3-15	Electrical = 2-10%	<2	2	1	1	2	2	2	**10**

S. No	Energy Conservation Opportunities	Investment (Lakhs)	Saving potential (%)	Payback (Years)	Performance improvement	Resource Saving Potential	Environment improvement	Replicability	Investment	Technical Risk	Priority Score (TRL)
17	Installation of Sintering panel to preheat the ramming mass	25	Electrical = 0.5 – 1% (Induction Furnace)	1.5-2	1	1	1	3	1	3	**10**
18	Fuel Shifting from Coal to PNG	50	Thermal – 20%	2.5-3	3	1	1	1	1	3	**10**
19	Installation of regenerative burners in the PNG fired reheating furnace	100	Thermal – 25%	2.5-3	3	1	1	1	1	3	**10**
20	Installation of energy efficient roller motor for each rolling strand	350	Electricity - 15%	10	3	1	1	1	1	3	**10**
21	Installation of Anti friction roller bearings	15-20	Electrical 5%	<2	2	1	1	2	2	2	**10**
22	Installation of Crop length optimization to enhance the yield	2	Yield - 0.5%	<1	1	2	1	1	3	2	**10**
23	Installation of Y- roller table/tilting table in 3-Hi mill stands of rolling mills	10	Electrical 10% (Higher mill utilization Increased productivity)	<2	2	1	1	1	2	2	**9**
24	Installation of membrane-based oxygen-enriched combustion	100-200	Thermal - 30%	<2	3	1	1	1	1	2	**8**

5. Recommendations and Implementation Plan

5.1 Background

Governments around the world are studying, developing, and implementing numerous policies to reduce energy use and GHG emissions. While the primary goal of these measures is to meet international commitments on climate change, most also seek to improve economic efficiency and competitiveness, energy security, and environmental performance.

The micro, small and medium enterprises (MSME) sector is one of the most significant sectors in the Indian economy. The sector contributes to 6% of GDP, accounts for 33% of exports. MSMEs are often termed as the growth engine of the Indian economy. It is no surprise that a large component of the government Rs 20 lakh crore (INR 20 trillion) stimulus package is earmarked for the MSME sector. SME development cuts across sectors involve multiple stakeholders and necessitate concerted actions by the public and private sectors. Therefore, SME development should be mainstreamed into the national development framework.

Despite several existing regulations and policy frameworks on the Steel sector in India. It was found that there are many challenges in promoting energy efficiency in the sector. Low penetration of energy-efficient (EE) technologies among SME units can be attributed to limited awareness, lack of access to improved EE technologies and services, limited availability of skilled operators to operate and maintain the latest machinery and adopt best operating practices such as the feeding of properly sized scraps to increase the bulk density, use of proper grade and quality of furnace lining (ramming mass) material), temperature monitoring of the stocks in reheating furnace and energy monitoring of different sections of the plant.

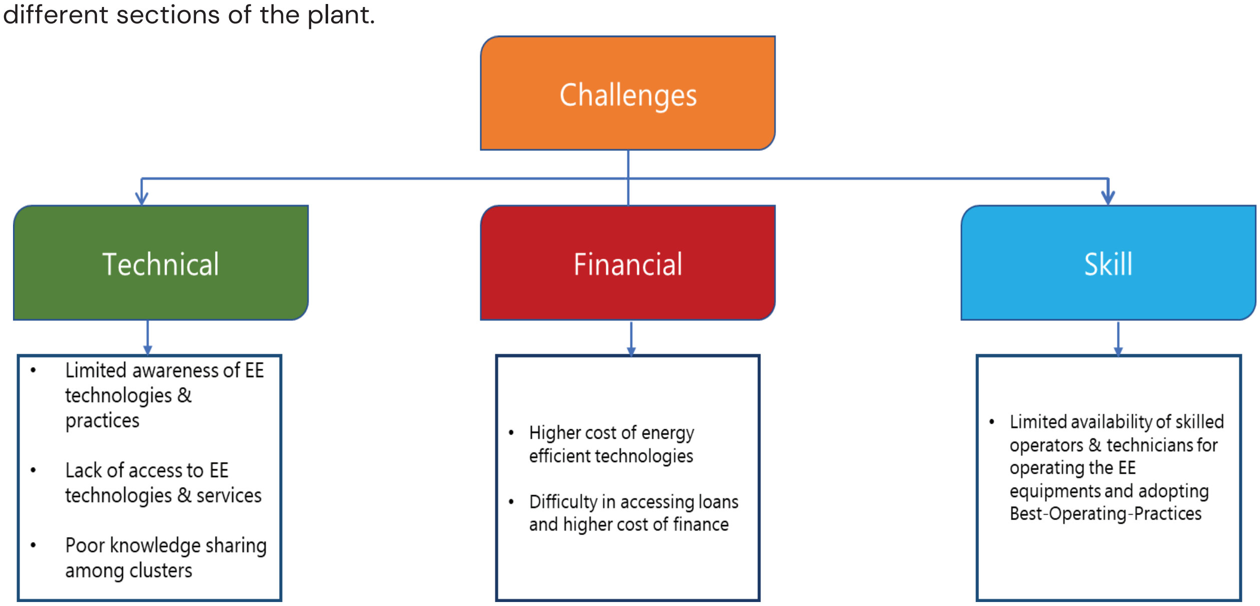


Figure 45: Policy recommendation challenges

There is a need to address these barriers through a series of policy instruments along with their implementation plan and timeline which would scale up the energy efficiency of the steel sector. These "Integrated Policy Package" are categorized into – Regulatory, Informatory, Financial, Market based, and Institutional framework-based policy instruments. The timeline for each of the measures is categorized into **(I) Short term** - within 3 years, **(II) Medium-term** – 3 to 5 years and **(III) Long term** – 5 to 7 years

Table 20: Integrated Policy Package

Requirements	Policy instrument	Timeline	Status
Regulatory	1. Promotion of uptake in Energy Management System (EnMS) standards	1. Short term	Incumbent
	2. Widening of the PAT scheme to include the Steel rerolling and steel re-rolling units	2. Medium-term	New
	3. Increase in Natural Gas/ Biofuel usage	3. Medium-term	Incumbent
	4. Promotion of Steel Scrap Recycling	4. Medium-term	Incumbent
	5. Promotion of Continuous Casting and Direct Rolling to eliminate 100% thermal energy usage from clusters	5. Short term	Incumbent
	6. Setting up of Solar Park in clusters	6. Long term	Incumbent
Institutional framework	7. Increase the participation of State Designated Agencies (SDA)	7. Short term	Incumbent
	8. Enhance the role of MSME associations in promoting energy efficiency	8. Short term	Incumbent
	9. Introduce diploma level steel Re-rolling curriculum	9. Short term	New
Financial	10. Soft Loans for EE technologies	10. Short term	Incumbent
	11. Adoption of energy-efficient technology through cluster-level ESCOs	11. Medium-term	New
Informatory	12. Formation of Cluster development centres	12. Medium-term	New
	13. Common Testing facility centres	13. Medium-term	New
Market-based	14. Emission Trading Scheme	16. Medium-term	New
	15. Introduction of Carbon pricing	17. Medium-term	New

The ideal policy package for energy efficiency integrated the five mechanisms:

- **Regulatory:** creates a strong push for EE technologies
- **Informatory:** promotes benchmarking and information sharing
- **Financial:** creates a market for EE technologies
- **Market-based instruments:** promotes energy efficiency based on the supply and demand among the units
- **Institutional framework:** creates an organizational structure for deeper penetration and handhold the SME units to uptake energy efficiency.

At present, industry, like many sectors, is facing financial challenges due to the Covid-19 economic crisis. With economic stimulus packages focusing on immediate efforts to deliver jobs, incentives will play a more significant role in economic stimulus packages. Positive drivers could aim at supporting training/capacity building and the rollout of energy management systems and rely on bulk procurement. Policymakers have the opportunity to place conditions on grants and funding, which could include implementation of EE technologies, benchmarking, and facility upgrades/ process improvements.

An integrated policy package consisting of a mix of information/technical assistance, financial incentive, and regulations is proposed to improve the energy efficiency of the SME Steel Re-rolling industry. The policies, regulations, frameworks, and other instruments collated and analyzed in this research form the basis of some preliminary recommendations for enabling a conducive policy environment and empowering SMEs to report on their sustainability impacts. After collating the results of the workshop with various stakeholders such as BEE, SDA, MSME-DI, Steel Re-rolling Associations and plant professionals, interviews and discussions with Secondary Steel sector experts and consultants and desk research carried out for this study, policy packages that foster a conducive environment for SME energy efficiency uptakes were identified.

The proposed policy package consists of a group of policies as shown in Figure below:

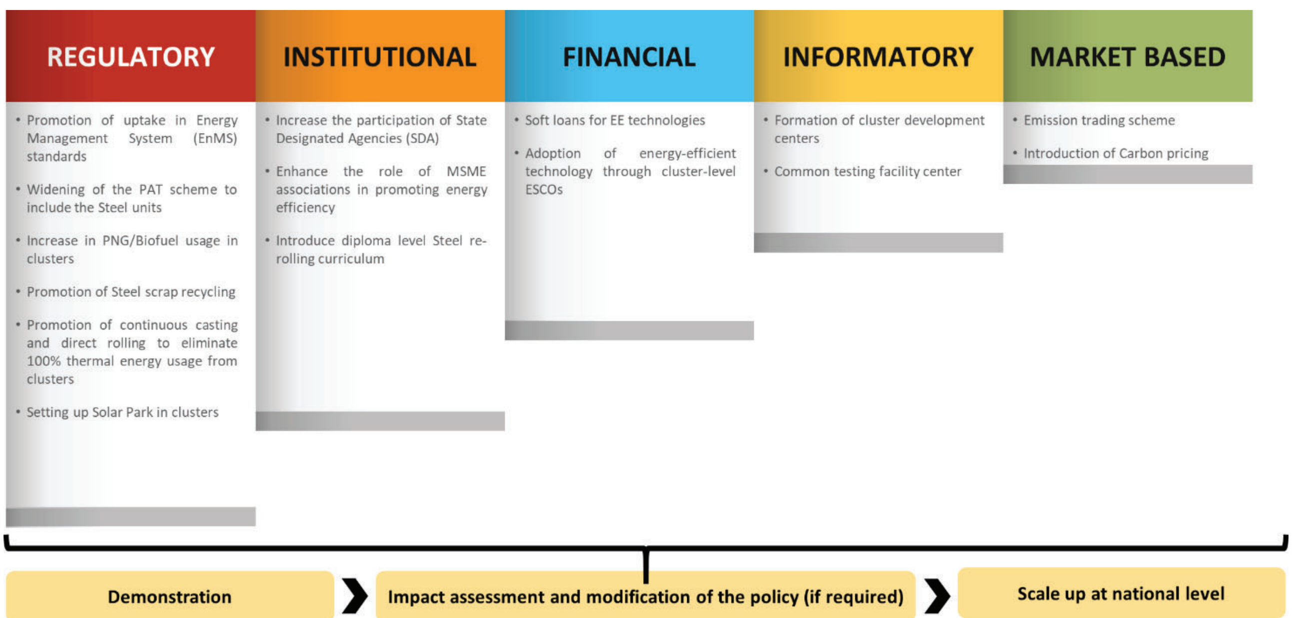


Figure 46: Integrated Policy Package for the Steel Re-rolling sector

5.2 Policy recommendations along with Implementation Road map to enhance the energy efficiency

The implementation road map to enhance energy efficiency can be segregated into cluster level and national level action plans.

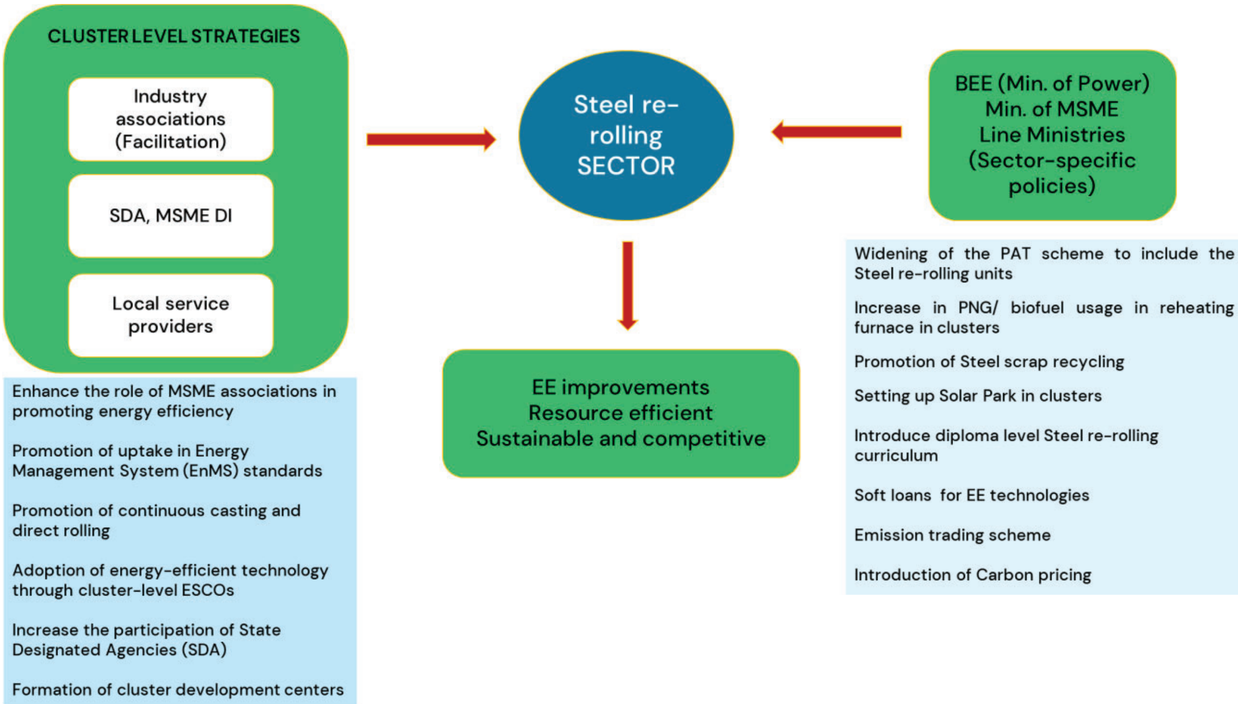


Figure 47: Policy recommendation for the sector

5.2.1 Sector Specific Policies

The policies to provide a conducive ecosystem for the uptake of energy efficiency in the Steel Re-rolling sector is tabulated below:

Table 21: Synopsis of sector-specific policy recommendation

Policy	Stakeholders Involved with responsibilities	
Promotion of Steel Scrap Recycling	BEE	To develop a policy to promote usage of scrap in Steel Re-rolling
	Cluster Association	To encourage member units to use scrap in steel production. Create community awareness programs
	Line Ministries	Steel Ministry to enforce the implementation of steel scrap recycling policy and enhance the scrap availability
Increase in Natural Gas/ Biofuel usage	BEE	To introduce policy promoting Natural Gas in the steel rerolling clusters
	State Government / SDA	To assist the central government in implementing natural gas usage at the regional level.
	Cluster Associations	To provide awareness among SMEs member units to uptake natural gas fuel
Introduce Steel curriculum in the diploma colleges	MoHRD / AICTE	To provide certification benefits to the diploma steel rerolling courses
	Engineering Colleges	To start professional diploma courses in Steel re-rolling technology
	Central / State Govt.	To regulate engineering colleges and provide financial aid programs in starting Steel re-rolling technology-specific courses.
Promotion of Direct rolling technology in the steel rerolling sector	BEE	To pilot demonstrate direct rolling in some of the units
	Cluster Associations	To encourage member units to use direct rolling technology in the production. Create community awareness programs
	Technology providers	To provide service for the implementation of the technology

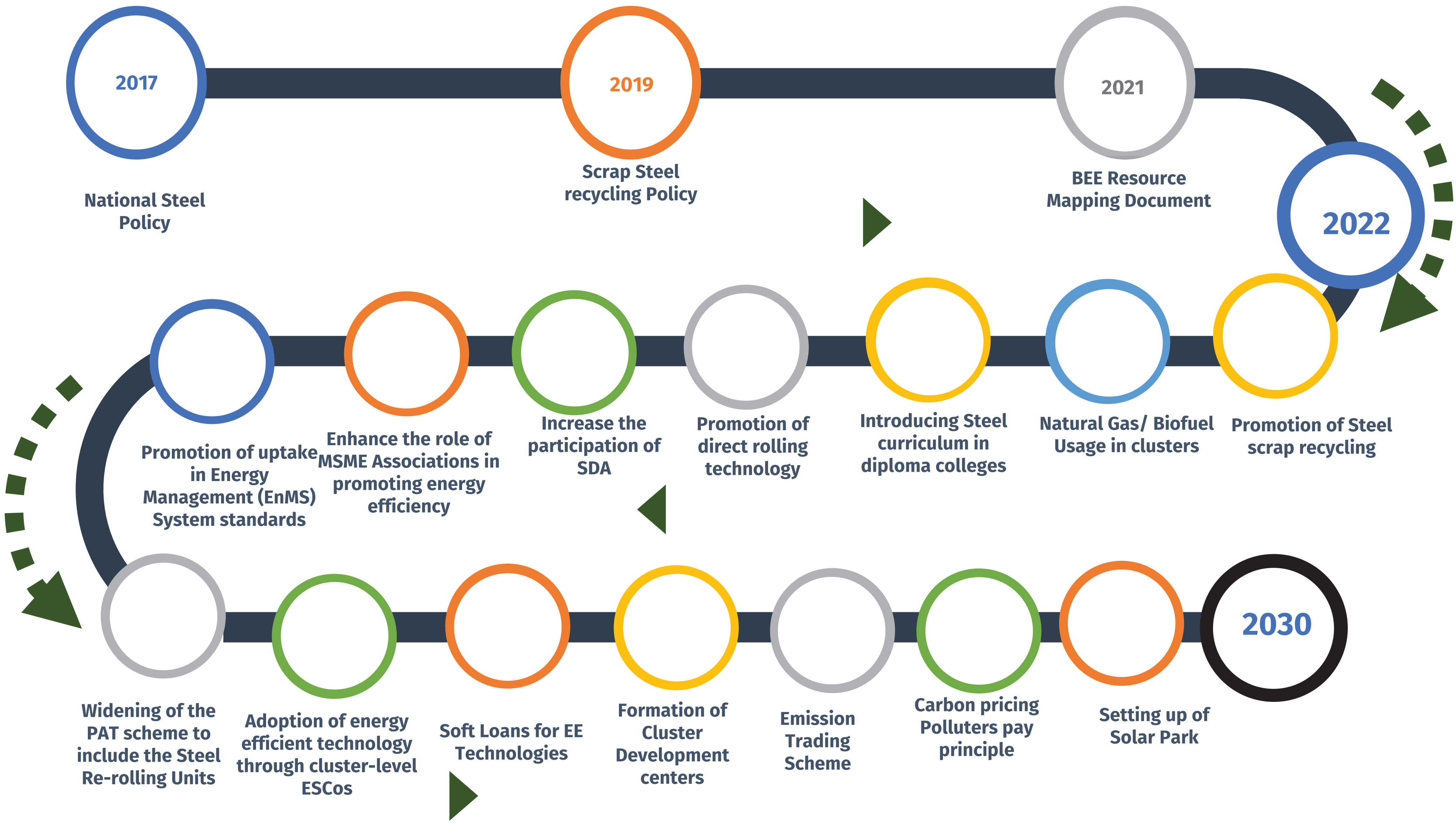
5.2.2 Sector Neutral Policies

Some of the sector-neutral policies that can be applied to other SME sectors as well are tabulated below:

Table 22: Synopsis of sector-neutral policy recommendation

Policy	Stakeholders Involved	
Increase the participation of State Designated Agencies (SDA)	BEE	To actively include SDA in all the cluster related programs for its better outcomes.
	State Level Govt. bodies	To actively participate in all the cluster programs of BEE.
Enhance the role of MSME associations in promoting energy efficiency	BEE	To develop an organizational framework to monitor the activities
	State Level Govt. bodies	To actively engage the associations
Promotion of uptake in Energy Management System (EnMS) standards	BEE	Develop a program for implementation of the EnMS system
	State Level Govt. bodies	Actively promote the uptake of the EnMS system
	Technical consultants	Provide services for the implementation of EnMS
	Technology Providers	Create awareness on their EE offerings
Widening of the PAT scheme to include the Steel rerolling units	BEE	Inclusion of steel rerolling units under the PAT scheme
	State Level Govt. bodies	To create awareness of the PAT scheme
	Technical consultants	Services for implementation of the PAT scheme
	Technology Providers	Create awareness on their EE offerings
Adoption of energy-efficient technology through cluster-level ESCOs	Manufacturers	Supply of Energy Efficient equipment
	Financial Institutions	Collateral free loan/soft loan to the ECSOs
	Cluster associations	Provide awareness among SMEs member units
	Technical consultants	Recommend EE technology and provide M&V support
	ESCOs	Provide EE technologies at no upfront cost to the SMEs
Soft loans for EE technologies	BEE	To develop schemes for accessing soft loans for EE technologies by SMEs
	Cluster Associations	Provide awareness among SMEs member units
	Financial Institutions	Provide the collateral-free loan to the SMEs
Formation of cluster development centres	BEE	To develop cluster development centres
	SDA	Awareness of the cluster development program
	Cluster Associations	Identify the key facilities required by the cluster
	Technical Consultants	Implementation of common facility centre
	Technology providers	Create awareness on their EE offerings
Emission Trading Scheme	BEE	To launch a national cap-and-trade program
	State Government / SDA	Enforce & implement emission trading schemes
	Cluster Associations	To provide awareness among SMEs member units
Carbon pricing (Polluters pay principle)	BEE	To introduce a carbon pricing policy
	State Government / SDA	To assist the central government in implementing carbon pricing policy at the regional level.
	Cluster Associations	Provide awareness among SMEs member units
Setting up Solar Park in clusters	BEE	To develop a scheme to set up solar parks in steel rerolling clusters
	Manufacturer	Participate in cluster level programs to create awareness on their products offering
	Cluster Associations	To encourage member units for solar adoption and assist in developing pilot projects

5.3 Implementation Roadmap for the Sustainability of the Steel Re-rolling Sector



5.3.1 Promotion of steel scrap recycling

The use of steel scrap in India is quite low (~23%) due to the lack of an effective collection mechanism. Out of the total scrap usage, India imported almost 7 million tonnes of scrap in 2019 – 2020. The scrap route of steel production can reduce the emission intensity and energy intensity by 63% and 68% respectively.

To alleviate this significant challenge, BEE could frame a policy to enhance the scrap usage in the melting units. In India, the industry can also find opportunities for job creation as cooperatives for recycling and waste collectors play an increasingly important and legitimate role in the recycling industry. The current steel production is expected to rise to 250 MT by 2030, and the requirement of scrap is around 70-80 MT. This will require about 700 scrap processing centres fed by 2800-3000 collections and dismantling centres.

Additionally, there is the requirement of providing deregistration authorization of scrapped vehicles to the units will enhance the availability of scrap in the cluster. The Bureau of Energy Efficiency should develop a program to support SME units in promoting recycling in Steel Re-rolling plants.

The graph below highlights the usage of scrap in steel production in major economies.

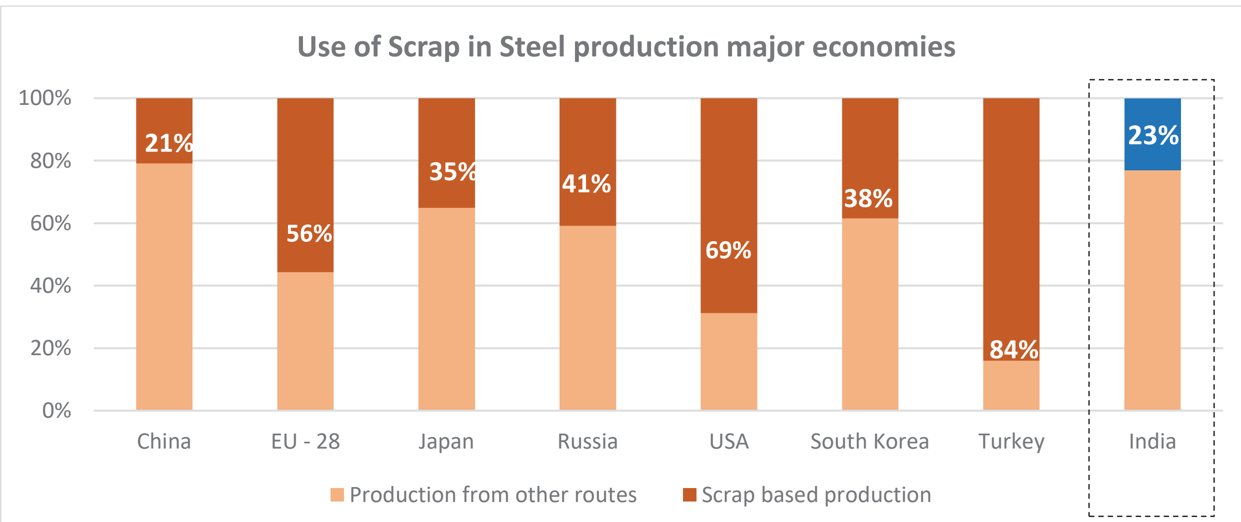


Figure 48: Use of scrap in Steel production in major economies

Key Benefits:

- Reduce the volume of waste in an environmentally friendly manner.
- Promotion to the concept of circular economy

Action points

The Bureau of Energy Efficiency should develop a program to support SME units in promoting recycling in Steel Re-rolling plants.

Roles and responsibilities of the Stakeholders

Stakeholders	BEE	Cluster associations
Responsibilities	To develop a scheme to promote Steel scrap recycling	To encourage member units to adopt recycling practices. Create community awareness programs

5.3.2 Increase in Natural Gas/ biofuel usage in clusters

The emission intensity of coal is about 55% higher than that of natural gas. Shifting to affordable natural gas-based cleaner fuels will not only reduce emissions but will also enhance productivity and improve the working environment.

The Steel Re-rolling sector is one of the few sectors that can become carbon neutral by adopting biofuel firing in the reheating furnaces (RHF) and solar energy to drive the motive loads. The feasibility of biomass firing in the RHF is in the R&D stage.

Key Benefits:

- Encourages innovation and promotes decarbonizing the Steel Re-rolling industry
- Adoption of biofuels/Natural gas will reduce the burden on the environment due to a reduction in GHG emissions
- It will help in achieving India's emission reduction target
- Potential to make Steel Re-rolling sector carbon-neutral

Action points

The Bureau of Energy Efficiency should develop a scheme to promote increased usage of natural gas in the Steel re-rolling cluster. Demand can be further increased by subsidizing Natural gas (where cost difference is high with coal) and penalizing fossil fuel usage, thereby making biofuel more attractive as a fuel

Roles and responsibilities of the Stakeholders

Stakeholders	BEE	Cluster associations	Manufacturer
Responsibilities	To develop a scheme to promote increased use of Natural Gas in cluster	To encourage member units to adopt Natural Gas/ biofuel and develop pilot project/ knowledge sharing at cluster level	Participate in various cluster level programs to create the awareness on their Natural Gas/ biofuel usage products offering.

5.3.3 Introduction of Steel Re-rolling curriculum in diploma colleges

At present no colleges/ universities run engineering courses on Steel re-rolling Technology. The Steel industry is in a transition from conventional technology to the use of new and advanced technologies for Steel production. It is necessary to equip the students with the essential knowledge and skills to take up the Steel Re-rolling sector challenges and provide solutions to the problems towards achieving sustainable Steel Re-rolling production

Key Benefits:

- Create employment opportunities
- Enhance the technical aptitude and operational skills of the workforce.

Action points

- Launch courses on Steel re-rolling Technology
- To initiate Steel re-rolling curriculum in diploma colleges

Roles and responsibilities of the Stakeholders

Stakeholder	MoHRD/ AICTE	Engineering Colleges	Central/ State Government
Responsibilities	To provide certification benefits to the diploma steel rerolling courses	To start professional diploma courses in Steel re-rolling technology	To regulate engineering colleges and provide financial aid program in starting Steel re-rolling technology specific courses.

5.3.4 Promotion of direct rolling technology in the Steel Re-rolling sector

The Indian steel Re-rolling sector is experiencing a transformation. Direct rolling technology is the promising technology to completely wipe out the thermal requirement from the sector. Composite mills consume the bulk of their energy in three stages.

1. The first is the Induction furnace, where raw metal is melted, and the molten steel routed through a Continuous Caster to form semifinished steel. These billets are then cooled to ambient temperature in the billet yard.
2. The second area of energy consumption is reheating furnace, where cooled billets are reheated to prepare them for rolling.
3. In the third stage, energy is consumed in a Rolling mill, where the hot billets are rolled to give them the final shape

Direct Rolling technology disrupts this traditional layout and creates a system to transfer billets directly from the coast to the rolling mill. It bypasses the reheating furnace, making it redundant.

For a successful application of this technology, the Bureau of Energy Efficiency should create a regulation that enforces the use of direct rolling in composite mills.

Key Benefits:

- Increased production and reduced specific energy consumption
- Reduced scale generation and support for direct rolling
- Improvement in quality of final product
- 100% elimination of thermal energy usage from the sector
- Reducing the emission intensity by 33% of the sector

Action points

- The Bureau of Energy Efficiency should undertake a pilot demonstration of direct rolling to eliminate the entire thermal energy consumption from the steel rerolling sector.

Roles and responsibilities of the Stakeholders

Stakeholders	BEE	Cluster Association	Technology Providers
Responsibilities	To pilot demonstrate direct rolling in some of the units	To encourage member units to shift towards direct rolling technology and reduce/ remove the usage of reheating furnace. Create community awareness	To provide service for the implementation of the technology

5.3.5 Increase the participation of State Designated Agencies (SDA)

At present almost all the SME programs are directly driven through BEE at the centre, with little involvement of State Designation Agencies (SDA's). More than 400 SME clusters are manufacturing energy-intensive products in India. Some of the clusters are located in very remote areas. Given the diversity and geographic spread of MSMEs, it is cumbersome for BEE to manage all programs simultaneously. For effective implementation of these programs' active participation from SDAs is imperative.

Key Benefits:

- Easy to manage cluster programs.
- Due to the local presence of SDAs, the cluster programs will leverage more trust from the association and units and will be more impactful.
- Increased participation of stakeholders

Action points

An operating model to be developed while formulating the cluster programs to larger participation from SDAs.

Roles and responsibilities of the stakeholders

Stakeholders	BEE	State Designated Agencies
Responsibilities	To actively include SDA in all the cluster related programs for its better outcomes.	To actively participate in all the cluster programs of BEE.

5.3.6 Enhance the role of MSME associations in promoting energy efficiency

Under the present schemes/programs, MSME associations do not come under direct contact with SDA's or BEE, but through the hired consultants. As per our experience, MSME associations tend to enjoy the greater trust of the member enterprises, on basis of which it is easier to change behavioural patterns and perceptions to drive energy efficiency measures. MSME Associations can locally drive certain activities which can reap immediate benefits.

Key Benefits:

- The role of MSME associations can be leveraged to scale up energy-efficient technologies (aggregation model).
- Quick communication and easy reach out to MSME units.
- Accelerate the promotion of Energy Efficiency.

Action points

An institutional framework to be developed so that key MSME associations become members under the certain scheme and are in direct contact on regular basis with SDAs.

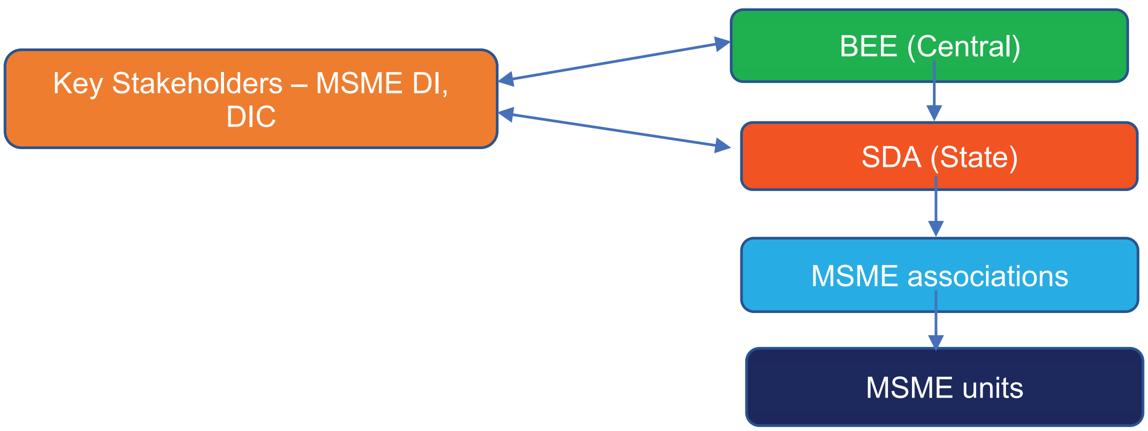


Figure 49: Institutional framework for key stakeholders

Roles and responsibilities of the Stakeholders

	State Level Govt. bodies	BEE
Stakeholders	State Level Govt. bodies	BEE
Responsibilities	To actively engaged the associations on any schemes/programs to have more confidence of the units.	To develop an organizational framework to monitor the activities of the state level Govt bodies and assess the involvement of MSME associations

5.3.7 Promotion of uptake in Energy Management System (EnMS) standards

The ISO Energy Management Systems aims to help organizations continually reduce their energy use, and therefore their energy costs and their greenhouse gas emissions. It will help the units in integrating energy performance into daily management practices and business systems, leading to a lasting change in organizational culture. During our field visit, we have seen that the SME units do not monitor the KPI of the process and lack consistent data on energy and operations. Implementation of EnMS will require the units to assess baseline energy use, actively monitor, control, and manage energy use and costs, reduce emissions and continue to improve energy use/product output over time.

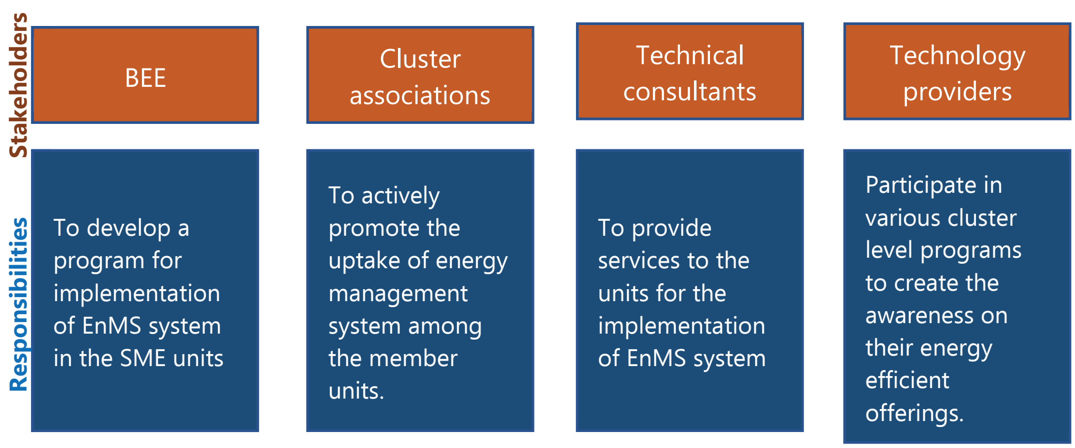
Key Benefits:

- Develop a policy for more efficient use of Energy.
- Fixed Targets and Objectives in line with the policy.
- Use data to make informed decisions about energy use.
- Measure the results to identify areas of energy efficiency improvements.
- Energy monitoring will help in benchmarking different processes.
- Ease out the monitoring and verification process for the EE projects.
- Review the policy's effectiveness and results of improvements.
- Continually improve Energy Management practices

Action points

The Bureau of Energy Efficiency should develop a program to support SME units in implementing EnMS in the pilot SME units.

Roles and responsibilities of the Stakeholders



5.3.8 Widening of the PAT scheme to include the Steel units

The PAT scheme has been highly successful in promoting energy efficiency among the larger industries. The scheme may be expanded to cover the medium-sized Steel Rerolling plants, say above the 5,000 toe threshold. To make it attractive for medium-sized units, the scheme for them could initially be voluntary and implemented in cooperation with the cluster level industry associations.

The initial phases of the scheme can target modest energy savings (say around 2%). Future phases can target a slightly higher rate of efficiency improvement (say 4-5%). The scheme can be strengthened by linking it with concessional loans for the EE technologies program. Investments made by SMEs on energy-efficient equipment under the PAT scheme will qualify for the loan on priority

Key Benefits:

- SMEs are nudged to move beyond "Business As Usual".
- Encourages innovation and compliance.
- Adoption of EE technologies and BOPs to reduce energy consumption.

Action points

The Bureau of Energy Efficiency should develop a voluntary program to include the Steel rerolling units under the PAT scheme.

Roles and responsibilities of the Stakeholders

Stakeholders	BEE	State Designated Agencies	Cluster associations	Technical consultants	Technology providers
Responsibilities	To develop a program for inclusion of Re-rolling units under the PAT scheme.	To create awareness on the PAT scheme through consultations, workshops	To identify the key member units (above the threshold energy consumption) and encourage them to participate under the PAT scheme	To provide services for the implementation of the PAT scheme and recommendation / implementation/ monitoring of the savings through energy efficient technologies	Participate in various cluster level programs to create the awareness on their energy efficient offerings.

5.3.9 Adoption of energy-efficient technology through cluster-level ESCOs

Our detailed energy assessment of the units has identified various energy-efficient (EE) technologies to reduce energy consumption. Low penetration of EE technologies in SMEs can be directly attributed to lack of technical support at the local level on one hand and absence of institutional mechanisms and financing models on the other. Large financial institutions and original equipment manufacturers (OEMs) find it difficult to provide loans as well as technical assistance for EE equipment to SMEs due to higher transaction costs and risk-return profiles.

The EE technologies with higher replication potential like – EE IE3 motors, pumps and compressors can be routed through Custer-level ESCOs. The proposed instrument will aim at removing these barriers by creating 'mini-ESCOs' of local service contractors who already work with SMEs at the cluster level. Local service providers are particularly sensitive to maintaining good customer relations and hence complex performance contracts are not necessarily needed to cover contingencies if actual energy savings is less than the guaranteed level.

Key Benefits:

1. Replicates the commercially proven technologies
2. Reduce the financial burden of the units in implementing the EE technologies
3. Reduces the cost of EE equipment through bulk procurement
4. Promotes high energy savings

Action points

To propagate the concept and identify the cluster level ESCO

Roles and responsibilities of the Stakeholders

Stakeholde	Manufacturers	Technical Consultants	Financial Institutions	Cluster Associations	ESCOs
Responsibilities	Supply of Energy Efficient equipment	To recommend the energy efficient technology and provide monitoring and verification (M&V) support	To provide the collateral free loan/soft loan to the ECSOs	To provide awareness among SMEs member units To provide the repayment assurance to the ESCOs	To implement the energy efficient technologies at no upfront cost from the SMEs.

5.3.10 Soft loans for EE technologies

The higher cost of energy-efficient technologies is a major reason for many MSMEs' inability to adopt them. The entrepreneur may be aware of energy-efficient equipment but would still use energy guzzler equipment because that is what they could afford. Difficulty in accessing loans and also higher cost of finance - which can make repayments difficult, acts as a big impediment in implementing EE technologies.

Financial Assistance to MSMEs through Special Credit lines (Loans with lower interest rates) should be given. It can be established by a public entity (government or donor organization) and enable financing of EE projects by the MSME units. The scheme will provide funds to local financial institutions at a low-interest rate, the public entity can encourage the institution to lend at a lower interest rate to units interested in developing EE projects. A similar scheme has already been installed by China and Thailand.

Bilateral agencies like JICA, KfW, AFD, and ADB have been supporting concessional financing of energy-efficient equipment among Indian MSMEs. Other agencies like GIZ have supported awareness generation and capacity building of bankers on the financing of energy efficiency projects. Multilateral agencies like GEF, through World Bank, and UNIDO are funding projects which support energy audits in selected energy-intensive sub-sectors.

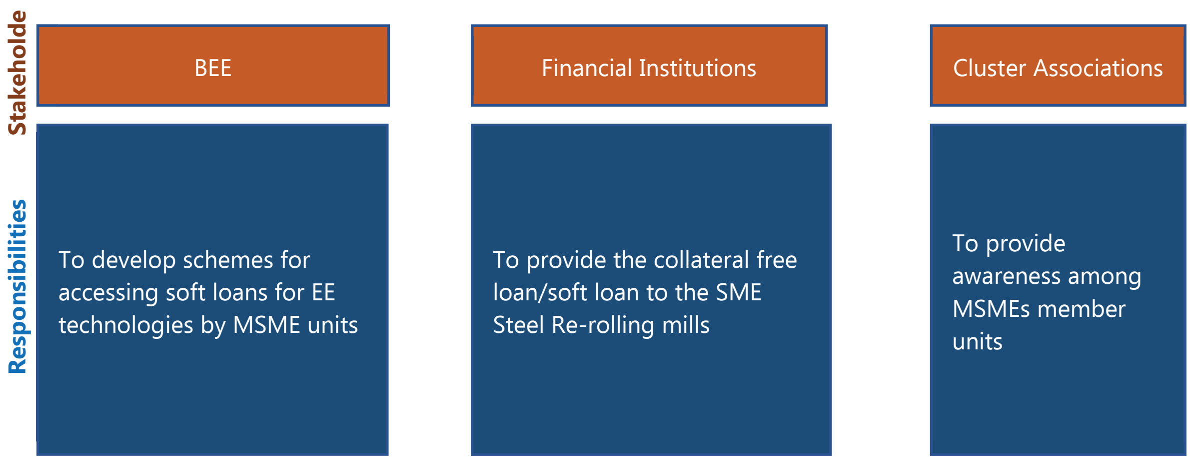
Key Benefits:

1. This will promote Energy Efficiency Investments in MSMEs.
2. The lending schemes can reduce energy consumption, enhance energy efficiency, reduce CO_2 emissions, and improve the profitability of the Indian MSMEs

Action points

Adequate focus on EE/ cleantech/ renewable energy financing by the banks

Roles and responsibilities of the Stakeholders



5.3.11 Formation of cluster development centres

BEE can adopt the cluster development approach as a key strategy for enhancing the productivity and competitiveness as well as capacity building of Micro, Small, and Medium Enterprises (MSMEs). This will lead to the creation of infrastructural facilities like skill development centres, testing facilities, energy management centres (EMC) which cannot be undertaken by individual units.

Key Benefits:

- To support the sustainability and growth of MSMEs by addressing common issues such as improvement of technology, skills & quality, testing facilities, market access, etc.
- To create/upgrade infrastructural facilities in the new/existing Industrial Areas/Clusters of MSMEs.
- Promotion of green & sustainable manufacturing technology for the clusters to enable units to switch to sustainable and green production processes and products.

Action points

Bureau of Energy Efficiency should develop cluster development centres which would entail the facilities like skill development, testing facilities for Steel Re-rolling units.

Roles and responsibilities of the Stakeholders

Stakeholder	BEE	State Designated	Cluster associations	Technical consultants	Technology providers
Responsibilities	To develop cluster development centers which would involve skill development, testing facilities etc.	To create awareness on the cluster development program through consultations workshops	To identify the key infrastructural facilities required by the cluster	To provide services for the implementation of common facility center	Participate in various cluster level programs to create the awareness on their energy efficient offerings.

5.3.12 Emission Trading Scheme

The first emissions trading scheme internationally was in 1995 which was successful in terms of addressing acid rain in California and reducing air pollution significantly. Compliance costs were less than half of those predicted by the US Environmental Protection Agency (USEPA), and many times lower than those predicted by industry. The other examples are European Union Emission Trading Scheme (ETS), China ETS, and Korea ETS. It is estimated that there are at least 45 schemes across the world that put a price on carbon. The current carbon market is valued at USD 277 Bn. The design of trading programs is critical to its success, as it will end up determining the transaction costs as well as the uncertainty and risk inherent in the trading system.

There should be a cap set for maximum emissions by industry, and surplus entities (achievers) can trade with non-achievers. This will push industries for cleaner and more energy-efficient technologies and the adoption of renewable energy. It can be initially started as a voluntary program and could be mandated with higher caps and trading. The Gujarat government has piloted the cap-and-trade program in 158 industries and have achieved around a 29% reduction in emission for the units that participated in the pilot project.

Key Benefits:

1. This scheme is efficient in reducing GHG emissions
2. Departure from the traditional command and control approach to environmental regulation.

Action points

The Bureau of Energy Efficiency should develop an Emission Trading Scheme to push the units to reduce carbon emissions by adopting EE/RE technologies.

Roles and responsibilities of the Stakeholders

Stakeholders	BEE	State government/ SDA	Cluster Associations
Responsibilities	To launch a national cap-and-trade program (emission trading schemes)	To enforce environment regulations and implement emission trading schemes at regional level. Allocation of permits and certificates.	To provide awareness among MSMEs member units to implement the scheme

5.3.13 Carbon pricing (Polluters pay principle)

The emissions produced by industries are a negative externality for the environment and the economy since their true social cost is not reflected by the market price of carbon-intensive goods and services. Thus, instituting a price that reflects the true cost of these emissions seems like an intuitive solution to address these climate change issues. This will drive the industry to push for alternative energy sources, cleaner fuel & renewables. Carbon pricing policy makes industries pay an external cost for carbon emissions and will help in raising revenues that can be spent on EE initiatives.

India does not have an explicit carbon price and BEE can introduce this mechanism. However, It will be important to address issues such as additional tax might suffocate industries in an already competitive market, administrative costs in measuring pollution, and collecting tax should be considered during designing carbon pricing mechanism.

Example: Sweden's economy grew by 60 percent since the introduction of the Swedish carbon tax in 1991, while its carbon emissions decreased by 25 percent

Key Benefits:

1. Carbon pricing can promote cost-effective abatement, deliver powerful innovation incentives
2. Avoid fiscal problems by adding to the government revenues which can be spent on EE initiatives

Action points

BEE can introduce a carbon pricing policy in the medium to long term. In the short term, India should focus on phasing out fossil-fuel subsidies and improving the efficiency of existing policies that place an implicit price on carbon.

Roles and responsibilities of the Stakeholders

Stakeholders	BEE	State government/ SDA	Cluster Associations
Responsibilities	To introduce carbon pricing policy	To assist central government in implementing carbon pricing policy at regional level.	To provide awareness among SMEs member units

5.3.14 Setting up Solar Park in clusters

The solar park gives clean, cheap, and reliable sources of energy, and can play a major role in reducing carbon footprint, promoting high-end technical investments, and empowering local communities. BEE may come up with a new scheme for setting up a solar park for the MSME sector. Such schemes will encourage significant solar adoption, which will reduce the cost of production and increase profitability.

MoMSME, Government of India schemes such as Micro and Small Enterprises Cluster Development Programme (MSE-CDP), as well as newly introduced 'Atmanirbhar Bharat Abhiyan', may facilitate credit-linked capital subsidy facilities for inclusion of setting up solar PV park in the MSME cluster. The demand for solar power is estimated to be 7 GW for the steel rerolling sector.

Key Benefits:

- Reduction of MSME Steel Re-rolling plant carbon footprint
- Meeting Renewable Purchase Obligation (RPO) mandates

Action points

The Bureau of Energy Efficiency should develop a program for setting up solar parks.

Roles and responsibilities of the Stakeholders

Stakeholders	BEE	Cluster associations	Manufacturer
Responsibilities	To develop a scheme to set up solar parks in Steel Re-rolling clusters	To encourage member units for solar adoption and assist in developing pilot project for scaling up solar parks in cluster	Participate in various cluster level programs to create the awareness on their products offering.

5.4 Sector Way Forward

Due to continuous efforts of the Bureau of Energy Efficiency (BEE), SDAs, Steel Re-rolling associations, and other stakeholders, SRRM in India have started to shift from a traditional strictly cost and quality approach to energy efficiency, zero waste, and reduced carbon emissions. Further, for bringing more competitiveness and making this sector more energy-efficient, it is essential to understand the consumption of energy and its flow within the facility along with the classification of energy usage and its relationship to processes and production outputs in the present scenario. Thus, it is envisaged that the energy scenario of MSMEs will cover energy usage patterns, detailed analysis of current and future (estimated) energy, production, and energy intensity in different units (Melting/ Re-rolling/ Direct Rolling units). The following scenarios are considered: Business as Usual (BAU) Scenario, Moderate Scenario and Energy Efficient Scenario.

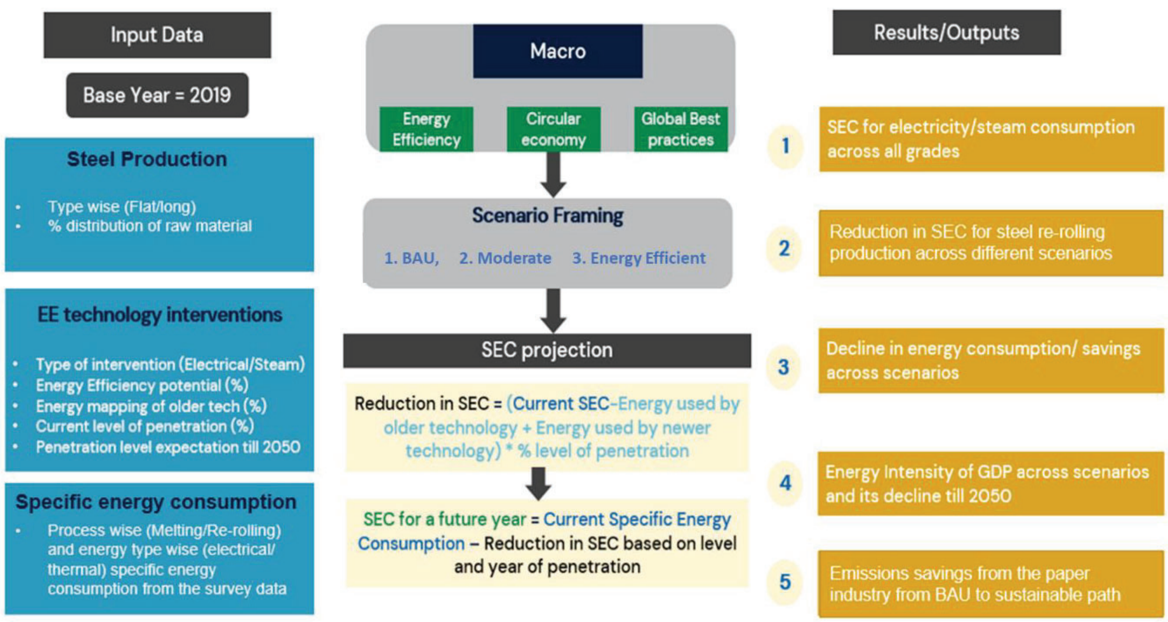


Figure 50: Scenario Analysis Methodology

The assumed penetration level of the energy-efficient technologies for different years for the scenarios considered: Business as Usual (BAU) Scenario, Moderate Scenario and Energy Efficient Scenario is provided in Annexure E7.

5.5 Energy Efficiency Potential Scenarios

The production data of the steel rerolling sector is taken from various sources like – Ministry of steel reports, JPC reports and vetted with stakeholders consultations. Based on the historical production data and projection of futuristic steel production from the National Steel Policy (NSP) report, CAGR (Compounded Annual Growth Rate) is calculated and the production from the steel rerolling sector is projected up to 2030. The specific energy consumption (SEC) (i.e. energy consumed to produce per tonne of product) for the steel rerolling sector is calculated from various energy audits conducted in the Energy and Resource mapping project. The SEC data has been validated by the industrial experts and various consultations conducted.

Table 23: Steel Re-rolling Production and SEC

Parameter	Production (FY 20-21)	SEC (Toe/Tonne)
Steel Rerolling products	33 Million Tonne	0.0629

Based on the assumption of penetration level of different technologies suggested for the reduction of energy consumption, three scenarios are computed.

a) **Business-As-Usual Scenario** – Present estimated specific energy consumption is projected till 2030 and the production level is projected from the National Steel Policy, to get the energy consumption.
b) **Moderate Scenario** - Some attention is paid to adopting the Energy Efficient technologies in Mills
c) **Energy-efficient scenario** - Policies are supportive and has resulted in the higher penetration of energy-efficient technologies.

Projections of energy-saving potential

Based on the assumed penetration level of the energy-efficient technologies and projection of quantum of production, the energy consumption and CO_2 emissions for different years are tabulated below:

Table 24: Projection of Energy Saving Potential[10]

Parameters	2020	2023	2025	2027	2030
Production form Steel rerolling sector (Million Tonne)	33	42.8	50.8	60.4	78.2
Scenarios – Energy consumption (Million TOE)					
Business-As-Usual (BAU)	2.08	2.69	3.20	3.80	4.92
Moderate	2.08	2.60	2.98	3.41	4.25
Energy efficient	2.08	2.45	2.62	2.77	3.09
Scenarios – Emissions (Million TCO_2)					
Business-As-Usual (BAU)	11.55	13.35	15.87	18.86	24.43
Moderate	11.55	12.92	14.80	16.92	21.07
Energy efficient	11.55	12.16	12.98	13.71	15.23

[10] As per data collected from the survey of different cluster and ICF estimation.

The energy consumption in the moderate scenario and energy-efficient scenarios is estimated to be 14% less and 37% less compared to the BAU scenario in 2030.

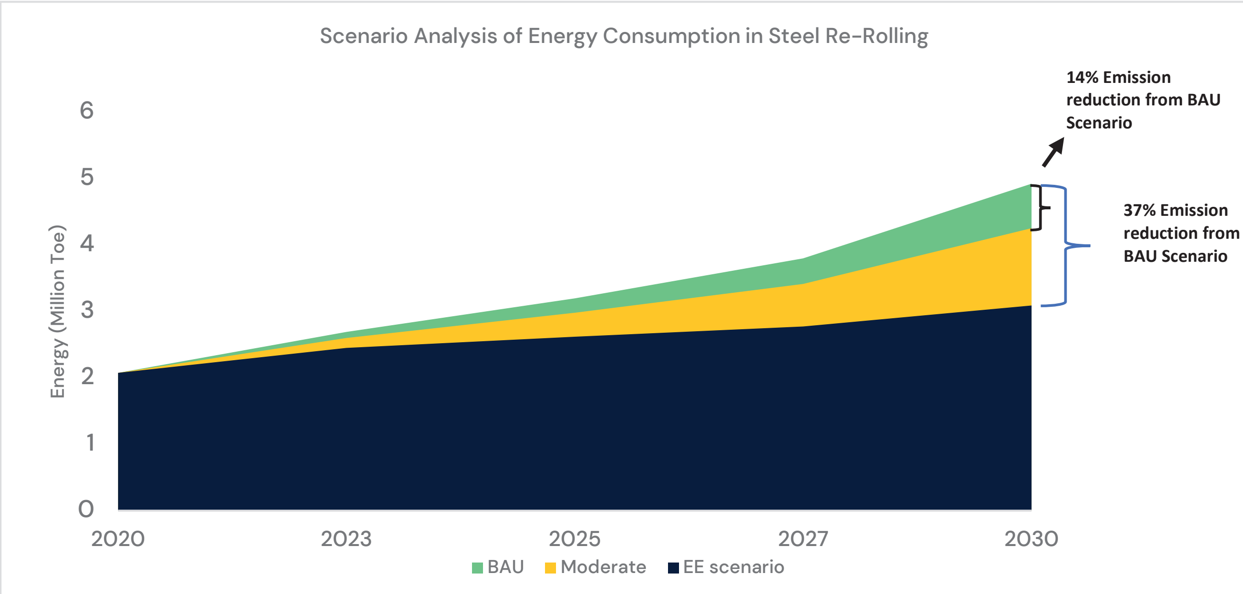


Figure 51: Energy consumption Scenario

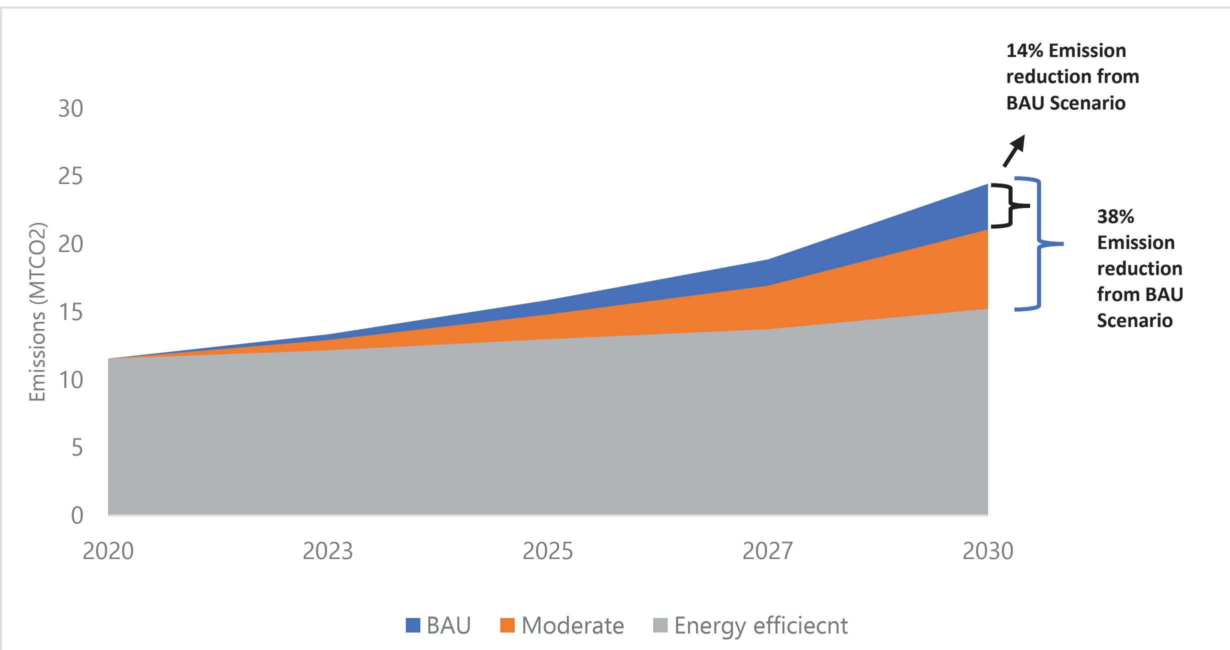


Figure 52: Scenario Analysis of emission

The implementation of EE technologies will lead to energy savings of 0.09 MTOE in 2023 and 0.67 MTOE in 2030 in the moderate scenario, and energy savings in the energy-efficient scenario is estimated to be 0.24 MTOE savings in 2023 and 1.83 MTOE in 2030.

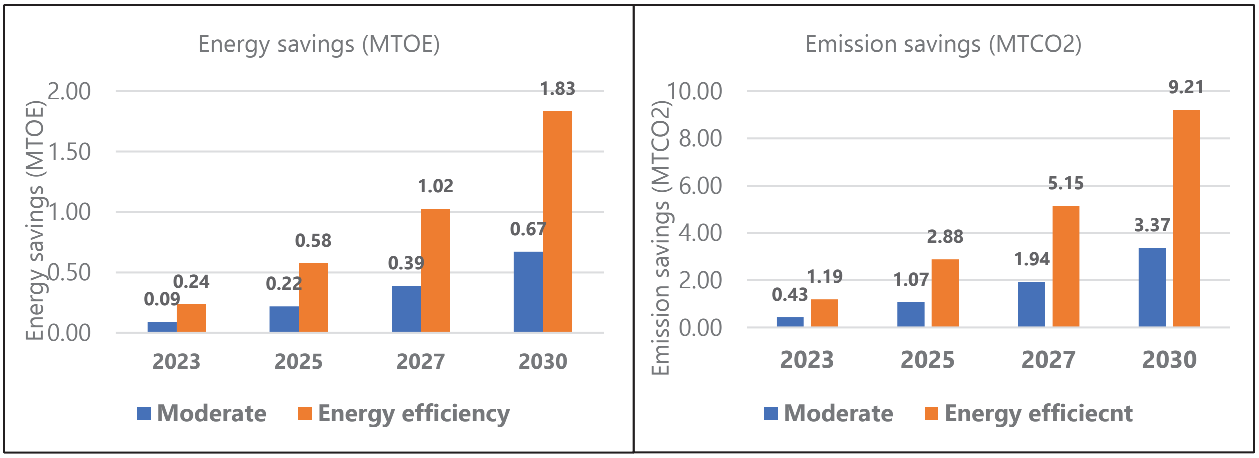


Figure 53: Energy savings and emission savings scenario

The implementation of EE technologies will lead to emission savings of 0.43 $MTCO_2$ in 2023 and 3.37 MTCO2 in 2030 in the moderate scenario, and emission savings in the energy-efficient scenario is estimated to be 1.19 MTCO2 in 2023 and 9.21 MTCO2 in 2030.

Annexure A: Production Process and Technology Adopted

A1: Production Process

The Steel rerolling sector have both - composite and non-composite units. Composite mills have the facility of both melting and re-rolling and the non-composite mills have either melting or re-rolling facility.

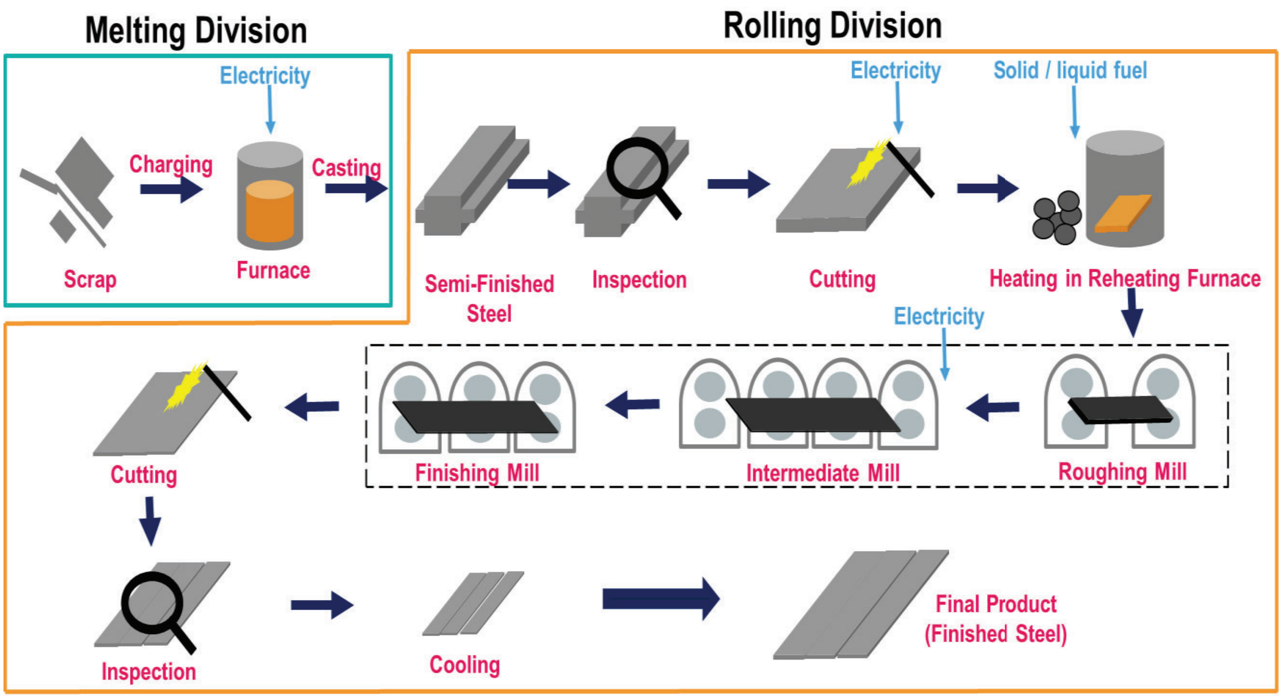


Figure 54: Production Processes

The major process steps involved in the melting units are:

(i) Charge preparation

The charge materials like - steel scrap, pig iron, in-house returns and end cuts are processed before charging to the induction furnace. The activities involved in charge preparation varies from unit to unit like –

1. Segregation of scrap based on types and quality.
2. Using shredding machine to cut the larger scraps into smaller pieces and also to remove rust and dust from the scrap
3. The bailer is used to compress scrap pieces for higher bulk density.
4. Use bucket feeding or Vibro-feeder for feeding compressed scrap into the furnace.

(ii) Charging

The processed raw material such as steel scrap, pig iron, in-house returns and end cuts are weighted and charged in the induction furnace for melting

(iii) Melting

The metal charge is melted in an induction furnace. The operator test chemistry of melt by drawing a sample and checking the molten metal temperature. The operator adjusts chemistry by alloying and bringing the temperature to the required level.

(iv) Slag removal

During the melting process, the oxides and the impurities with the charged raw material are removed in the form of slag. The slag flows over the molten metal because of the lighter density. The operator removes the slag with the help of skimmers.

(v) Tapping

After melting, the molten metal is transferred and poured into the moulds using ladles operated either manually, by monorail or using overhead cranes.

(vi) Products

The molten metal is cooled in the continuous casting machine to form the product – billet/ingot/blooms.

The major process steps involved in the re-rolling units are:

(i) Raw material preparation and shearing

The raw material like – billet/blooms/ingots are segregated as per final product profiles. The main criteria for segregation include the thickness and length of the final products. The most common type of cutting process is shearing using shearing machines and gas cutters. The waste or unused sheet after cutting is sold to the steel melting units.

(ii) Charging and reheating

Reheating of steel is the first step in hot rolling that helps in achieving sound mechanical and chemical properties of products. In reheating process, the material is stacked to the hearth at the charging end of the reheating furnace and the temperature is set close to 1250°C. The temperature requirement is dependent on sheet thickness and final finishing required. The sheets/billets are heated in the reheating furnace to prepare them for subsequent rolling. The retention time of the material inside the furnace and the corresponding temperature profile of heating and soaking zones are key parameters in rolling mills to provide smooth rolling without any defects.

(iii) Rolling and finishing

In rolling, the shape of metal is changed due to plastic deformation by passing between rolls, that is, reduction of cross-sectional area or general shape of the metal. Two-high and three-high mills are generally used for initial and intermediate passes during hot rolling, while four-high and cluster mills are used for final passes. After the final section, the product goes to the cooling section and thereafter end cutting.

A2: Technologies employed

Different equipment/machinery is required to manufacture different types of rolling mill products. The major technologies and equipment used in process areas and utility sections is tabulated below.

Table 25: Technologies employed in the sector

Section	Major Equipment
Melting	1. Induction Furnace
Reheating Furnace	2. Reheating Furnace – pusher type
Rolling Mill Equipment	3. Mill Housings
	4. Mill Bearings
	5. Rolls
	6. Lead Spindle
	7. Mill Pinions
	8. Spindles
	9. Reduction gearboxes/reducers
	10. Guides
	11. Repeaters
	12. Roller Table
	13. Tilting or Lifting Table
	14. Shears
Auxiliaries	15. Centralized Lubrication system
	16. Compressor
	17. Cooling water system (Pumps)
	18. Power supply, distribution, instrumentation, and control system

(i) Induction Furnace

There are two main types of Induction furnaces

- Core less Induction furnace
- Iron core Induction furnace

Most of the re-rolling units are using a core less Induction furnace type induction furnace. The induction furnace uses electric currents to melt the metal. The principle of the induction furnace is induction heating, which is a form of noncontact heating for conductive materials. The average power rating of the furnace varies between 3,000 kW – 10,000 kW with the capacity of 10 tons to 25 tons per batch and batch duration ranging from 1.5 to 3 hours.

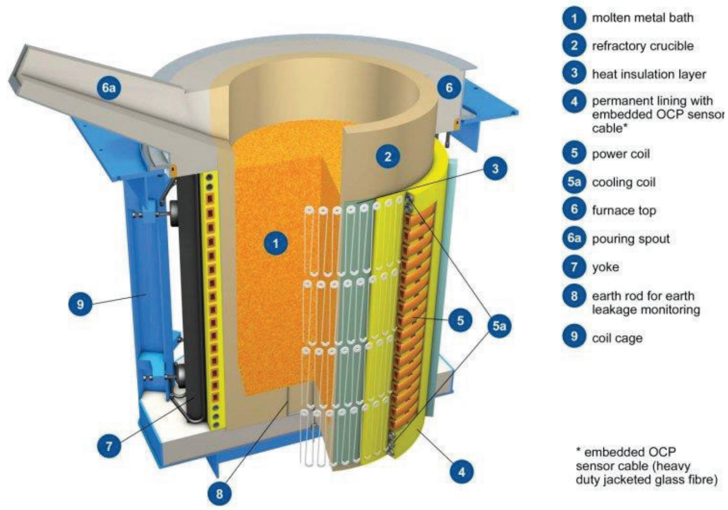


Figure 55: Induction Furnace

(ii) Reheating furnace

Reheating furnaces are used in hot rolling mills to heat the steel stock (Billets, blooms or slabs) to the rolling temperatures of around 1200 deg C which is suitable for plastic deformation of steel and hence for rolling in the mill. The heating process in a reheating furnace is a continuous process where the steel stock is charged at the furnace entrance, heated in the furnace, and discharged at the furnace exit. Heat is transferred to the steel stock during its traverse through the furnace mainly using convection and radiation from the burner gases and the furnace walls.

Pusher type Furnace - Most of the reheating furnaces in the sector are using pusher type furnaces with a capacity ranging from – 2 TPH to 20 TPH. Cold steel stock is pushed forward with the help of pushers at the charging side. The hearth of earlier furnaces was short in length and sloped downward longitudinally towards the discharge end to permit easy passage of steel stock through the furnace.

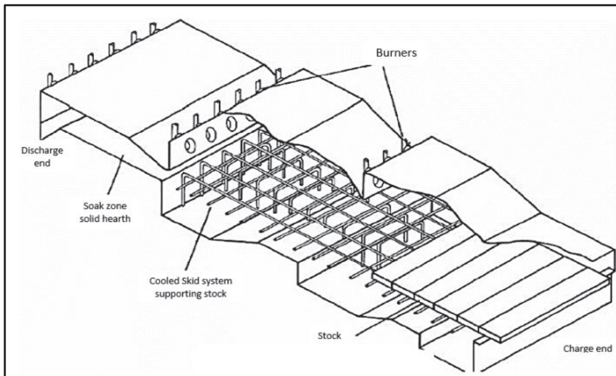


Figure 56: Pusher Type Reheating Furnace

These furnaces normally have three zones namely (i) preheating zone, (ii) heating zone, and (iii) soaking zone. Additional combustion zones are introduced to increase the furnace's throughput by changing and placing the burner in multiple locations, such as front-fired, side-fired-bottom, or top-fired furnaces.

The typical energy balance of the reheating furnace is depicted below:

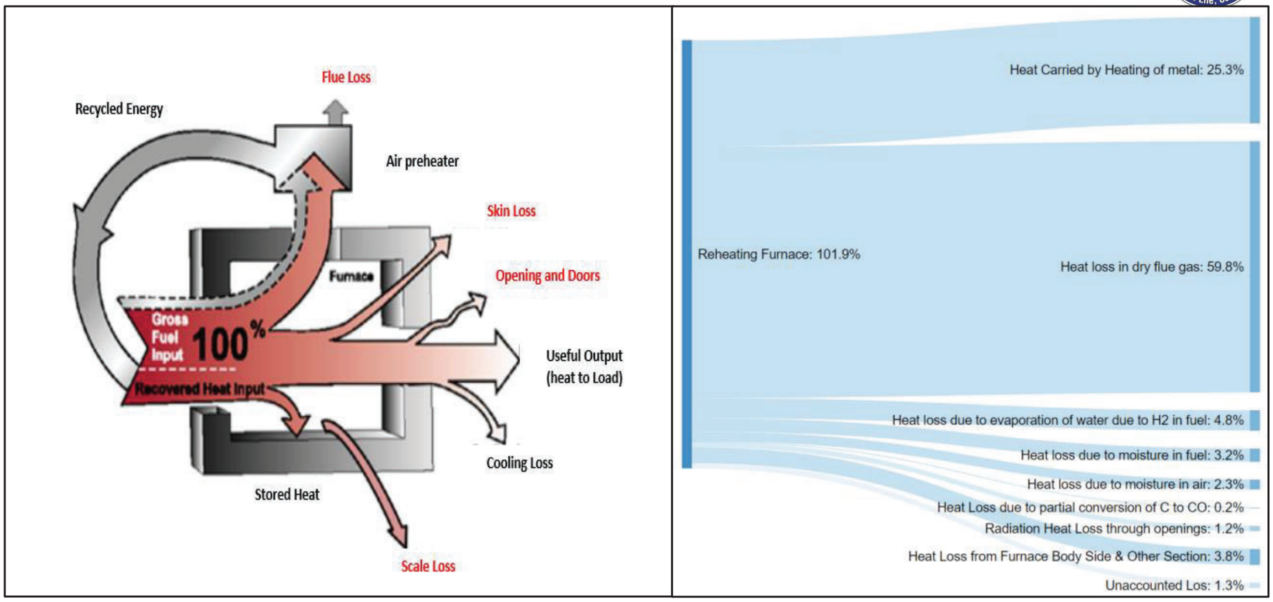


Figure 57: Energy balance of reheating furnace

(iii) Rolling mill

There are three types of rolling mills in common use i.e., 2-Hi, 3-Hi, and 4-Hi mills. This classification is based on the mode of arranging rolls in the housings. Mills having 6 or more rolls are generally termed cluster mills.

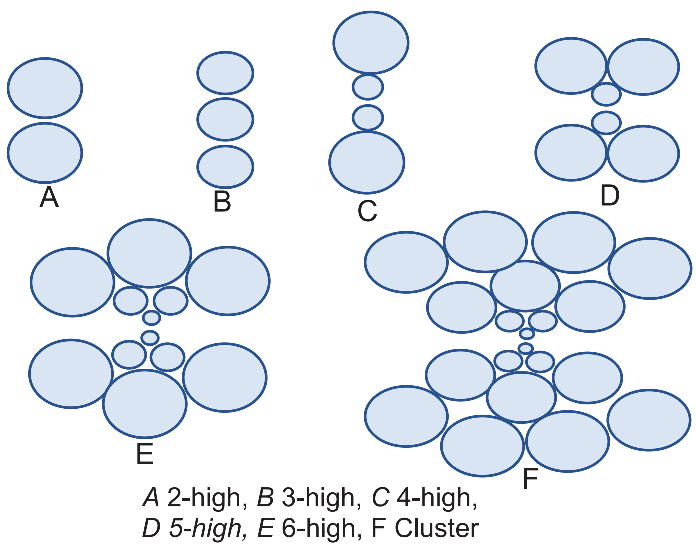


Figure 58: Rolling Mill Design

Rolling Mill Equipments

Rolling mills consist of many types of equipment which together contributes to executing the rolling process with ease and efficiency. Some of the equipment is essential to constitute rolling operation while many of them are additional equipment used to improve productivity and efficiency. The main equipment used in rolling mills is briefed below.

Mill Housings

Housings are parts of a rolling mill that hold chock assemblies, adjusting mechanisms, and other mechanisms in place. Through the nuts of the adjusting mechanism, the forces acting on the rolls during rolling are completely transferred to them. Heavy roughing mills, such as blooming, slabbing, billet, and plate mills, use one-piece cast housings with a simple form (rectangular section). The housing of this type is referred to as the "closed type." In mills where rolls are changed frequently (merchant and structural mills), the housing may have a detachable top for easy roll removal, especially in linear mills. Housings of this type are known as 'open type' housings.

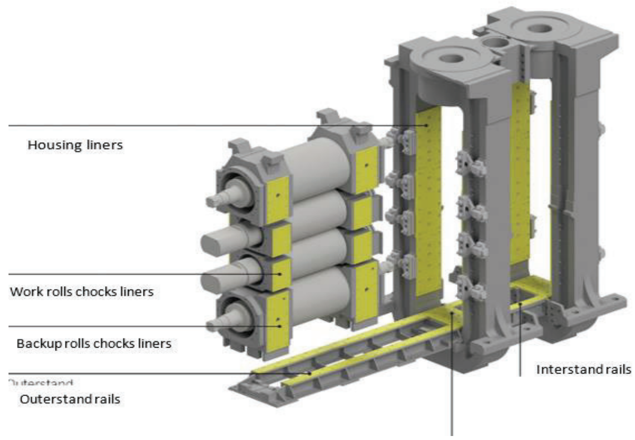


Figure 59: Mill Housing

Mill Bearings

The load on the rolls gets transferred to the bearings and their assembly (chocks). The mill bearings can be classified into three types. – a) Slider bearings b) Hydrodynamic bearings c) Anti-friction roller bearings


Figure 62: Slider Bearing


Figure 61: Hydrodynamic Bearing


Figure 60: Anti Friction Roller Bearing

Anti-friction bearings have the lowest friction and have the ability to operate at low speeds.

Rolls

The deformation of the metal workpiece is directly accomplished by the rolls. The rolling stresses are first of all applied on rolls and after that transmitted to other sections of a mill. Consequently, the rolls had to be harder and more resistive to deformation than the metal under processing.

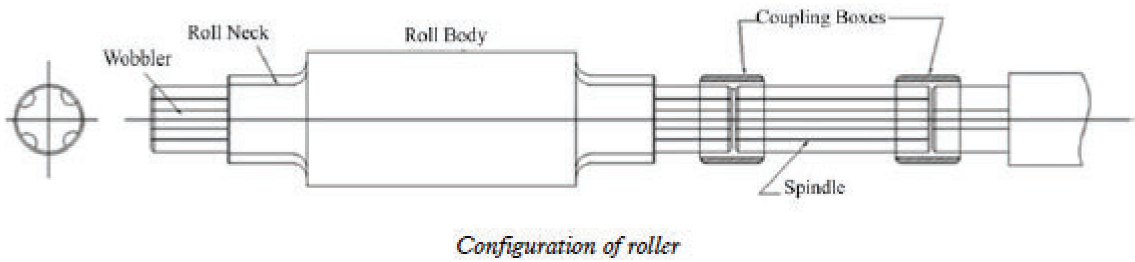


Figure 63: Rolls

Conventional Roll Cooling

The conventional cooling of work rolls reduces its life and causes production delays due to frequent roll changes and poor product quality as a result of uneven wear. In conventional cooling, the rolls are cooled without much consideration for location and water distribution.

Effective Roll Cooling

Effective roll cooling is based upon the principle of rapid heat extraction from the roll surface. Cooling starts immediately after the roll has lost contact with the hot metal and is carried over a fixed segment for the shape profile. Spray density and water pressure should be selected to suit pass configuration, rolling rate, roll material and stock temperature.

Table 26: Distribution of water for Effective Cooling in different Mills

Type of mill	Type of Cooling	Water flow rate (m^3/hr)	Water pressure (kg/cm^2)
Heavy structural and rail mill	Segmental 70° on the exit side	6.0-10.0	3.5-5.0
Wire rod and Bar mill	Segmental 90°-100° on exit side	1.0-2.0	2.5-4.0
Medium section mill	Segmental 70°-80° on exit side	5.0-7.0	2.5-4.0
Narrow hot strip mill	Concentrated water jets	15.0-20.0	5.0-7.0
Wide hot strip mill	Concentrated water jets	400.0-750.0	5.0-7.0

Lead Spindle

The lead spindle is used to connect the prime mover with the pinions and may be of universal type, either short-coupled or long with carrier bearings, depending on the position of the motor in layout. The lead spindle is attached to the bottom pinion of 2-Hi mills, and the centre pinion of 3-Hi rolling mills.

Mill Pinions

The pinions are gears serving to divide the power transmitted by the drive between the 2 or 3 rolls, driving the adjacent rolls in opposite directions. The earlier pinions had either spur teeth or a divided face and staggered spur type teeth, but the present practice is to use double helical teeth. Helical gears provide a smoother drive, as some parts of the teeth are in contact at all times, making the transmission of power continuous.

Spindles

Spindles are used to connect pinions with rolls of the mill if not a direct driven type. Indirect drive case, the spindle is connected directly to the motors. Spindles are made of cast or forged steel and are fitted at each end with wobblers similar to those on the rolls or with the universal couplings, depending upon the type of mill.

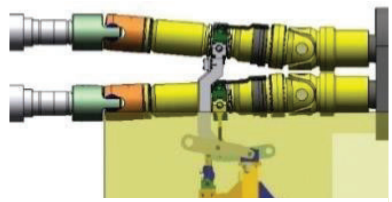


Figure 64: Spindles

Reduction gearboxes/reducers

The reduction gearboxes 'reducers' used in the installation having speed of the motor is higher than required for rolls. Depending on the required reduction in speed, reducers can be used in 1, 2 or 3 stages.

Repeaters

Repeaters are devices used to receive the workpiece as it emerges out from one stand and loops it through 180 degrees into an adjacent stand automatically. This consists of grooved channels or troughs which guide the leading end of the stock through 180 degrees or in some cases through an S-shaped path in forwarding running repeaters.


Figure 65: Repeaters

Roller Tables

The roller tables consist of a series of rollers either driven by line shafting and bevel gears from a common drive or by individual motors. In some improved designs, the bevel gears have been replaced with spur gears. The roller tables serve to feed the rolled piece into the rolls and receive it from the rolls. Hence, they operate under severe conditions of mechanical impact, repetitive short-term duty cycles and dynamic transients (acceleration and decelerations).


Figure 66: Roller Table

Tilting or Lifting Tables

In large 3-Hi mills, the stock has to be mechanically lifted from the pass line of the middle and bottom rolls to the higher pass line of middle and top rolls. To achieve this, the tables on either or both sides of the stand may be designed to tilt.

Shears

The shears are hydraulically or electrically driven with up-cutting or down-cutting blades used to crop the segregated and deformed ends of the stock. The different types of shears used in rolling mills depending on applications are – 1) Bloom and slab shears, 2) Pendulum shears, 3) Flying shears, 4) Crop and cobble shears, 5) Snap shears.

(iv) Rolling motors and Auxiliary drives

Rolling is a continuous process and the main mill stand drive motors are exposed to high stresses. Any unscheduled stoppage or failure of equipment and drive leads to significant loss of energy, production, and time. Therefore, the drive system for main and auxiliary equipment is one of the critical utilities to undertake periodic operational and maintenance practices. The drive used for these is known as primary auxiliary drives. Secondary auxiliary drives are used for driving fans (furnace combustion system), cooling water pumps, and lubrication systems. In a multi-strand continuous hot rolling mill, the power and speed of motors must be selected to suit the rolling schedule.

Figure 67: Rolling Motor

The motors used in rolling mills can be broadly classified into two types, AC motors and DC motors. AC motors are generally used where the stand is to operate at constant speed in one direction, whereas for variable speeds and reversible drives, DC motors are generally used.

(v) Centralised oil lubrication system

The centralized oil lubrication system helps in automatic lubrication of gears of the gearbox, pinion box, etc. The lubricating oil is filtered, cooled, and re-circulated in a closed loop.

(vi) Compressors

Generally, the screw type of compressor is prevalent in the rolling mills to cater for the compressed air requirement in the units. The compressed air is used for the operation of snap shear, looper system, pinch rolls, kick of system in cooling bed and for the operation of various pneumatic valves.

(vii) Cooling water system

Cooling water system helps in cooling of mill stand rolls, bearings, etc. The water is cleaned, cooled to ambient temperature with the help of cooling towers and re-circulated in a closed loop.

(viii) Power supply, distribution, instrumentation, and control system

- The mill's electrical power supply and distribution system mainly include transformers circuit breakers, high tension capacitor banks, and control panels.
- Variable Voltage Variable Frequency (VVVF) drives for regulating the speed of AC motors
- PC-PLC instrumentation and control system for automation of front and end cropping shears, TMT water-cooling system, flying shear, etc. with valve actuators.

Yield

There are different types of losses in the melting and re-rolling section. In the melting division, around 5 - 10% of losses are encountered due to the slag formation. In the Re-rolling division, 1 to 2% of losses take place in the reheating furnace on account of the scale and burning loss. Further, 1-2% of the losses are encountered in the rolling section due to trimming loss, end cut loss and miss-roll loss. Thus, in a composite loss, the total yield varies between 85-90% and in the stand-alone re-rolling mills, the yield varies from 96-98%.

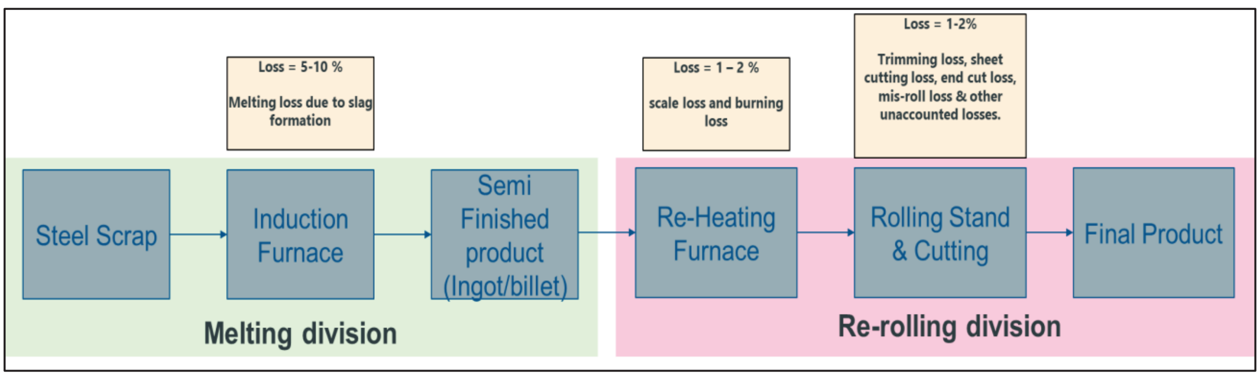


Figure 68: Yield of Melting Division and Rolling Division

Annexure B: EE Technology Compendium

B1 – EE Technologies and EE Retrofits (Utilities)

Replacement of SCR based induction furnace with energy-efficient IGBT based induction furnace[11]

An Induction furnace consists of a non-conductive crucible surrounded by a coil of copper wire. The power source supplies a powerful alternating current that flows through the wire. The coil creates a rapidly reversing magnetic field that penetrates the metal. The magnetic field induces the eddy currents which heat the bulk metal by joule heating. The intensity of the power supply drives the efficiency of the furnace. The power source panel converts the AC input into DC output, the output is then fed into an inverter through the DC choke, this is then further inverted to the AC output of 0.5 kilohertz to 50 kilohertz as per requirement. The power received is then fed to a tank circuit which is a combination of an inductor and a capacitor. Conventionally silicon-controlled rectifier (SCR) based power circuits are used which have some inherent disadvantages such as –

- Low response time,
- low power factor creation of harmonics,
- inability to be used in higher frequencies,
- high melting cycle time

An insulated-gate bipolar transistor (IGBT) based power circuit is an efficient alternative to the conventional one. The IGBT type Induction furnace saves about 8-10% of energy compared with a traditional SCR type induction furnace.

Figure 69: IGBT based Induction Furnace

Advantages of IGBT induction furnaces are:

- Higher inverter voltage, low current and low line loss
- High Power factor due to which the reactive power loss is small.
- Constant power output with 100% transformer utilization, increases the melting speed and reduces the batch time

Table 27: Energy Savings and Payback - IGBT based Induction Furnace

Sectoral Investment	Rs. 24,750 lakh
Percentage of energy savings	8 – 10%
Approx. Reduction in energy consumption (toe/year)	11,728
Approx. Reduction in GHG emission TCO_2	111,826
Simple Payback Period	1 - 2 years

11 Bureau of Energy Efficiency - Installation of IGBT based Induction furnace

Installation of Sintering panel to preheat the ramming mass[12]

Figure 70: Sintering Panel

Installation of the sintering panel can overcome the limitations associated with sintering heat. The sintering panel is a dedicated power panel applicable during sintering heat. During the sintering heat, it can share the load between the induction furnace under operation and the newly ready crucible that needs preheating before the charge feed.

The load sharing can be done in a certain ratio, so that it does not affect the melting under the furnace and simultaneously preheats the newly ready crucible up to 500 to 700° C. With the installation of the sintering panel

- Heat time, production and overall power quality can be enhanced.
- Power-sharing can increase kVA utilization.
- It reduces the heat time of sintering heat to normal heat time and will increase productivity.
- It doesn't consume any extra power. The result is reduced SEC, enhanced production and better power quality and utilization during the sintering heat.

Table 28: Energy Savings and Payback - Sintering Panel

Sectoral Investment	Rs. 2700 lakh
Percentage of energy savings	0.5 – 1%
Approx. Reduction in Electricity consumption (toe/year)	533
Approx. Reduction in GHG emission TCO_2	2,700
Simple Payback Period	<1 year

Installation of the Scrap processing unit to reduce melting cycle time and energy consumption in the induction furnace

An electric induction furnace uses the electricity to melt the charge mix and the quality of the product in the electric induction furnace is largely dependent on the quality of the raw material fed into the furnace. In addition to the energy consumption, the quality of the material also affects the time of the heat. The scrap generally used in a factory is in an unprocessed manner, which results in air pockets or voids between the scrap pieces that subsequently low power density and ultimately increase the heat per cycle time. The size and shape of the scrap play an important role in running the induction

12 Ministry of Steel - Installation of Sintering Panel to preheat the ramming mass

furnace and drawing the full power on load is the best operating practice.

The more the furnace runs at full power, will lower the total energy losses leading to low energy consumption. Small and dense pieces are preferred for optimum results. To adopt this best practice, it is proposed to adopt the following process.

5. Segregate scrap based on types and quality.
6. Use a shredding machine to cut the larger scraps into smaller pieces
7. The shredder also removes rust and dust from scrap
8. Use bailer to compress scrap into pieces with higher bulk density.
9. Use bucket feeding or Vibro-feeder for feeding compressed scrap into the furnace.

The processed scrap due to its higher bulk density increase the charging rate and the furnace operates at its maximum power input which increases the melt rate thus reducing heat per cycle time. Processed scrap has many advantages over other types of scraps.

Advantages of the processed scrap,

1. Better power coupling
2. Less slag generation.
3. More lining life
4. Better productivity
5. Less air pollution

Table 29: Energy Savings and Payback - Installation of the Scrap processing unit

Sectoral Investment	Rs. 6,750 lakh
Percentage of energy savings	5%
Approx. Reduction in Electricity consumption (toe/year)	2,962
Approx. Reduction in GHG emission TCO_2	28,239
Simple Payback Period	<1 year

Installation of VFD on CCM pump to optimize the pressure and flow & Replacement of multiple cooling water pumps with a single energy-efficient pump.

Pumps are used widely in the steel industry to provide cooling and lubrication services, transfer fluids for processing and provide motive force in hydraulic systems. In the steel rolling sector, pumps represent 5–10% of the electricity used in utilities. Pump reliability is very important—often critically so. In cooling systems, pump failure can result in equipment overheating and considerable damage to product quality.

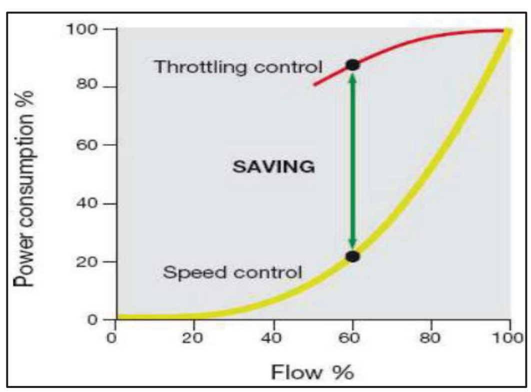


Figure 71: VFD on CCM pumps - Flow vs Power consumption chart

The pumps are required to operate in a wide range of conditions. The process cooling systems experience variable loads due to changes in product shape and size and production demands. To accommodate demand changes, flow can be controlled by any of these four methods—

1. Bypass lines,
2. Throttle valves,
3. Multiple pump arrangements
4. Pump speed adjustments

To maintain the desired flow rate efficiently, speed adjustment is the most efficient means of control. The VFDs adjust the electrical frequency of the power supplied to a motor to change the speed over the continuous range.

It is recommended to replace multiple cooling pumps and install one pressure based VFD controlled energy efficient pump to cater for the required flow and head.

Table 30: Energy Savings and Payback - VFD on CCM Pump & Replacement of Multiple cooling water pump with single energy-efficient pump

Sectoral Investment	Rs. 3,024 lakh
Percentage of energy savings	20-25%
Approx. Reduction in Electricity consumption (toe/year)	2,582
Approx. Reduction in GHG emission TCO_2	24,619
Simple Payback Period	1-2 year

Improvement in the efficiency of Induction Furnace by using proper grade and quality ramming mass[13]

Quartz powder with a silica purity of 96-98% is called ramming mass. The quality of ramming mass has a direct impact on the heating performance of the furnaces leading to the smooth working of furnaces, optimum output and better metallurgical control. It comes in three variants – acidic (made from silica), basic (made from magnesia) and neutral (made from alumina). Silica ramming mass (also known as acidic ramming mass) is the most commonly used owing to its inherent advantages and application in the induction furnace of the steel industry,

Advantage of Quartz ramming mass

- It has the lowest thermal conductivity resulting in low energy loss, low expansion coefficient leading to the stable lining, and good resistance to temperature
- High Silica content (>98.9%) facilitates in oxidizing the impurities present in the output charge by forming slag.
- Cost is nearly 10 – 20% low compared to that of alumina or magnesia based ramming mass.

[13] https://www.reportjunction.com/Preview/Raghav-Productivity-Enhancers-Ltd-2017-118867.htm

Comparison advantage of Quartz ramming mass over others

Table 31: Comparison of different ramming mass

Type of refractory material	Quartz	Alumina	Silica
Nature	Acidic	Neutral	Basia
Melting point (°C)	1,723	2,050	2,800
Free energy at 1450 °C (kj/mol)	-594	-758	-732
Average thermal conductivity between 0°C - 1,200°C (W/mk)	1.7	2.6	4
Expansion coefficient between 0°C - 1,200°C (x106)	12.2	8.2	13.8
Cost (relative to silica)	1	5 – 10 times	5 – 10 times

The estimation of the benefits and energy savings is tabulated below:

Table 32: Energy Savings and Payback Proper grade and quality ramming mass

Sectoral Investment	Rs. 1,440 lakh
Percentage of energy savings	2%
Approx. Reduction in Electricity consumption (toe/year)	1,895
Approx. Reduction in GHG emission TCO_2	18,073
Simple Payback Period	<1 year

Implementation of continuous casting and direct rolling to eliminate the requirement of reheating furnace[14]

The charge mix (Metal scrap/sponge iron/Pig iron) is melted in the Induction furnace. The molten metal at elevated temperature is brought into a ladle and directly cast into moulds to form ingots.

The mould filling using the runner in gate system is the traditional practice of converting molten metal into ingots. The system does not require any additional energy consumption but for every heat cycle, it has associated energy loss of

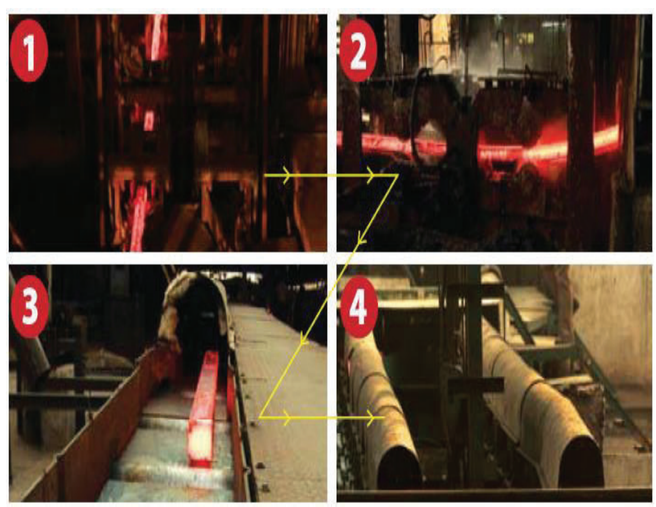


Figure 72: Direct Rolling Process

[14] UNDP Project - Direct Rolling in SRRM

melting almost 500 to 600 kgs of molten metal are lost in the runner and gates resulting in increased specific energy consumption. The process of continuous casting is a cost-effective and environmentally friendly technology. In this, the ladle is placed above a tundish and the metal is poured continuously through the tundish into the caster. The primary and secondary cooling of the caster helps the metal to solidify during the process into billets/slabs. In the case of composite units where the rolling mill also exists, the hot billets coming out of the induction furnace can be directly charged into the rolling mill thus eliminating the need for reheating furnace. The advantages are:

- Increased production and reduced specific energy consumption
- Reduced scale generation and support for direct rolling
- Improvement in quality of final product
- 100% elimination of thermal energy usage from the factory

Table 33: Energy Savings and Payback Direct Rolling

Sectoral Investment	Rs. 37,500 lakh
Percentage of thermal energy savings	100%
Approx. Reduction in Electricity consumption (toe/year)	357,459
Approx. Reduction in GHG emission TCO_2	1,082,000
Simple Payback Period	<1 years

Installation of Oxygen and CO sensor to optimize the excess air of the furnace

Every fuel required a precise stoichiometric amount of air (i.e. theoretical air) for the proper combustion of the fuel. In the standard practices, the combustion conditions are never ideal, and additional or "excess" air must be supplied to completely burn the fuel. To ensure complete combustion about 10-11% of excess air or 2% of excess O2 is recommended in the exhaust flue gas.

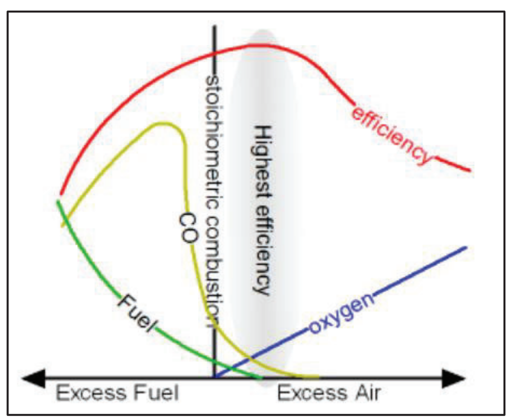


Figure 73: Efficiency of the boiler vs fuel and air supplied

The figure shows the relation between air supplied, fuel supplied and the efficiency of the boiler operating in two modes.

1. **Excess Fuel Mode** – When the quantity of the air supplied is low, as compared to the requirement of air for the complete combustion of the fuel supplied. This will lead to poor combustion of the fuel and a high carbon monoxide percentage will be formed.

2. **Excess Air mode** – When the quantity of the air supplied is high, as compared to the requirement of air for the complete combustion of the fuel supplied. In this case, higher heat will be carried away by the flue gas leading to high dry flue gas loss and the efficiency of the boiler decreases.

The diagram depicts the increase in the air supply into the furnace, the flue gas temperature and the dry flue gas loss increase.

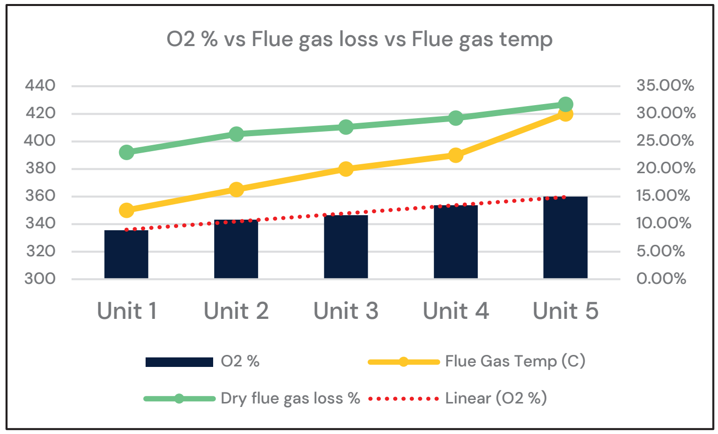


Figure 74: O2 vs Flue gas loss vs Flue gas temp.

The efficiency of the furnace is high when a slight percentage (10-11%) of excess air (depicted in the figure) or 2% of excess oxygen is supplied to ensure the proper combustion of the fuel. The oxygen analyzer installed in the flue gas path of the chimney will continuously monitor the excess air in the flue gas and will enable us to supply the required air into the furnace to ensure high efficiency and proper combustion of the fuel.

Table 34: Energy Savings and Payback O2 and CO sensor

Sectoral Investment	Rs. 3,600 lakh
Percentage of thermal energy savings	10-15%
Approx. Reduction in Thermal consumption (toe/year)	105,092
Approx. Reduction in GHG emission TCO_2	318,078
Simple Payback Period	<1 years

Installation of automation and temperature control system in the reheating furnace

The temperature of the billet and ingot (stock) is not monitored in the furnace. The operator's experience decides that the stock is ready for rerolling and the heated billets and ingot are then taken out of the furnace.

Overheating of the stock leading to high fuel consumption and under heating cause frequent breakdown of mills

Automation and temperature control systems will help in maintaining the correct furnace temperature regime and the corresponding air-fuel ratio, thereby leading to a reduction in specific fuel consumption.

Figure 75: Automation and Temperature Control system

Different levels of automation are mentioned below:

Level 1 – On/off control
Leve 2 – PID based control
Level 3 – PC – PLC based control system with HMI (Human Machine Interface)

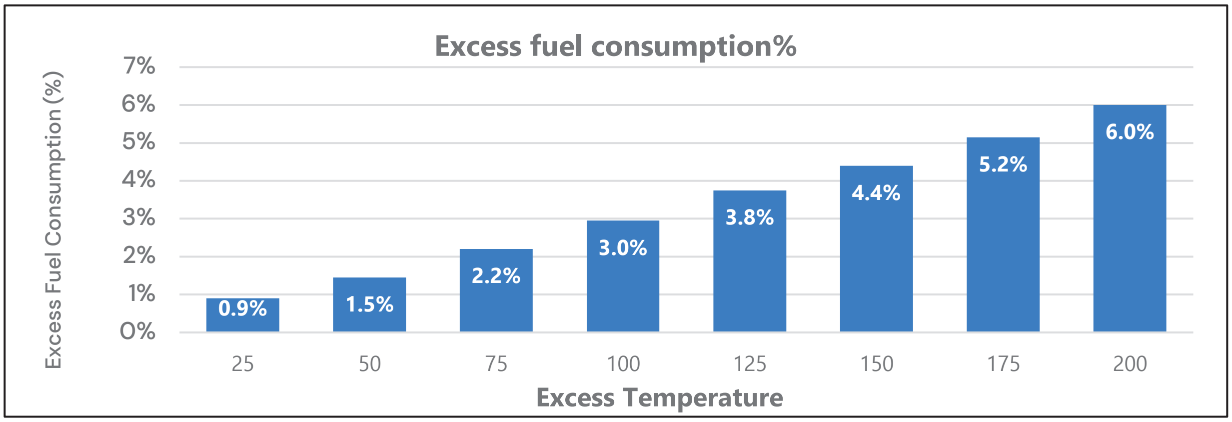


Figure 76: Excess Fuel Vs Temperature chart

The chart above represents the linear relationship between the excess fuel consumption in the furnace and overheating the stock temperature.

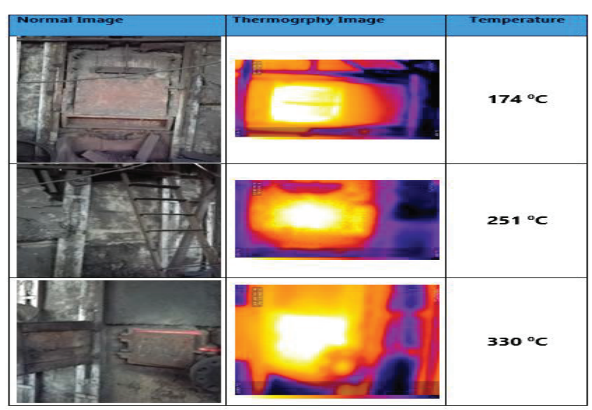
Table 35: Energy Savings and Payback automation and temperature control system

Sectoral Investment	Rs. 2,000 lakh
Percentage of thermal energy savings	4%
Approx. Reduction in Thermal consumption (toe/year)	33,629
Approx. Reduction in GHG emission TCO_2	101,785
Simple Payback Period	<1 year

Overhauling of the furnace with proper insulation lining

The efficiency of the furnace directly depends upon the heat stored within the furnace structure. Heat loss from the furnace can be through

- Radiation loss through the openings and the furnace
- Cooling loss through water-cooled skid pipes



For successful overhauling of the furnace lining –

- Evaluate the furnace liner with IR thermography inspection,
- Use online maintenance repair
- Choose the right material for furnace rebuilds, replacing the conventional insulating materials with low thermal mass insulation materials can reduce the heat losses through the furnace.

Figure 77: IR thermography inspection of Reheating

The chart represents the surface temperature and heat loss at different insulation conditions of the furnace. Higher is the surface temperature, higher will be the heat loss.

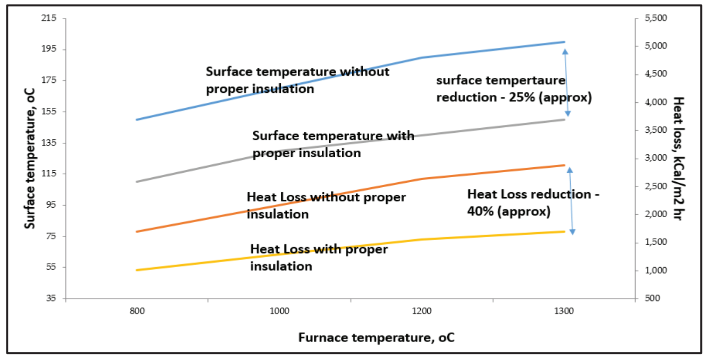


Figure 78: Heat loss reduction chart

Table 36: Energy Savings and Payback Overhauling of Reheating Furnace

Sectoral Investment	Rs. 800 lakh
Percentage of thermal energy savings	5-7%
Approx. Reduction in Thermal consumption (toe/year)	54,648
Approx. Reduction in GHG emission TCO_2	165,401
Simple Payback Period	<1 year

Installation/ Overhauling of the recuperator to reduce the flue gas heat loss

The product of combustion leaves the reheating furnaces furnace at a temperature higher than the stock temperature. Sensible heat losses in the flue gases, while leaving the chimney, carry 35 to 55% of the heat input to the furnace. The higher the quantum of excess air and flue gas temperature, the higher would be the waste heat loss. The below table presents an estimate of waste heat loss at different flue gas temperatures.

Table 37: Flue gas temperature vs % of net heat loss[15]

Flue Gas Temperature (°C)	% of net heat loss
600	25%
800	35%
1000	45%
1200	55%
1400	65%
1600	75%

[15] https://www.researchgate.net/publication/260293545_Waste_Heat_Recovery_in_Steel_Bars_Re-Rolling_Mill

With proper Waste Heat Recovery, the sensible heat in the flue gases can be utilized for the following purposes –

- Charge (Stock) Preheating
- Preheating of combustion air
- Other processes

Benefits are - Improved heating system efficiency, Lower flue gas temperature in a chimney, higher flame temperatures, faster furnace startup, increased productivity.

Table 38: Energy Savings and Payback Overhauling of Recuperator

Sectoral Investment	Rs. 6,000 lakhs
Percentage of thermal energy savings	10-15%
Approx. Reduction in Thermal consumption (toe/year)	105,092
Approx. Reduction in GHG emission TCO_2	318,078
Simple Payback Period	2.5 - 3 year

Fuel shifting from coal to PNG

Thermal energy is used in the reheating furnace to heat the steel stock (Billets, blooms or slabs) to the rolling temperatures of around 1200 deg C which is suitable for plastic deformation of steel and hence for rolling in the mill. Coal is predominantly used in the rolling mills in India. Shifting from Coal to Natural gas in the reheating furnace has the following advantages –

- Environmentally Friendly – Natural gas is one of the cleanest burning fuels, Coal when combusted, release a higher ratio of carbon emissions, Nox, Sox and Ash Particles.
- Low Maintenance Cost – No scaling or sooting takes place in the use of natural gas and hence reduces maintenance costs.
- No storage space required
- Uninterrupted supply – avoids inconvenience caused due to unavailability
- No spillage or pilferage
- No Pre-heating required in winter

The emission intensity of coal is about 55% higher than that of natural gas. Shifting to affordable natural gas-based cleaner fuels will not only reduce emissions but will also enhance productivity and improve the working environment. The demand for natural gas (at the present production level) for the entire rerolling sector is estimated to be 1329 million SCM.

Table 39: Energy Savings and Payback Fuel shifting to PNG

Sectoral Investment	Rs. 7,200 lakh
Percentage of thermal energy savings	20%
Approx. Reduction in Thermal consumption (toe/year)	30,266
Approx. Reduction in GHG emission TCO_2	91,606
Simple Payback Period	2.5 – 3 year

Installation of regenerative burners in the PNG fired reheating furnace

A regenerative burner is a heat recovery system that recovers the waste heat of the furnace exhaust gas to heat the combustion air of the furnace. Then the burners switch so that the one accumulating heat combusts the fuel and the other now accumulates exhaust heat.

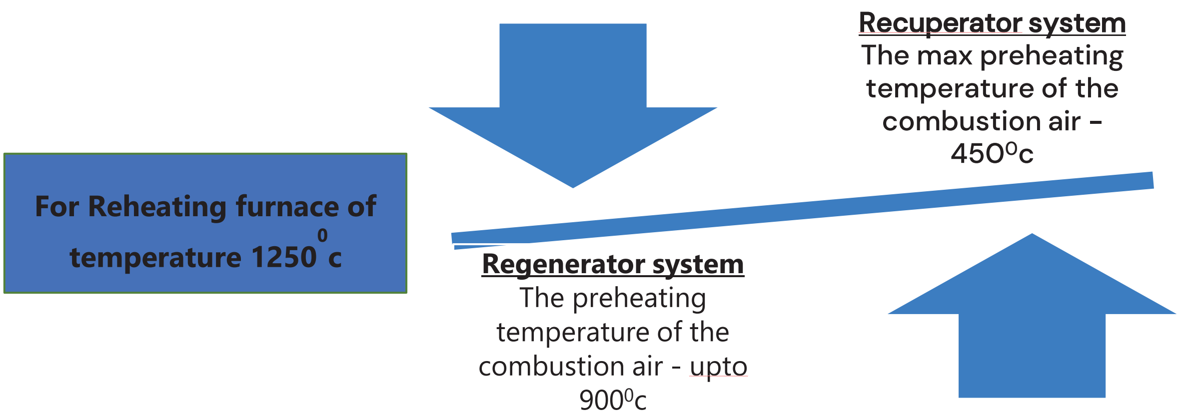


Figure 79: Regenerator vs Recuperator System

In this technology, there is a pair of burners that works in a switched-mode which means when one burner is in firing mode then the other is absorbing the heat from the flue gas. A regenerative burner system is more effective than a recuperator system to recover heat from the flue gas, which is depicted in the picture below:

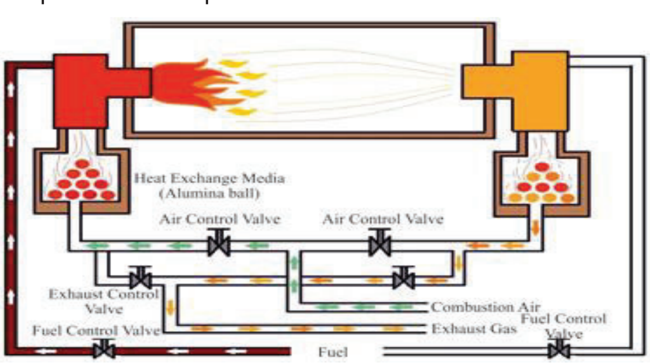


Figure 80: Regenerative Burner system

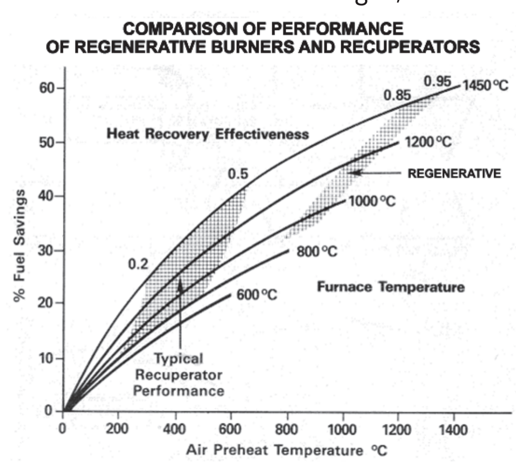


Figure 81: Comparison of Performance of Regenerative Burners and Recuperators

Table 40: Energy Savings and Payback Regenerative burner

Sectoral Investment	Rs. 9,600 lakh
Percentage of thermal energy savings	25%
Approx. Reduction in Thermal consumption (toe/year)	25,222
Approx. Reduction in GHG emission TCO_2	76,339
Simple Payback Period	2.5 - 3 year

Installation of the energy-efficient furnace with top and bottom firing

In typical Pusher type furnaces, the burner is located at the top. In the case of billets that have a large cross-section, Pusher type furnace results in improper heating and soaking. Top & Bottom Fired Furnaces are mainly used for the higher cross-section. In the top and bottom firing system, there is a burner on both sides top and bottom which gives uniform heating from both ends.

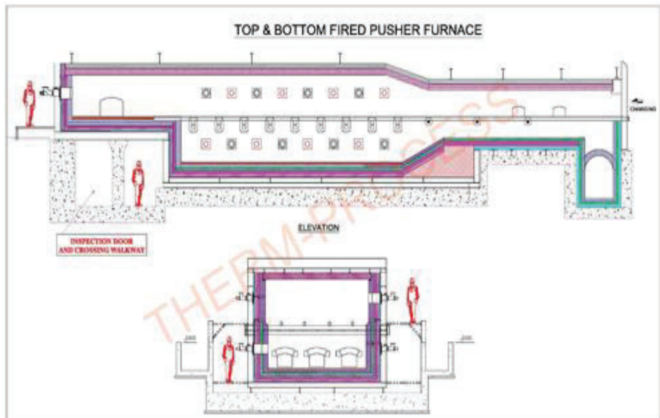


Figure 82: Reheating Furnace with top and bottom firing system

The advantages of top and bottom firing system are –

- Faster healing of feedstock
- Lower temperature differences within feedstock and reduced residence time
- Lower scale losses thus improved yield
- Reduced specific energy consumption and low emissions

Table 41: Energy Savings and Payback Top and Bottom firing

Sectoral Investment	Rs. 27,500 lakh
Percentage of thermal energy savings	20%
Approx. Reduction in Thermal consumption (toe/year)	10,509
Approx. Reduction in GHG emission TCO_2	31,808
Simple Payback Period	<2 year

Installation of membrane-based oxygen-enriched combustion[16]

Air contains only 21% oxygen, the remaining 79% is nitrogen. In combustion processes, nitrogen does not take part in the combustion but has to be heated up, consuming unnecessary additional energy from the fuel. Oxy-fuel combustion refers to the practice of replacement of ambient air (as the source of oxidizer for combustion) with industrial-grade oxygen (typical purity 99.5%.). Reduction of nitrogen in combustion allows for higher flame temperature and combustion efficiency as lower combustion gas volume reduces the amount of heat taken from the flame and lost to the exhaust.

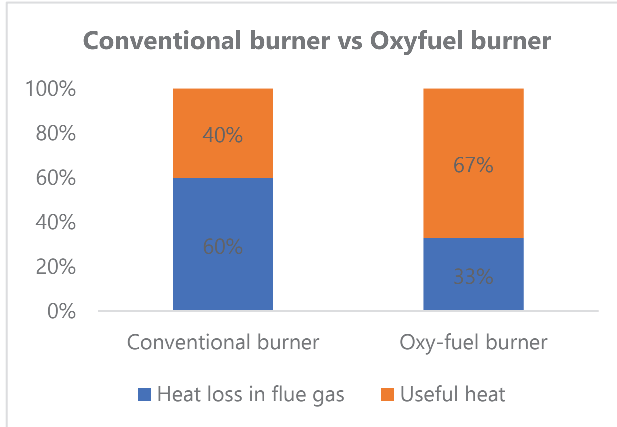


Figure 83: Conventional Burner vs Oxyfuel Burner

The benefits of using oxy-fuel as compared to air-fuel combustion are as follows:

- Reduced energy consumption and emissions
- Increased heating rate resulting in higher production (with no increase in furnace temperature set point)
- Reduced scale formation

Table 42: Energy Savings and Payback Oxy-fuel enrichment

Sectoral Investment	Rs. 11,250 lakh
Percentage of thermal energy savings	30%
Approx. Reduction in Thermal consumption (toe/year)	23,646
Approx. Reduction in GHG emission TCO_2	71,568
Simple Payback Period	<2 year

Installation of energy-efficient roller motor for each rolling strand

Roller motor operating more than 1 stand ends up consuming more power due to frequent overloading. It was observed that if a mill installs a separate energy-efficient motor for separate stands then there is a possibility of at least 20 - 30 % of lesser power consumption compared to a single motor operating all the stands.

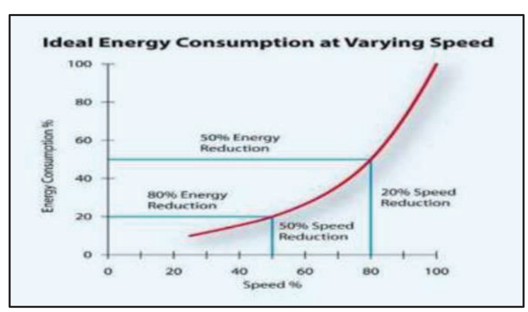


Figure 84: Energy consumption load curve

Inefficient operation of motors caused by:

[16] https://nitsri.ac.in/Department/Chemical%20Engineering/EE1.pdf

- Use of inefficient IE1 class motors
- Oversizing of the motors
- Fixed speed control of variable torque motors
- Single motors operating multiple strands

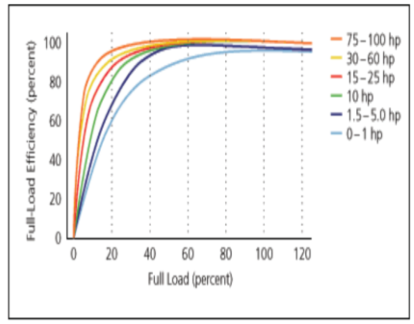


Figure 85: Energy consumption load curve

About 90-95% of the life cycle cost of the motor is towards the electrical energy cost

Energy Saving Measures in the motor system –

- Proper sizing of the motor with optimum loading
- Use of VFD to control the operation of variable load motors
- Installation of roller motors for each strand

Table 43: Energy Savings and Payback Oxy-fuel enrichment

Sectoral Investment	Rs. 42,000 lakh
Percentage of Electrical energy savings	15%
Approx. Reduction in Electricity consumption (toe/year)	2,398
Approx. Reduction in GHG emission TCO_2	22,863
Simple Payback Period	<1 year

Installation of Y- roller table/tilting table in 3-Hi mill stands of rolling mills[17]

The roughing mill is generally used for heavy reduction of charge conventionally after a pass rolling charge is transferred to the next pass using a guide through manual intervention. The manual handling is done by a tongs man who holds the rear end of the hot charge and enters it into the next pass, the delays in the process of charging also leads to cooling of the charge which affects the machine life. The manual handling of the charge is an unsafe process. An automatic material handling system is the energy-efficient alternative for a manual handling system.

For automatic handling of hot charged in three high roughing mills stand a "Y-table" or tilting table are used. A Y-table is a steel fabricated structure in the shape of a Y, the structure is made of roller conveyors and a metal lid used in the Y joint which allows only one-way travel of the charge (the charge after rolling from the bottom middle rolls passes through the rear end of the table). The metal lid falls once the charge has completely passed through during return

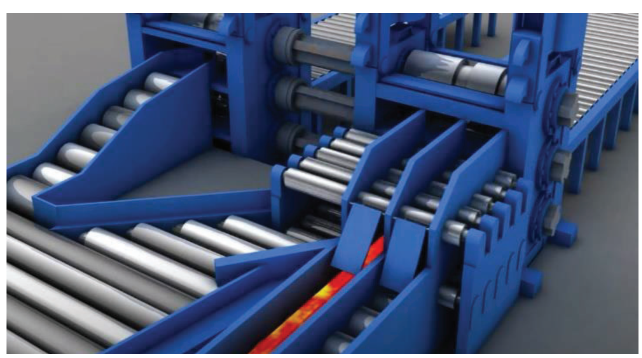


Figure 86: Y-roller table

[17] Ministry of Steel - Installation of Y-roller table

the metal charge passes through the top end thus transfer of billet to the next pass is facilitated.

Y table is common in TMT mills wherein one side of the stand Y tables are installed and the opposite side drop tilters are present. The tilting mechanism is quite similar to the Y table and used for higher cross-sections especially in structure mills. These systems contribute towards increasing mill utilization. Other benefits include –

- Increased productivity,
- Safer operations,
- Reduced delays.

Table 44: Energy Savings and Payback Y-roller table

Sectoral Investment	Rs. 2,500 lakhs
Percentage of Electrical energy savings	10%
Approx. Reduction in Electricity consumption (toe/year)	3,390
Approx. Reduction in GHG emission TCO_2	32,322
Simple Payback Period	<2 year

Installation of Crop length optimization to enhance the yield[18]

To minimize the amount of material cut off from both ends of the bar (in the steel re-rolling mill plant) the crop optimization system is used to control the crop shear. The crop end control technique can reduce crop end losses by over 50% and thus improve the yield of the rolling mill by up to 3%. Laser and non-contact devices are used to measure the position of the head, and pattern software (centralized control based system) is used to classify the shape of the system.

Particular	Saving
Percentage of Yield Improvement	0.5%

Installation of Universal Spindles and Couplings[19]

Couplings and spindles are devices used to connect two pieces of rotating equipment or shaft. Couplings are used for transmitting power. Spindles are used for transmitting rotation to the rolls from pinion stands or electric motors.

Traditionally Wobbler couplings are the most commonly used in steel re-rolling. These wobbler

[18] https://enviro.bppt.go.id/Publikasi/EfisiensiEnergi/Manual%20revised%20on%20Energy%20Efficiency%20in%20Steel%20Rolling%20%20Industries.pdf

[19] Ministry of Steel - Universal Spindles and Couplings

couplings are normally used with nylon or wooden packings. The roughness or improper pairing gives rise to low metal to metal contact further the wobbler connections do not allow flexibility towards inclination from the roll axis beyond 1 to 2 degrees. The disadvantages of using wobbler couplings are –

- Jerking loads on drive motor due to wear out of nylon/ wooden pads
- Higher loads on drives due to limited flexibility of inclination of the spindles
- Higher mill downtime and lower mill utilization

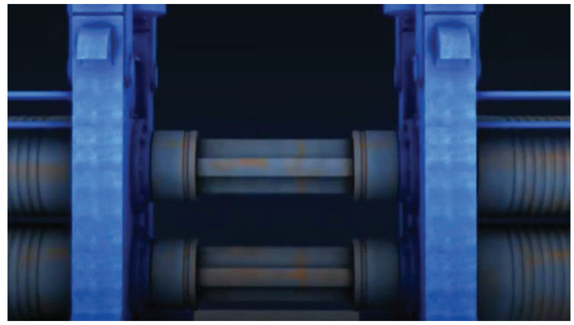


Figure 87: Wobbler Coupling

As an alternative to wobbler coupling and spindles, the energy-efficient way is to use universal couplings and spindles. Universal spindles allow rotation to be translated to the rolls at considerable angles to up to 8 to 10 degrees in the axis of the spindle and the axis of rolls or pinion over the pinion stand. The horizontal projection of the length of the spindle alters in accordance with the angle of inclination for this reason one of the hinges is usually fixed at the end of the driving shaft and the other end is not fixed.

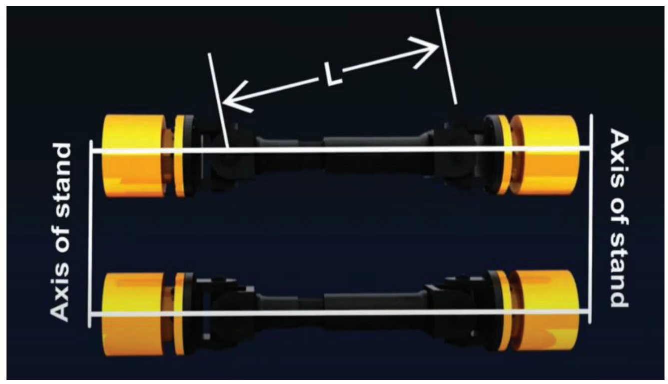


Figure 88: Universal Spindles & Coupling

The advantages of universal couplings are –

- High torque and transmission capacity
- Simple design and easy maintenance
- Negligible backlash and radial clearance
- High operational life and low operational cost
- Uniform loading in drive motors
- Reduces power, increases mill utilization
- Increased roll life

Table 45: Energy Savings and Payback universal spindles and couplings

Sectoral Investment	Rs. 1,800 lakhs
Percentage of Electrical energy savings	2-10%
Approx. Reduction in Electricity consumption (toe/year)	1,627
Approx. Reduction in GHG emission TCO_2	15,514
Simple Payback Period	<2 year

Installation of Anti-friction roller bearings[20]

Bearings are one of the most critical equipment in the rolling mill and perform three basic functions –

- Carrying a load
- Reducing Friction
- Positioning moving machine parts

Rolling mill bearings are required to withstand extremely severe operating conditions including heavy shock loads, varying speeds and extreme temperature variations. In most cases, bearings have to withstand both the radial roll separating force and the roll-in thrust.

Traditionally many types of bearings are used in rolling mills of which fibre or fabric bearing is the most commonly used one. A fabric bearing is subjected to linear contact with the rotating rolls, thus these bearings result in more friction thereby leading to significant mechanical losses and comparatively higher power consumption.

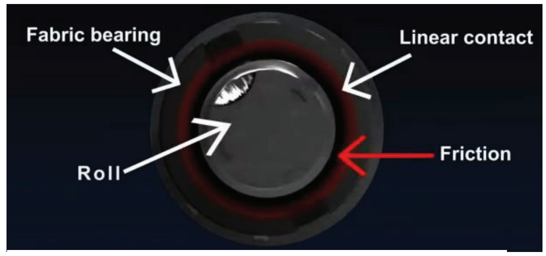


Figure 89: Fabric Bearing

An alternative to fabric bearing is an anti-friction roller bearing. It consists of an inner ring and outer ring rolling elements and a retainer in a typical installation. The outer ring is fixed and doesn't move. As the shaft rotates the inner ring also rotates. The retainer positions the rollers equally along with the rings and ensures that the load is distributed equally on each roller. The advantages of roller bearings are –

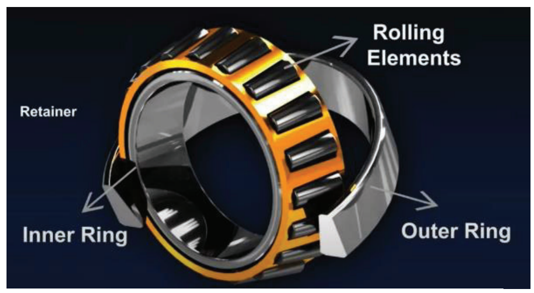


Figure 90: Anti friction Roller Bearing

- Point contact as compared to line contact in fabric bearing
- The coefficient of friction for rollers is 0.005 compared to 0.54 for fabric leading to less friction and heat
- Rollers are subjected to less starting and running torque compared to fabric bearing leading to less power consumption
- The hardness of steel bearing is superior to fabric bearing leading to a longer life.
- Roller bearing improves mill availability

Table 46: Energy Savings and Payback Anti friction Roller Bearing

Sectoral Investment	Rs. 5,250 lakhs
Percentage of Electrical energy savings	5%
Approx. Reduction in Electricity consumption (toe/year)	2,034
Approx. Reduction in GHG emission TCO_2	19,393
Simple Payback Period	<2 year

[20] Ministry of Steel - Anti-friction Roller Bearing

Installation of Energy Monitoring System (EMS) to optimize the power consumption in a different section of the Plant

Energy management systems (EMS) are automation systems that collect energy measurement data from the field and make it available to users through graphics, online monitoring tools, and energy quality analyzers, thus enabling the management of energy resources. Installing Energy Management System (EMS) in the plant can save up to 3% of electricity consumed in the plant.

The main functions of an Energy Management System (EMS) in general are –

- The recording and visualization of all relevant energy turnovers and operating data (plant states as well as production plans)
- Using this data for the prediction of the short-term energy turnovers, and
- Controlling (in sense of planning and accounting) internal energy production and the purchase of external energy carriers.

Table 47: Energy Savings and Payback Energy Monitoring System

Sectoral Investment	Rs. 1,600 lakh
Percentage of Electrical energy savings	3%
Approx. Reduction in Electricity consumption (toe/year)	16,352
Approx. Reduction in GHG emission TCO_2	155,919
Simple Payback Period	<1 year

Replacement of the existing compressor with energy efficient (low specific power consumption) compressor

The specific power consumption (SPC) (i.e. the power consumption to deliver one-unit CFM of compressed air, power KW Compressed airflow, kW/CFM) is the key performance of the compressor. The ageing of the compressor leads to wear and tear of the compressor piston or poor maintenance or fouled heat exchanger are the various reasons due to which the air delivery of the compressor reduces, which leads to higher specific power consumption.

If the specific power consumption is higher than 0.165 kW/CFM, it is recommended to replace the compressor with an energy-efficient compressor. The compressor in the rolling mill is used in quenching operations, most mills use a reciprocating compressor. Replacing reciprocating compressor with screw compressor has benefits associated with energy savings depicted in the figure below:

Type - Reciprocating
Rated FAD – 53 CFM
Specific Power Consumption – 0.22 kW/CFM

Type - Screw
Rated FAD – 56 CFM
Specific Power Consumption – 0.165 kW/CFM
Energy Savings – 25.3%

Figure 91: Types of compressors

Table 48: Energy Savings and Payback VFD on compressor

Sectoral Investment	Rs. 240 lakh
Percentage of Electrical energy savings	30%
Approx. Reduction in Electricity consumption (toe/year)	308
Approx. Reduction in GHG emission TCO_2	2,940
Simple Payback Period	<1 year

Installation of VFD in the compressor to eliminate the no-load power consumption

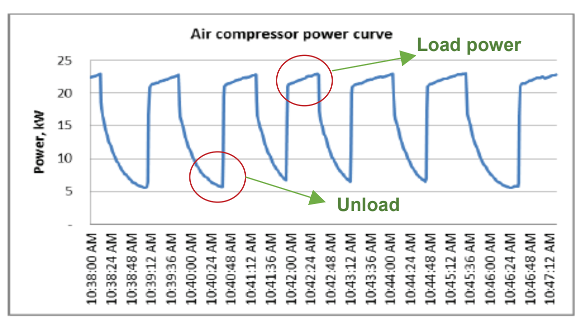


Figure 92: compressor Power Curve

Installing an air compressor with a variable frequency drive (VFD) or retrofitting the company's existing air compressors with VFDs. The VFD is an electronic module, which is used to change the speed of the motor by varying the frequency applied to the motor. The motor speed is directly proportional to the frequency and thus changes in frequency impact the motor speed and the amount of power consumed. The VFD can transform air compressors that have traditionally been known as power guzzlers into energy-efficient equipment.

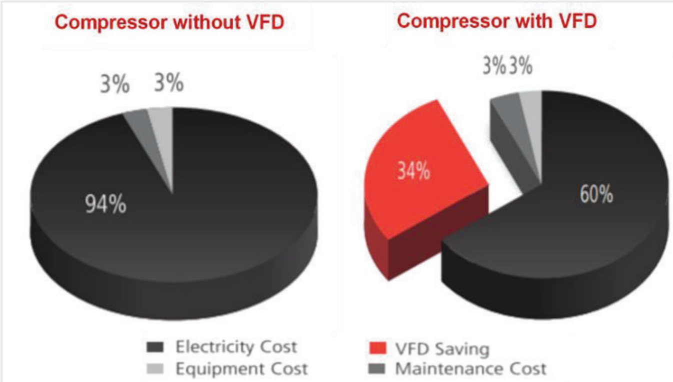


Figure 93: compressor Performance with or without VFD

The Life cycle analysis of the compressor reveals that only 3% of the cost is attributed to the equipment cost, and 94% cost is incurred due to electricity consumption.

The application of VFD in controlling the operation of the compressor will eliminate the no-load power consumption of the compressor motor and will save energy.

In a fixed speed compressor with a star-delta starter, starting current is as high as three times the full load current. The installation of VFD has many electrical and mechanical advantages such as -

Electrical advantages:

- Low Starting Current
- High Efficiency
- Improved Power Factor
- Reduced Maximum Demand

Mechanical advantages:

- Minimum maintenance
- Smooth start
- Smooth control

Table 49: Energy Savings and Payback VFD on Compressor

Sectoral Investment	Rs. 360 lakh
Percentage of Electrical energy savings	7-10%
Approx. Reduction in Electricity consumption (toe/year)	524
Approx. Reduction in GHG emission TCO_2	4,997
Simple Payback Period	<1 year

B2: State of the art technologies

As the Indian steel rolling industry is largely fragmented with small units dominating the sector, there is negligible penetration of energy efficiency technologies. One of the main reasons identified is the unproven commercial viability of energy-efficient technical packages, which inhibited investors' confidence but at the same time, the significant market potential was detected for energy efficiency technologies. Adoption of new technology by domestic Steel Re-rolling producers would lead to the emergence of more competitiveness in critical areas including a quantifiable increase in productivity, quality improvement with reduced cost, improvement in energy efficiency and better compliance with environmental protection legislation safeguards for eco-sustainability of the products. Because the nature of emerging technologies is constant and rapid change, the information presented in this report is also subject to change. The following are the list of innovative emerging technologies:

Note:
Research & Development: The Technology is still in the study phase and has not yet been
Demonstration: The technology has been piloted in a few mills
Commercial: The technology is proven and is being widely used among rolling mill units

Table 50: Innovative Emerging Technologies

No.	Technology Name	Status	Description	Potential Benefits	Link
1	Thermochemical Recuperation for High-Temperature Furnaces	Demonstration Stage	Thermo Chemical Recuperation (TCR) is a new technique that recovers sensible heat in the exhaust gas from an industrial process, furnace. The TCR then uses that heat to transform the hydrocarbon fuel into a reformed fuel with a higher calorific heat content and utilizes this reformed fuel for process heating.	This technology can reduce the fuel consumption in the furnace by 25% or more. CO_2 NOx emissions will be reduced	Source
2	Preventing Scale Formation in Rolling	Research Stage	Scale formation during the reheating and rolling operations results in a loss of material, adversely affect the material quality and require further processing. The research focuses on developing a thorough understanding of the scale formation mechanisms by conducting laboratory and field tests. Based on the findings a model-based control system for temperature and furnace atmosphere is to be developed to reduce scale formation.	Energy consumption and material loss will be reduced. Reduced energy and material costs, and minimization of subsequent corrective measures will reduce the costs.	Source
3	High-Temperature Membrane Module for Oxygen Enrichment of Combustion Air	Research stage	The flame temperature in the reheat furnace can be raised by enriching the combustion air with oxygen. Thermal processing equipment which previously had to rely on high-quality fossil fuels can now be operated with previously unusable process gases and biogases. This benefit arises from oxygen enrichment. To produce O_2 at a low cost, a new method involving ceramic membranes was. Following this, investigations were conducted on the lab-scale furnace to determine whether the combination of high-calorific gas and air could be replaced by a combination of low calorific gas and oxygen for use in reheating furnaces. It was demonstrated that the necessary furnace chamber temperature can also be achieved with low-calorific gases.	Process gas and low calorific gas can be reused.	Source
4	Oscillating Combustion	Demonstration Stage	This project focuses on a new technology that reduces NOx emissions while increasing furnace efficiency for both air- and oxygen-fired furnaces. Oscillating combustion is a retrofit technology that involves the forced oscillation of the fuel flow rate to a furnace. These oscillations create successive, fuel-rich	Efficiency or productivity increases by 5% or more. It improves heat transfer by up to 13%.	Source

No.	Technology Name	Status	Description	Potential Benefits	Link
			and fuel-lean zones within the furnace. The load heats up faster due to the more luminous fuel-rich zones and a longer overall flame length.		
5	Hot Charging	Commercial stage	Charging slabs at an elevated temperature into the reheating furnace of the hot rolling mill will save energy. In addition, hot charging improves material quality, reduces material losses, enhances productivity (by up to 6%), and may reduce slab stocking. The layout of the plant will affect the feasibility of hot charging because the caster and reheating furnace should be located in proximity to one another to avoid a long, hot connection between the two.	Hot charging has reduced specific fuel consumption in the heating furnace by 0.005 toe/tonne product	Source
6	Flameless Burners - Dilute Oxygen Combustion	Commercial	The flameless burner technologies carry out combustion under diluted oxygen conditions using internal flue gas recirculation and the flame becomes invisible. Flameless air-fuel combustion uses air as an oxidizer, while flameless oxyfuel uses commercial oxygen as an oxidant. Flameless oxyfuel gives high thermal efficiency, higher levels of heat flux, and reduced fuel consumption compared to conventional oxyfuel These benefits are combined with low NOx emissions and better thermal uniformity.	In addition to significantly reducing fuel consumption and CO2 and NOx emissions, a flameless oxy-fuel combustion system enabled a plant in the US to increase material throughput by 25% and reduce scale formation by 50%	Source
7	Thin Slab Casting	Commercial	In Thin Slab Casting, the steel is cast directly to slabs with a thickness between 30 and 60 mm, instead of slabs with a thickness of 120 and 300 mm. Thin slab or strip casting processes reduce the steel rolling energy needs significantly. This technology enables faster production of thin products. It results in considerable savings in capital cost outlay, completion and delivery times and energy costs.	Thin slab casting is estimated to reduce CO2 emissions by 779 kg per ton of product.	Source
8	Crop Length Optimization	Commercial	To minimize the amount of material cut off from both ends of the bar (in the steel re-rolling mill plant) the crop optimization system is used to control the crop shear. The crop end control technique can reduce crop end losses by over 50% and thus improve the yield of the rolling mill by up to 3%.	Improves yield	Source

No.	Technology Name	Status	Description	Potential Benefits	Link
9	Spindle and Coupling	Commercial	Universal spindles and couplings enable uniform loading of drive motors, reduced power consumption, and increased roll life	Electrical Savings – 5%	Source
10	Installation of Y-roller table	Commercial	In 3-Hi mills, Y-roller tables are used to enhance productivity with added benefits. It enables uniform temperature drops and ensure minimal damage to the front and back ends of the stock during feeding. It also ensures reduced crop-cutting and misrolls, and has the added advantage of not being dependent on manpower.	Electrical savings of 2 – 10%	Source
11	Computerized roll pass design	Commercial	Typically, rolling in an SRRM unit follows a design developed by the foreman, who is not formally trained and cannot employ scientific methods of roll pass design (RPD). Developed by a Swedish software company, the computerized RPD rationalizes power consumption, increases the life of drive motors, and delivers better product quality.	The computerized RPD rationalizes power consumption, increases the life of drive motors, and delivers better product quality.	Source
12	Use of Pulverized biomass fuel in reheating furnace	Research	The use of biomass fuel in firing the stock in the reheating phase is in the research phase and is experimental in the Jalna cluster. The technology will eliminate the emissions by 33% from the sector	Reduction in emission from the sector by 33%	

B3: Best Operating Practices

The aim of the 'best operating practices' (BOPs) is to assist in the optimization of operational parameters and specific energy usage near the design level. This chapter covers critical and energy-intensive equipment, systems, and processes. It gives an overview of applicable BOPs for the steel rolling industry to follow.

The purpose of this guide is also to provide the Operations and Maintenance (O&M)/plant maintenance team and energy practitioner, with useful information about O&M management, technologies, energy efficiency, and cost-reduction approaches.

Table 51: Best Operating Practices

Areas	Best practices	Monitorable parameters	Key Performance Indicators
Induction Furnace	1. Use of Lid based mechanism to reduce the heat loss 2. Use of good quality lining for the furnace 3. Optimize the charging time and holding time (during Spectro analysis)	➢ Electricity consumption per tonne of liquid metal (kWh/tonne)	➢ Refer Benchmarking section
Reheating furnaces	1. Avoid overheating and burning of metal. 2. Minimizing local cold spot (skid mark) due to water-cooled skids 3. Minimizing temperature difference between surface and centre to the desired level as low as 15°C. 4. Minimizing scale formation, decarburization 5. Proper fuel combustion with minimum oxygen in the combustion product 6. Hot charging of material, wherever possible 7. Recovery of waste heat with the recuperator	➢ Fuel consumption (Unit/tonne) *Unit is – *Ltr for FO, SCM for PNG, Kg for coal*	➢ Refer Benchmarking section
Rolling Mill	1. Thermal cover of roll table in the mill 2. Higher mill speed to reduce the specific heat consumption 3. Reduce idle running of the mill	➢ Mill speed ➢ Rolling motors (Voltage, Current, Power factor and electricity consumption)	➢ Rolling mill Motor average Loading should be greater than 80%
Electrical system	1. Installing capacitors in the AC circuits to enhance the power factor. 2. Minimizing the operation of idling or lightly loaded motors 3. Avoiding the operation of equipment above its rated voltage 4. When replacing motors, use energy-efficient motors	➢ **Motors:** ○ Voltage (Volt) ○ Current (Ampere) ○ Power factor ○ Electricity consumption (kWh)	➢ Transformer Efficiency = 99.5% & above ➢ IE3/IE4 Standard motors recommended

	5. Check the power supply for harmonics and apply filters if required 6. Use: • Direct coupling where possible • Synchronous belts or cogged V-belts in place of V belts • Helical gears in place of worm gears 7. Rewinding: avoid rewinding after 2 times and replace with an EEM, or use a reliable rewinding contractor (up to 2-3 times)	➢ **Transformers:** ○ Voltage (Volt) ○ Current (Ampere) ○ Power (kVA) ○ Oil temperature (°C) ○ Winding temperature (°C) ○ Tap position ○ Harmonics % ➢ **Lighting System:** ○ Illumination (lux) ○ Electricity consumption (kWh)	➢ LED Lighting as per requirement ➢ Motor Loading close to 100% ➢ P.F. should be maintained around 1. ➢ Transformer LT voltage should be maintained around 410 to 415 volts. ➢ Transformer(s) should be operated at above 40-50% load of the rated power.
Pumping System	1. Operate pumping near the best efficiency point. 2. Modify pumping to minimize throttling. 3. Adapt to wide load variation with variable speed drives or sequenced control of smaller units. 4. Balance the system to minimize flows and reduce pump power requirements. 5. Use siphon effect to advantage: don't waste pumping head with a free-fall (gravity) return.	➢ Electricity consumption (kWh) ➢ Suction head (meter) ➢ Delivery head (meter) ➢ Flow rate (m^3/sec.) ➢ Fluid temperature (°C)	➢ Pump Efficiency should be greater than 80%.
Fan & Air Blower	1. Use smooth, well-rounded air inlet cones for fan, blower air intakes. 2. Avoid poor flow distribution at the fan inlet. 3. Minimize fan, blower inlet, and outlet obstructions. 4. Clean screens, filters, and fan blades regularly. 5. Use aerofoil-shaped fan blades. 6. Minimize fan, blower speed.	➢ Electricity consumption (kWh) ➢ Suction head (mm WC) ➢ Delivery head (mm WC) ➢ Fluid temperature (°C)	➢ **Peak Efficiency Range (%)** ○ Airfoil backward curved/inclined = 79% to 83%

	7. Use low-slip or flat belts. 8. Check belt tension regularly. 9. Use variable speed drives for large variable fan, blower loads.		○ Modified radial = 72% to 79% ○ Radial = 69% to 75% ○ Pressure blower = 58% to 68% ○ Forward curved = 60% to 65%
Air Compressors	1. Consider variable speed drive for a variable load on positive displacement compressors. 2. Change the oil filter regularly. 3. Periodically inspect compressor intercoolers for proper functioning. 4. Study part-load characteristics and cycling costs to determine the most efficient mode for operating multiple air compressors. 5. Avoid oversizing -- match the connected load. 6. Reduce air compressor discharge pressure to the lowest acceptable setting. Reduction of 1 kg/cm^2 air pressure would result in 7% input power savings. This will also reduce compressed air leakage rates by 10%) 7. Minimize purges, leaks, excessive pressure drops, and condensation accumulation. (Compressed air leak from 1 mm hole size at 7 kg/cm^2 pressure would mean power loss equivalent to 0.5 kW) 8. Take air compressor intake air from the coolest (but not air-conditioned) location.	➢ Air pressure (kg/cm^2) ➢ Inlet temperature (°C) ➢ Loading time (sec.) ➢ Unloading time (sec.) ➢ Electricity consumption (kWh)	➢ **Reciprocating:** ○ FAD Range (cfm) = 20 to 7000 ○ Pressure range (bar) = 0.8 to 12 ○ SPC range (kW/cfm) = 0.20 to 0.35 ➢ **Screw (Single stage):** ○ FAD Range (cfm) = 50 to 1500 ○ Pressure range (bar) = 0.8 to 13 ○ SPC range (kW/cfm) = 0.14 to 0.25 ➢ **Screw (Multistage):** ○ FAD Range (cfm) = 50 to 1500 ○ Pressure range (bar) = 0.8 to 24

			○ SPC range (kW/cfm) = 0.18 to 0.35
Cooling Tower	1. Control cooling tower fans based on leaving water temperatures. 2. Control to the optimum water temperature as determined from the cooling tower and chiller performance data. 3. Use two-speed or variable-speed drives for cooling tower fan control if the fans are few. Stage the cooling tower fans with on-off control if there are many. 4. Turn off unnecessary cooling tower fans when loads are reduced. 5. Periodically clean plugged cooling tower water distribution nozzles. 6. Replace splash bars with self-extinguishing PVC cellular-film fill. 7. Optimize cooling tower fan blade angle on a seasonal and/or load basis.	➢ Ambient dry bulb temperature (°C) ➢ Ambient wet bulb temperature (°C) ➢ Cooling water inlet temperature (°C) ➢ Cooling water outlet temperature (°C) ➢ Cooling duty water flow rate (m^3/hr.) ➢ Makeup water (m^3/day)	➢ The cycle of concentration (COC) should be maintained between 8 to 10. ➢ The approach should be maintained at 4 °C to 5 °C. ➢ Drift loss should be 0.001 % – 0.005 % of the circulating flow rate

Annexure C: Strategies for Decarbonization and Circular Economy

C1: Steel in the circular economy

The circular economy is a move from linear business models, in which products are manufactured from raw materials and then at the end of their useful lives, the products or their parts are repaired, reused, returned and recycled. The circular economy reduces or eliminates waste and conserve resources.

Circular Economy impacts steel demand via multiple channels.

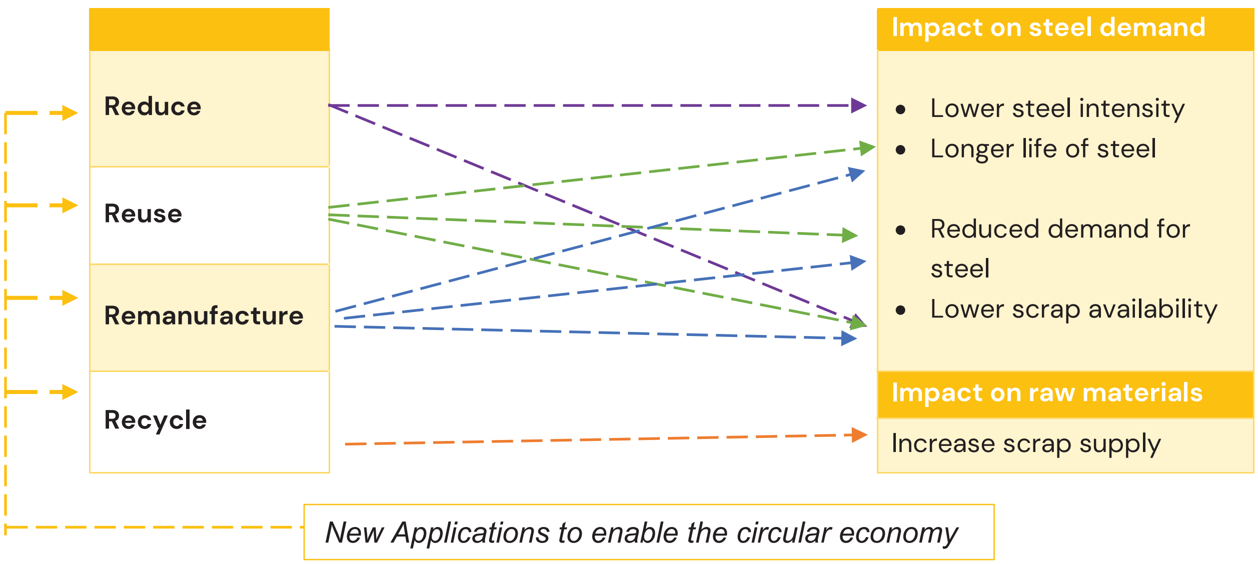


Figure 94: Steel supporting circular economy (Source: Steelforum steel in circular economy)

1. **Reduce:** Steel industry is actively promoting and developing the use of high-strength steel grades in many applications. These grades contribute to the lightweight of applications, as less steel is needed to provide the same strength and functionality.

2. **Reuse:** Because of its durability, steel can be reused or repurposed in many ways, with or without remanufacturing. Reusing a steel beam in its existing form is better than remelting it and rolling a new steel beam, i.e. the energy used to remelt and re-roll the beam is saved.

3. **Remanufacture:** Many steel products can be remanufactured for reuse to take advantage of the durability of steel components. Good quality scrap is suitable for rerolling into bars and shapes.

4. **Recycling:** Steel is 100% recyclable and can be recycled over and over again to create new steel products in a closed material loop. Recycled steel maintains the inherent properties of the original steel. Over 650 Mt of steel is recycled annually, including pre-and post-consumer scrap.

Use of Scrap in steel making

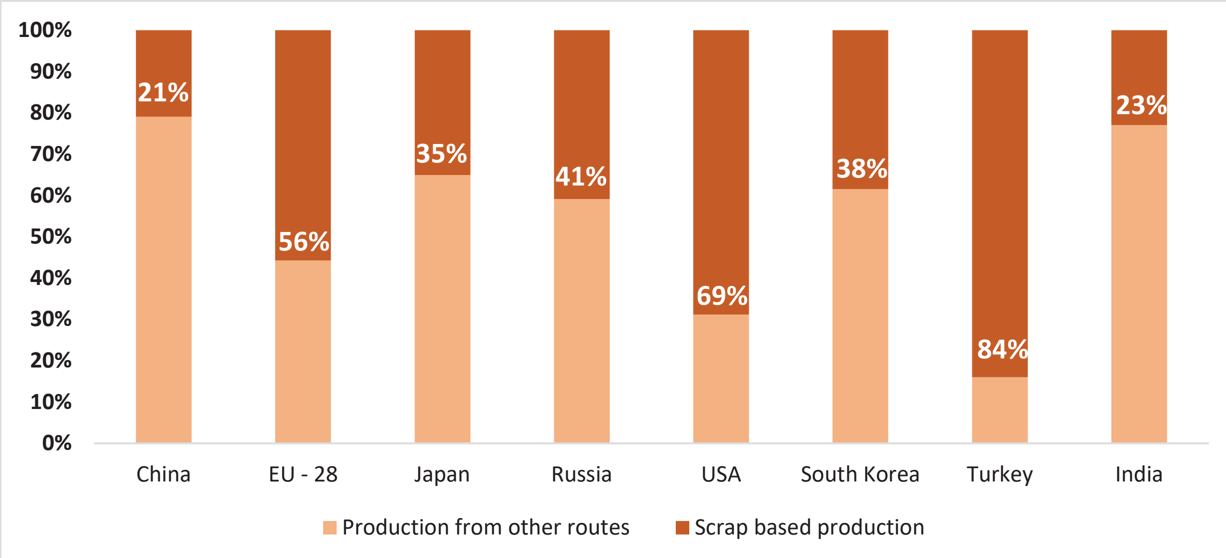


Figure 95: Use of Scrap in Steelmaking (source: BIR, Niti Ayog)

Steel scrap serves as the primary input into steelmaking through the electric arc furnace and the induction furnace routes. Steel from scrap requires 70-75 per cent less energy to produce than steel from iron ore and coal.

As can be seen from the above graph, Turkey uses a higher proportion of scrap about 84% in crude steel production. In India, about 23 percent of the steel is produced from scrap, which shows huge potential to shift from iron ore to scrap-based steel production.

C2: Decarbonizing Steel Sector

Switching to RE based Power Generation

[21]India is endowed with vast solar energy potential. About 5,000 trillion kWh per year of energy is incident over India's land area with most parts receiving 4-7 kWh per sq. m per day. Solar photovoltaics power can effectively be harnessed providing huge scalability in India. India is going to become a global leader in solar energy by creating the policy conditions for solar technology diffusion across the country as quickly as possible. **The country has a target of installing 300 GW grid-connected solar power plants by the year 2030**. This is in line with India's Intended Nationally Determined Contributions (INDCs) target to achieve about 40 per cent cumulative electric power installed capacity from non-fossil fuel-based energy resources and to reduce the emission intensity of its GDP by 33 to 35 per cent from the 2005 level by 2030.

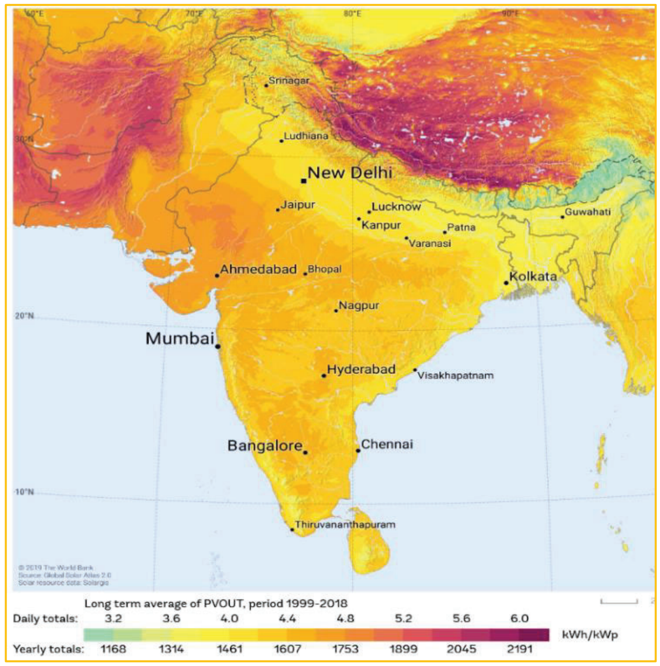


Figure 96: Photovoltaic Power Potential - India

The current installed capacity of solar energy in India as of 30th November 2021 was 48.55 GW. India has recently announced to increase the solar share to 300 GW by 2030. There lies a promising growth trajectory of solar in the coming future.

To meet the Steel Re-rolling sector's electricity requirements, an estimation of about 7 GW of solar systems is required to phase out full electricity demand from grid power plants generating electricity mostly from fossil fuels and move to renewable energy sources.
Steel rerolling mills are often large, with high energy usage. Over the past few years, more and more factories have seen the potential to harness free renewable energy simply by increasing the solar power share in their operations. Factories and warehouses are bringing their energy costs down by using low-cost solar power.

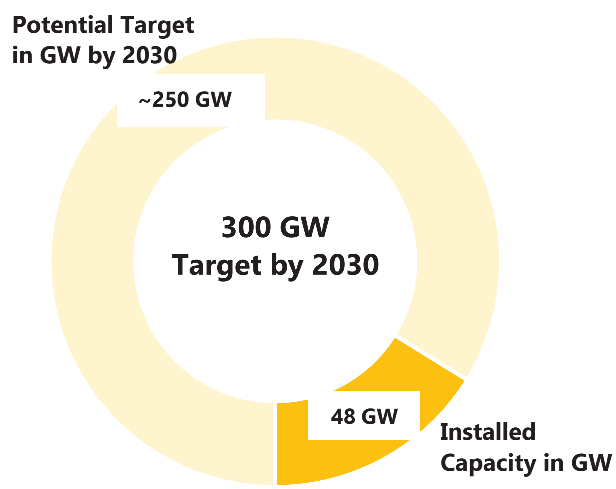


Figure 97: Solar existing capacity vs Target capacity

The Solar system has an estimated payback period of over

[21] https://mnre.gov.in/solar/current-status/
PV Potential – India Map: World Bank, ESMAP, SOLARGIS

4-6 years depending upon the capacity.

The below table provides an estimation of Solar potential in different clusters, the investment required, emission reduction potential.

Table 52: Solar potential in different steel rerolling clusters

Particular	Solar potential (GW)	Investment required (Million Rs.)	Emission saved (Million TCO2)	%of reduction in emissions
Solar Potential in different clusters				
Mandi Gobindgarh & Ludhiana	0.47	1,659	0.52	47%
Jaipur	0.17	591	0.19	51%
Jalna	1.80	6,308	2.00	94%
Raipur	0.61	2,149	0.68	57%
Bhavnagar	0.17	591	0.19	36%
Steel Re-rolling Sector – India				
India Level	7	24,544	7.76	67%

Fuel Switch Possibility from fossil-based fuel to electricity

The composite units have the facilities of melting and rerolling for production. The different energy used in the different processes is mentioned below –

Table 53: Energy Mapping - Process wise

Process	Energy Used	Application
Induction Furnace	Electricity	The charge mix fed into the furnace is moulted. The molten steel is routed through an ingot caster to form semi-finished steel (Billet/Ingot). The semi-finished steel is placed in the yard and charged into reheating furnace for further processing.
Reheating Furnaces	Coal	To raise the temperature of the feedstock to re-rollable temperature
Rolling Mill & Auxiliaries	Electricity	Shaping and sizing of the stock

Continuous Casting and Direct Rolling Technology disrupts the traditional layout and creates a system for continuous casting of billets and transfer the billets from continuous casting to the rolling mill. It bypasses the reheating furnace which in turn eliminate the use of fossil fuel from the unit.

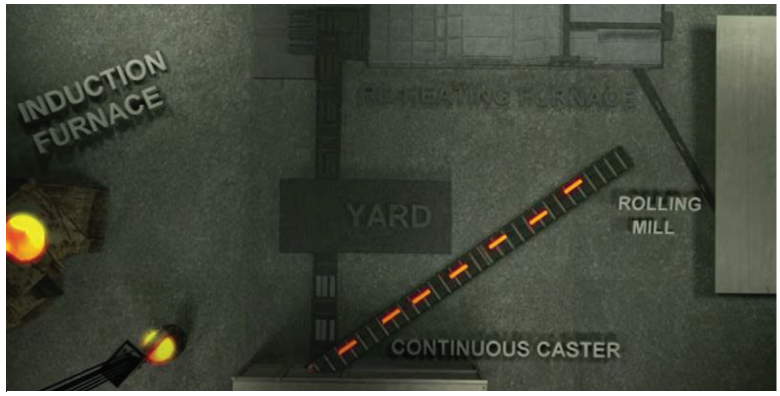


Figure 98: Continuous Casting & Direct Rolling Technology

Continuous Casting – It is a cost-effective and environmentally friendly technology, in which the ladle is placed above tundish, and the molten metal is poured continuously from tundish into the caster. The primary and secondary cooling of the caster helps the metal to solidify during the process.

Direct Rolling – The hot billets coming out of the induction furnace can be directly charged into the rolling mill thus eliminating the process of reheating the furnace.

The advantages of using a CCM with direct rolling are –

- Eliminated use of Re-heating furnace completely
- Avoiding the use of fossil fuel from the unit
- Slight increase in specific power consumption by 10% due to the addition of the roller conveyor system and power consumed in Continuous Casting Machine (CCM) operation.
- Increase in mill yield by 2-2.5%
- Complete elimination of burning loss
- Reduced GHG Emissions

There are around 400 composite mills in the Steel Re-rolling sector of which 150 units have yet to adopt the continuous casting and direct rolling technology. The average annual production from composite factories is around 39,718 MT. The implementation of direct rolling technology will reduce the CO_2 emissions by 1.08 Million tCO_2.

Table 54: Fuel Switch Possibility

Parameter	Unit	Values
Number of Composite units	Nos	400
The present Penetration level of CCM and Direct Rolling Technology (DRT)	Percentage	High (~ 60%)
Average production from composite units	Million Tonne	39,718
Increase in electricity consumption due to implementation of CCM & DRT	Percentage	10%
Additional electricity demand	Million kWh	67.17
Investment required for implementation of CCM & DRT	Million Rs.	3,750
Solar Capacity required to meet additional electricity demand due to the implementation of CCM & DRT	MW	49.76
Investment required for providing additional electricity through solar	Million Rs.	1,742
The total reduction in GHG emission	Million tCO_2	1.08

Use of Green Hydrogen in Steel

The use of hydrogen instead of thermal energy to heat steel is still being tested. However, under the correct circumstances, we may employ Hydrogen heating in rolling mill furnaces, reducing our carbon footprint from the secondary steel industry significantly. It has been observed that hydrogen can be used to heat steel without altering the quality of the metal. If we can make this investment, it will have a significant environmental benefit. Green hydrogen is hydrogen produced by splitting water into hydrogen and oxygen using renewable electricity. It was observed that the current best processes for water electrolysis have an effective electrical efficiency of 70-80%. So that producing 1 Kg of hydrogen (heat value 120-142 Mj/Kg)[22] requires around 53-54 KWh of electricity. The potential of using Green Hydrogen in Steel re-rolling sector is analyzed in the below table-

Table 55: Green Hydrogen potential

Particular	Unit	Value
Total Production	(MTPA)	33
Thermal Energy Consumption	(MTPA)	1.261
Coal Consumption	(MT)	2.04
PNG Consumption	(Million SCM)	30.79
FO Consumption	(Million Litre)	10.6
Green Hydrogen to replace the thermal energy usage		
Potential Green Hydrogen requirement	(MT)	0.403
Requirement of additional Electricity from renewable sources to produce green hydrogen[23] –	(Million KWh)	18,358
GHG Reduction	(Million TCO_2)	3.8

[22] https://world-nuclear.org/information-library/facts-and-figures/heat-values-of-various-fuels.aspx
[23] https://web.archive.org/web/20110702210000/http://www.bellona.org/reports/hydrogen

Annexure D: Existing EE policy initiatives and programs for the sector

Different schemes by the government bodies in the MSME units are given below:

Table 56: Financial Schemes by Government Bodies

Programs	Implementation Agency	Description	Nature of assistance	Source
Micro and Small Cluster Development Program	Ministry of MSME (Govt. of India)	To improve the competitiveness of MSME clusters by focusing on common problems. Primary focus on sustainability and growth of MSMEs by addressing common issues such as "access to technology", "skills and quality", "market access", "access to capital", etc.	**Common Facility Centers:** Grant up to 70% of total project cost (maximum INR 20 Cr)	Link
		Also targeting the capacity development, create/upgrade infrastructural facilities in industrial parks such as training centres, testing centres, effluent treatment plant, etc.	**Infrastructure Development:** Grant up to 60% of total project cost (maximum INR 10 Cr for Industrial estate & INR15 Cr for the flatted factory complex	
Credit linked Capital Subsidy Scheme (CLCSS) *(At present the Scheme is under revision and will be launched soon after obtaining the necessary approvals.)*	Ministry of MSME (Govt. of India)	The primary objective of this scheme is to aid the technology up-gradation of micro and small enterprises, especially in rural and semi-urban areas. Industries that are transforming from small-scale to medium-scale due to the sanction of additional loans under the CLCSS are also eligible for the subsidy.	Businesses can avail of up to 15% subsidy (with a maximum limit of up to Rs. 1 crore) on investment in eligible machinery.	Link
			The subsidy of 15% is available only to businesses that have invested in eligible plant machinery by using term loans borrowed from the pre-approved list of PLIs (Public Lending Institutions).	
Credit Guarantee Fund Trust	Ministry of MSME (Govt. of India) and Small Industrial Development Bank of India (SIDBI)	The scheme is jointly promoted by MoMSME and SIDBI. Trust fund created is to implement "Credit Guarantee Scheme" for providing collateral-free loans up to a limit of INR 200 lakh to individual MSME on payment of a guaranteed fee to the bank by the MSME.	Credit Guarantee Scheme for providing collateral-free loans up to a limit of INR 200 lakh to individual MSME	Link
		The corpus of CGTMSE is contributed by the Government of India and SIDBI. Max up to 85% of the loan amount to the bank is guaranteed by the Trust Fund.		

Scheme of Micro Finance Programme	The Development Commissioner of Small-Scale Industries (SSIs) under the Ministry of MSME	SIDBI offers micro-credit facilities to MSMEs who are engaged in industrial activities. These credit facilities are offered through Micro Finance Institutions (MFIs) or (NGOs). MFIs/NGOs source funds from SIDBI and make the funds available to MSMEs for their commercial needs.	The Government of India provides funds for Micro-Finance Programme to SIDBI, which is called the 'Portfolio Risk Fund' (PRF). At present, SIDBI takes a fixed deposit equal to 10% of the loan amount. The share of MFIs/NGOs is 2.5% of the loan amount and the balance of 7.5% is adjusted from the funds provided by the Government of India.	Link
Energy Efficiency in Small and Medium Enterprises (SMEs) sector	Bureau of Energy Efficiency (BEE)	To improve the energy efficiency of the SME sector in India through accelerating adoption of energy-efficient technologies, knowledge sharing, capacity building, and development of financial innovative financial mechanisms.	Following are the key activities under implementation – a) Technical Assistance and Capacity Building of energy-intensive SME sectors. b) Promoting Energy Efficiency and Technology Upgradation in SMEs through the ESCO route. c) Energy mapping of SME clusters on pan India basis	Link
Promoting Energy Efficiency and Renewable Energy in MSMEs in India (GEF – UNIDO – BEE Project)	Bureau of Energy Efficiency (BEE)	The project "Promoting Energy Efficiency and Renewable Energy in MSMEs in India" aims towards developing and promotion of market environment for introducing energy-efficient technologies and enhancing the use of renewable energy technologies in process applications in energy-intensive MSMEs in 5 sectors (brass, ceramics, dairy, foundry, and hand tools). The project further has scaled up the activities to the national level (in 12 Clusters) to reduce energy usage per unit of product, improve the productivity and competitiveness of units, thereby reducing overall carbon emissions and improving the local environment	Implementation of more than 50 energy-efficient technologies as pilot projects. Around Rs. 1 Crore has been sanctioned as a grant for the implementation of the pilot projects. The project has so far achieved annual energy savings of more than 8500 TOE with Annual monetary savings of 3802 Lakhs rupees. Implemented 17 demo projects in 7 clusters with the financial assistance of INR 87.9 Lakhs.	Link
Financing of Energy Efficiency at MSME (GEF – WB – BEE Project)	Bureau of Energy Efficiency (BEE)	To increase demand for energy efficiency investments in target micro, small and medium enterprise clusters and to build their capacity to access commercial finance. The project is being implemented in two phases and more than 20	Annual Energy savings of 25000 TOE with an average ROI of 18 months has been achieved under this project so far. Three Hundred Fifty (350) energy-saving measures were identified during the implementation of ISO – 50001. Thus, an annual saving	Link

		clusters in India	of INR 900 Lakhs was estimated. Approximately, 330 crores rupees of investment were made by participating MSMEs to implement 3000 energy efficiency measures.	
Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE)	Bureau of Energy Efficiency (BEE)	The Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE) is a risk-sharing mechanism to provide commercial banks with partial coverage of risk involved in extending loans for energy efficiency projects. The Government of India has approved around INR 312 crores for PRGFEE.	BEE will select a Public Financial Institution as the Implementing Agency (IA) for implementing all the activities under PRGFEE. The PFI will take a guarantee from the PRGFEE before disbursement of the loan to the borrower. The Guarantee will not exceed INR 300 lakhs per project (proposed to increase up to INR 1,500 lakhs) or 50% of the loan amount, whichever is less	Link
ZED Certification Scheme for SME	Ministry of MSME (Govt. of India)	ZED Certification scheme that supports Micro, Small, and Medium Enterprises (MSMEs) to achieve Zero Defect and Zero Effect (ZED) manufacturing. It also provides ZED Assessment for certification which promotes the manufacturing of world-class quality products. This scheme supports the 'Make in India' campaign. It is financed by the Government of India and falls under the Ministry of Micro, Small, and Medium Enterprises.	The subsidies provided by the government under this scheme are as follows: • Micro enterprises: 80% • Small enterprises: 60% • Medium enterprises: 50% • An additional subsidy of 5% is provided to MSMEs that are owned by women in the SC/ST category. • An additional subsidy of 5% is provided to MSMEs located in northeast India and J&K.	Link

Different schemes by the financial institutions to uptake the energy efficiency in the MSME units is given below:

Table 57: Financial Schemes by Financial Institutions/Banks

Schemes	FIs/Bank	Purpose	Eligible Borrower	Interest rate	Loan Amount and Tenure	For more information
Timely Working Capital Assistance to Revitalise Industries in Times of Corona Crisis (TWARIT)	Small Industrial Development Bank of India (SIDBI),	The objective of the scheme (ECLGS) is to provide needed relief to MSMEs, whose operations are impacted by COVID - 19	All existing borrower accounts including under Credit Delivery Arrangement with combined outstanding credit facilities up to ₹25 crores as of 29.2.2020, and an annual turnover of up to ₹100 crores for FY 2019-20 are eligible under the Scheme	Uniform rate of 8.25% p.a. with annual reset	Up to 20% of total outstanding loans with SIDBI up to ₹25 crores as of February 29, 2020, with cap exposure of ₹5 crores or as modified by Govt of India / NCGTC, subject to borrower meeting all the eligibility criteria.	Link
			The Scheme is valid for existing customers on the books of the Bank. All borrowers which have not been classified as SMA 2 or NPA by any of the Member Lending Institutions as of 29th February 2020 will be eligible for the Scheme		Tenure - 4 years (moratorium of 1 year + repayment of principal in 3 years)	
SIDBI Assistance to Facilitate Emergency Response Against	Small Industrial Development Bank of India (SIDBI)	To meet emergency / additional working capital requirement of all existing MSMEs having confirmed	For New to Bank customer - At least two years of cash profits and account not in SMA1/2 category	5% p.a. fixed on reducing balance basis	Maximum up to ₹100 Lakh (linked to turnover of the unit)	Link

Schemes	FIs/Bank	Purpose	Eligible Borrower	Interest rate	Loan Amount and Tenure	For more information
Corona Virus – Plus (SAFE PLUS)		order(s) from Central/ State Govt./ Govt. agencies nominated for the purpose and who are manufacturing any products or providing any services directly related to fighting Corona Virus (Covid-19)	For existing Bank customers - Cash profit in last audited balance sheet and account not in SMA1/2 category		Tenure: Revolving WCTL - Repayable over 4-month cycle based on execution schedule of govt orders i.e. each draw against each order to be repaid gradually over a period of 4 months and payment may be made anytime during these 4 months	
Financing End to End Energy Efficiency Investments in MSMEs (4E Financing Scheme)	Small Industrial Development Bank of India (SIDBI)	For implementing Energy Efficiency measures on an end-to-end basis. For meeting the part cost of	MSME units in the manufacturing or services sector.	9.25% to 10% p.a.	Up to 90% of Project cost	Link
		i. capital expenditure for the purchase of equipment/ machinery, installation, civil works, commissioning, etc. (Energy Efficiency measures as recommended in DPR),	Applicant unit should be in operation for at least three years and should have earned cash profit in the last two years of operation and should not be in default to any bank/FI.		Loan amount INR 10 – 150 lakhs	
		ii. Any other related expenditure required by unit, provided it is not more than 50% of (i).			Repayment period (incl. moratorium period of up to 6 months) shall not be	

Schemes	FIs/Bank	Purpose	Eligible Borrower	Interest rate	Loan Amount and Tenure	For more information
		Financing of second-hand machinery/equipment; purchase of land and construction of a building (except minor civil works) shall not be taken up under the scheme.			more than 36 months for loans up to INR 50 lakh and 60 months for loans beyond INR 50 lakh	
SIDBI – Loan for Purchase of Equipment for Enterprise's Development Plus (Speed Plus)	Small Industrial Development Bank of India (SIDBI)	Machinery purchased from identified OEMs manufacturing high-end machines or authorized dealers / Indian subsidiaries of such foreign OEMs, which have a strong brand reputation and with whom SIDBI has entered into an MoU	MSME units with at least 5 years of operations with stable sales and cash profits in the immediate past 3 years.	9.25% to 10% p.a.	Up to 100% financing	Link
		For Existing Customer: Any OEM Proposed machinery should relate to the same line of business	Minimum net sales of ₹ 5 crores and no operating loss in the immediate past two years		2 to 5 years including a moratorium of 3-6 months.	
SIDBI Term-Loan Assistance for Rooftop Solar Pv Plants (Star)	Small Industrial Development Bank of India (SIDBI)	Financing for Solar Panels / Equipment (Including all accessories) from established suppliers, manufacturers, aggregators, etc.	Age of unit: New – 4 years, Existing – 2 years 2 years cash profits & satisfactory repayment track record Proposed Solar rooftop capacity not to exceed the connected load Only On-site projects Stand-alone and Grid-connected, both covered	9.10% to 10.20% p.a.	Up to 100% financing Repayment up to 5 years (including moratorium of 3 to 6 months)	Link

Schemes	FIs/Bank	Purpose	Eligible Borrower	Interest rate	Loan Amount and Tenure	For more information
SIDBI Make in India Soft Loan Fund for Micro Small and Medium Enterprises (Smile)	Small Industrial Development Bank of India (SIDBI)	To support the MSME enterprises in the manufacturing as well as services sector undertaking expansion, to take advantage of new emerging opportunities, as also undertaking modernization, technology up-gradation, or other projects for growing their business	Covering new enterprises in the manufacturing as well as services sector.	Attractive Interest Rates starting from 8.36% onwards (subject to change)	Quantum of assistance: Minimum Loan Size - ₹ 10 lakh for Equipment Finance & Others: ₹ 25 lakh	Link
			Existing enterprises undertaking expansion, to take advantage of new emerging opportunities, as also undertaking modernization, technology up-gradation, or other projects for growing their business		Tenure and moratorium: Repayment period up to 10 years and moratorium of up to 36 months	
					Minimum Promoter Contribution of 15% subject to Maximum DER of 3:1	
Energy Savings for Micro, Small & Medium Enterprises	Canara Bank	To support the MSME enterprises for acquiring/ adopting energy conservation/savings equipment	Units under Small and Medium Enterprises	Attractive Interest Rates	Maximum Rs 100 lakhs in the form of Term loan	Link
			The cost of energy for the unit should constitute not less than 20% of the total cost of production		Tenure and moratorium: Repayment period up to 5-7 years and moratorium of up to 6 months	
			The unit should possess an energy audit report issued by an approved energy Consultant/Auditor		Margin: 10% of the project cost	
Scheme for Financing Energy Efficiency Projects	Bank of Baroda	Financing SMEs for the acquisition of equipment, services and adopting measures for enhancement of energy	Units under Small and Medium Enterprises	Base rate plus 4.00% p.a	Up to 75% of the total project cost, subject to a maximum of Rs. 1/- crore. (Minimum amount of loan Rs. 5/-	Link

Schemes	FIs/Bank	Purpose	Eligible Borrower	Interest rate	Loan Amount and Tenure	For more information
		efficiency/conservation of energy.			Lakhs). IRDEA, at present, gives a grant of Rs. 25,000/- for projects costing Rs. 1/- crore or below to meet the partial cost of Energy Audit. This grant is available for the first 100 projects (SME Sectors only) approved by them. Maximum 5 years, including moratorium, if any.	
SBI - Project Uptech	State Bank of India	To provide financial assistance to the MSME for technology up-gradation e.g., productivity improvement aids, quality control, testing equipment, special purpose machines, low-cost automation, computers, product development, consultancy, etc.	MSME units with Investment in Plant & Machinery up to Rs 10 Crores	SBI Prime lending rates	Medium Term Loan Quantum: 90% of the project cost subject to a Maximum of 1 Crore and a Minimum of Rs.2 Lacs. Tenure: 5-7 years including a moratorium period of 12 months.	Link

Different schemes run by the Ministry of Micro Small and Medium Enterprises for the MSME units are given below:

Table 58: Schemes run by Ministry of Micro Small and Medium Enterprises

Programs	Implementation Agency	Description	Nature of assistance	For more information
Lean Manufacturing Competitiveness Scheme	The Government of India (GoI)	The Government of India (GoI) has upscaled the Lean Manufacturing Competitiveness Scheme (LMCS) for Micro, Small, and Medium Enterprises (MSMEs) to reduce waste in the manufacturing process and improve global competitiveness in the MSME sector.	Lean Management consultants will work with the specially formed team Special Purpose Vehicle (SPV)/Distinct Product Group (DPG) for Lean Management in the unit for 18 months.	Link
			The 80% of hiring cost of LMC is reimbursed through NMIUs to SPVs/Units and 20% of the cost has to be borne by the SPVs/units	
Technology and Quality Upgradation Support to MSMEs	NMCP (National Manufacturing Competitiveness Program) along with GOI	The scheme advocates the use of energy-efficient technologies (EETs) in manufacturing units to reduce the cost of production and adopt a clean development mechanism.	Funding support of up to 75% for awareness programs, subject to a maximum of Rs 75,000 per program;	Link
			Implementation of energy-efficient technologies in MSME units 75% of actual expenditure for cluster-level energy audit and preparation of model DPR;	
			Setting up of Carbon Credit Aggregation Centres. 50% of actual expenditure subject to maximum Rs 1.5 lakh per DPR	
			25% of the project cost as subsidy by the Government of India, balance amount to be funded through a loan from SIDBI/banks/ financial Institutions.	
			75% subsidy towards licensing of products to national/ international standards: up to 1.5 lakh for national and up to 2 lakh for international standard	

Annexure E: Miscellaneous

E1: Questionnaire

QUESTIONNAIRE- STEEL RE-ROLLING SECTOR

Unit Information

Name of the MSME	
Address of the MSME	
Contact Person	
Designation of Contact Person	
Phone No. And Email of Contact Person	
Commencement Year of the MSME	
Category of the MSME (Micro/Small/Medium)	
Installed Capacity	
Plant running hours per day	
Annual plant operating days	
Products Manufactured	
Raw Materials Used	

Composite Mill (Please Tick✓)	**Yes [ ]**	**No [ ]**

Energy Related Information

S.L. No.	Type of Fuel	Monthly average consumption	Cost of Electricity (INR/unit)
1	**Electricity (kWh)**		

S.L. No.	Type of Fuel	*Solid fuel*	*Liquid fuel*	*Gaseous fuel*
1	**Month average consumption** (Kg or m^3 or scm)			
2	**Calorific Value of Fuel** (kcal/kg or scm/m^3)			
3	**Cost of fuel** (INR/unit)			

Production Related Information

S.L. No.	Product Name	Monthly Average Production (Tonnes)
1		
2		
3		

Process Flow Diagram

Other Information

Technology Details:

- Type of melting furnace and temperature
- Type of reheating furnace and temperature
- Type of rolling Mills and its Load
- Yield (%)

Figure 99: Survey Questionnaire

E2: Project Flyer

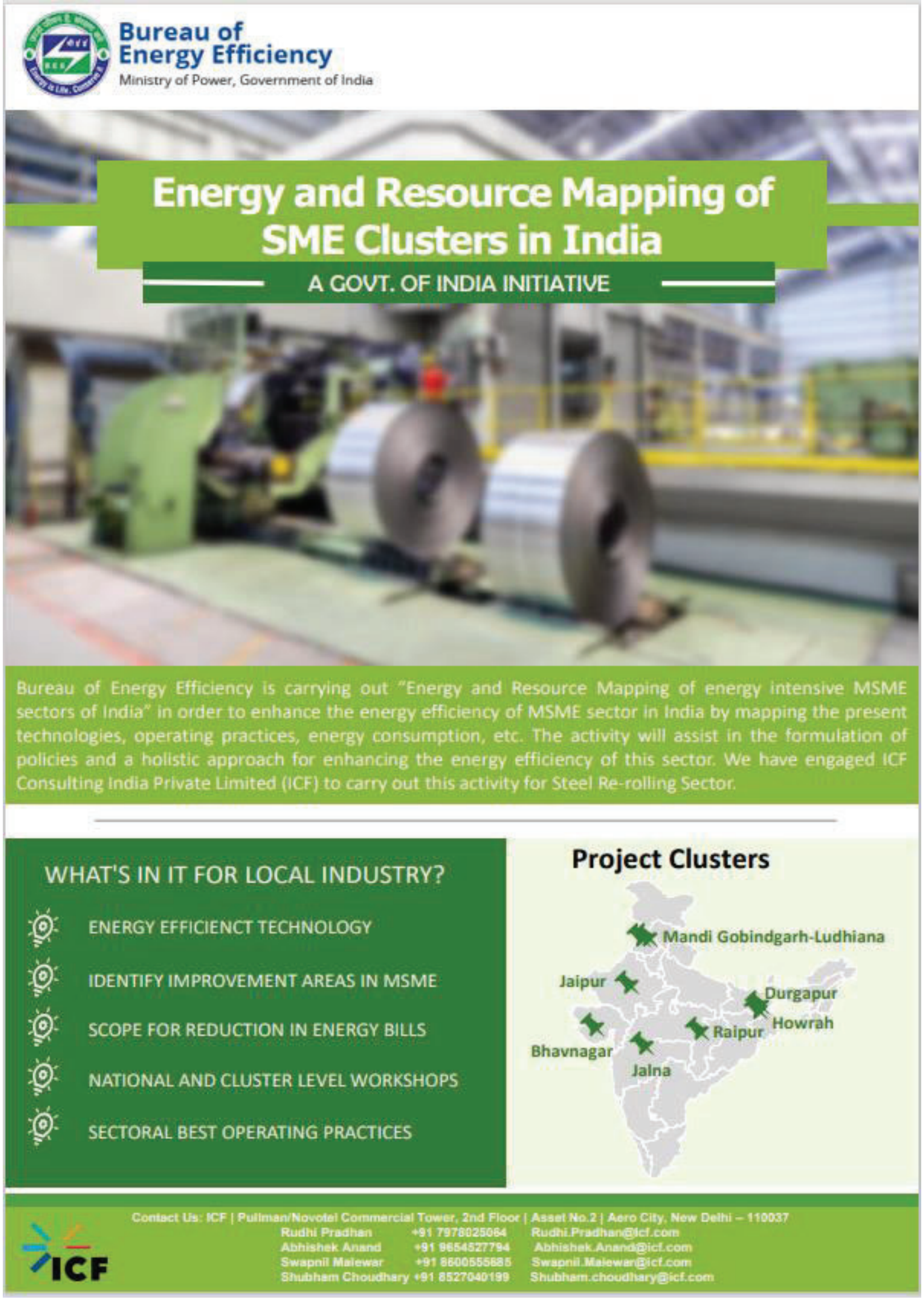


Figure 100: Project Flyer

E3: Sample Agenda

NATIONAL LEVEL DISSEMINATION WORKSHOP
"ENERGY AND RESOURCE MAPPING OF MSME CLUSTERS IN INDIA"
Steel Rerolling SECTOR

11th February 2022 (Friday)
(Venue: Golden Grain Club, Khanna, Punjab)

Background

The Micro, Small, and Medium Enterprises (MSME) sector contribute significantly to the economic and social development of the country by fostering entrepreneurship and generating the largest employment opportunities. The operation of the MSME units accounts for a sizeable portion of energy in its manufacturing costs. The majority of the units are operating on obsolete and low-efficiency technology. To address this issue the Bureau of Energy Efficiency (BEE), Ministry of Power, Government of India has initiated an ambitious project of mapping the energy intensive MSME sub-sectors across the country.

The Steel Rerolling sector is among the other energy intensive MSME sub-sectors covered under the project. The BEE has entrusted ICF to undertake the study in the Steel Rerolling sector. In this regard, workshops have been conducted at Mandi Gobindgarh (Punjab), Ludhiana (Punjab), Jaipur (Rajasthan), Raipur (Chhatisgarh), Jalna (Maharashtra), and Bhavnagar (Gujarat) to take inputs/feedback on policy support required from various stakeholders.

ICF is organizing a national level dissemination workshop for the Steel Rerolling units in the "Mandi Gobindgarh-Ludhiana" region.

Objective

ICF has done a holistic study regarding energy and resource mapping in selected Steel Rerolling clusters of the country. Based on this study, ICF has prepared a draft of the policy roadmap for the sector. The objective of the workshop is to disseminate our findings through this project and to present a sectoral roadmap for advancing towards the low carbon operations to make the sector energy & resource-efficient and environmental friendly.

AGENDA (Draft)

4:30 - 5:00 PM	**REGISTRATION AND TEA**
5:00 - 5:45 PM	**INAUGRAL SESSION**
	• Mr. Pawan Kumar Tiwari, Director, ICF • Mr. Vinod Vashishta, President, All India Steel Rerollers Association (AISRA) • Mr. K.K Garg, President, Ludhiana Steel Re-rollers Association, Ludhiana • Mr. Debaditya Chakrabarti, Director, Steel Rolling Mill Association (SRMA) (Online) • Mr. Bake Bihari Agarwal, General Secretary, Chhattisgarh Steel Rerolling Association (Online) • Mr. Hareshbhai K Patel, President, Bhavnagar Steel Re-rolling Association (Online) • Mr. Nitin Kabra, Steel Manufacturers Association of Maharashtra (Online) • Representative from Punjab Energy Development Agency (PEDA) • Representative from MSME-DI, Ludhiana • Mr Abhay Bakre, Director General, Bureau of Energy Efficiency (BEE)
	Vote of Thanks
	• Mr R.K. Rai, Secretary, BEE
5:45 - 7:15 PM	**Project Overview**
	• Mr. P. Shyam Sunder, Bureau of Energy Efficiency (BEE)
	Presentation on Sectoral Overview, Policy Recommendation and Steel Rerolling Sector Roadmap
	• Mr. Swapnil Nalewar, ICF
	Input from Stakeholders
	• Shri Parmjeet Singh, Addl. Industrial Adviser, Ministry of Steel, Government of India • Shri C R Das, Ex-Industrial Adviser, Ministry of Steel, Government of India • Shri Rajib Kumar Paul, Director, National Institute of Secondary Steel Technology
7:15 - 7:30 PM	**Way Forward & Closing remarks**
	• Shri Milind Deore, Director, Bureau of Energy Efficiency, Ministry of Power
Networking & Dinner	

Conducted By

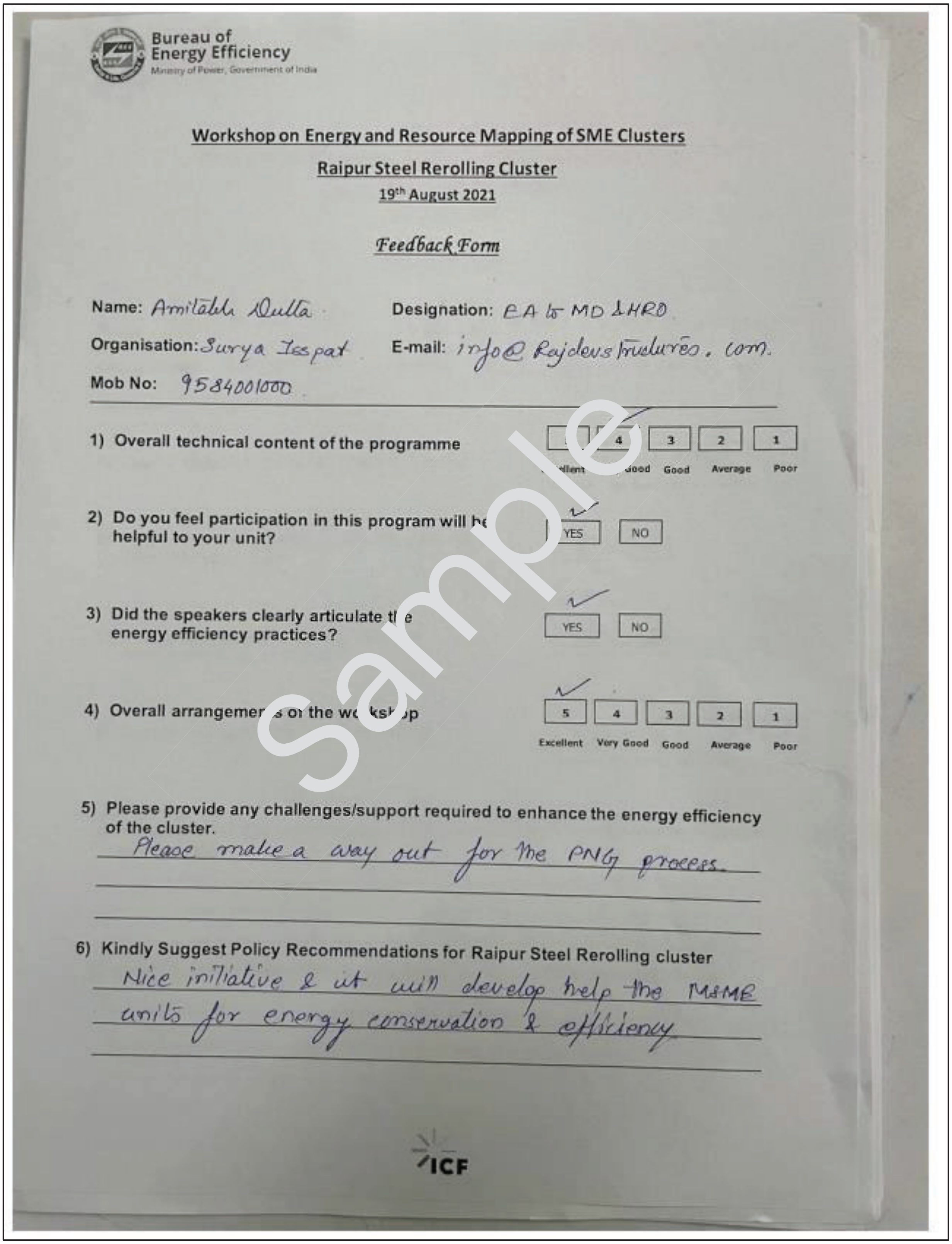
ICF Consulting India Pvt. Ltd., New Delhi

Supported By

Bureau of Energy Efficiency, Ministry of Power

Figure 101: Sample Agenda

E4: Sample Feedback Form



Bureau of Energy Efficiency
Ministry of Power, Government of India

Workshop on Energy and Resource Mapping of SME Clusters

Raipur Steel Rerolling Cluster

19th August 2021

Feedback Form

Name: Amitabh Dutta Designation: EA to MD & HRD

Organisation: Surya Ispat E-mail: info@ Rajdevstructures. com.

Mob No: 9584001000

1) Overall technical content of the programme — 5 Excellent / 4 Very Good / 3 Good / 2 Average / 1 Poor

2) Do you feel participation in this program will be helpful to your unit? — YES ✓ / NO

3) Did the speakers clearly articulate the energy efficiency practices? — YES ✓ / NO

4) Overall arrangements of the workshop — 5 Excellent ✓ / 4 Very Good / 3 Good / 2 Average / 1 Poor

5) Please provide any challenges/support required to enhance the energy efficiency of the cluster.
Please make a way out for the PNG process.

6) Kindly Suggest Policy Recommendations for Raipur Steel Rerolling cluster
Nice initiative & it will develop help the MSME units for energy conservation & efficiency

ICF

Figure 102: Feedback Form

E5: List of Major Stakeholders

Some of the major stakeholders in of these clusters along with their roles and activities are briefed below

Table 59: Major Stakeholders and their roles and responsibilities

Category	Stakeholders	Roles and Responsibilities
National Level Research and Development Organization	**Bureau of Energy Efficiency (BEE)**	1. Create awareness and disseminate information on energy efficiency and conservation 2. Arrange and organize training of personnel and specialists in the techniques for efficient use of energy and its conservation 3. Strengthen services in the field of energy conservation 4. Promote research and development 5. Develop testing and certification procedures and promote testing facilities 6. Formulate and facilitate implementation of pilot projects and demonstration projects 7. Promote the use of energy-efficient processes, equipment, devices and systems 8. Take steps to encourage preferential treatment for use of energy-efficient equipment or appliances 9. Promote innovative financing of energy efficiency projects 10. Give financial assistance to institutions for promoting the efficient use of energy and its conservation 11. Prepare educational curriculum on efficient use of energy and its conservation 12. Implement international co-operation programs relating to efficient use of energy and its conservation
	National Institute of Secondary Steel Technology (NISST)	1. To provide trained technical manpower to the steel sector through short-term and long-term courses and to update their knowledge base. 2. To bring awareness about the State of Art Technology by holding Seminars, Workshops, Symposia etc. 3. To provide various industrial services and testing facilities. 4. To extend consultancy services to industries in terms of solving technical problems related to product quality, productivity, performance improvement studies to reduce the cost of production through process audits, improving energy efficiency and reducing pollution levels. 5. To conduct Research, Development and Design work in frontier areas for providing

		updated technology to this sector. 6. To organize documentation and information retrieval services for the industry. To provide the platform for interaction between industry and education as well as research institutions.
	Material Recycling Association of India (MRAI)	1. Provide policy updates – Keeping its members updated about the notifications relating to the recycling industry 2. Provide market updates – provide access to the latest market report and publications. 3. Represents the interest and issues faced in the recycling industry to the government authorities 4. Promote free trade of recycling material 7. Spreading the awareness of more use of the steel scraps
	Biju Patnaik National Steel Institute (BPNSI)	1. Catalyze the development of quality human resources 2. Synergize industry and academia to foster symbiotic growth 3. Build a Technological Knowledge Base 4. Networking for Technological Information Interchange & Dissemination 5. Consultancy Services on Cutting Edge Technologies
	Steel Research and Technology Mission of India (SRTMI)	1. Spearhead R&D programs of national importance in iron & steel. 2. Facilitate the development of innovative, cutting edge technologies indigenously. 3. Augment expertise and skill level through human resource interventions. 4. Establish world-class manufacturing capabilities through joint collaborative programs. 5. Develop world-class steel products for high-end applications thereby minimizing imports. 6. Enhance dissemination and interaction among the industry-academia – R&D organizations – MoS, GoI through the development of a strong IEC program. 7. Pursue and manage collaborations and synergy amongst industry, national R&D laboratories and academic institutes as per national objectives and aspirations. 8. Meet the National Steel Policy (NSP-2017) goals through strategic R&D interventions. 5. Enhance R&D investments to 1% of turnover in a phased manner.
	National Small Industries Corporation (NSIC)	1. Provides Raw Material Assistance to MSMEs by financing the purchase of Raw Material (Both indigenous & imported) to focus better on manufacturing quality products 2. Provides information on business, technology and finance, and also exhibit the core competence of Indian MSMEs through digital presence 3. Provides technical support to MSMEs through NSIC Technical Service Centres (NTSC)

		and Technology Incubation Centre (TIC) spread across the country 4. Provides Single Point Registration Scheme (SPR) to MSMEs for availing different exemptions and participation in public procurement 5. Provides material and product testing, energy audits through its various testing laboratories accredited by NABL / BIS
	SAIL RDCS	1. Know-how transfer of technologies developed by RDCIS 2. Consultancy services / Contract research 3. Specialised testing services 4. Provide training
State Government Bodies	**State Designated Agency (SDA)**	1. Co-ordinate, regulate and enforce the Energy Conservation Act 2. Demonstration of energy efficiency projects 3. Creating awareness on energy efficiency through various programs/seminars
	State Council for Science & Technology	1. Policy and planning for science & technology. 2. Facilitate and demonstrate technologies to industries especially MSMEs. 3. Capacity building of the workforce of varied industrial sectors
	MSME – DI	1. Advising in policy formulation for the promotion and development of MSMEs. 2. Providing techno-economic and managerial consultancy, common facilities and extension services to MSMEs. 3. Providing facilities for technology up-gradation, modernization, quality improvement and infrastructure. 4. Developing Human Resources through training and skill up-gradation. 5. Facilitating cluster development as a vehicle for MSME Ecosystem development
	District Industries Center (DIC)	1. Development and expansion of industrial clusters 2. Surveys the existing traditional and new industries and raw materials and human resources 3. Prepares techno-economic feasibility reports to give investment advice to the entrepreneurs. 4. Conducts training for the skill development of the entrepreneurs and workers 5. Facilitates arrangements for credit facilities to provide financial assistance to the entrepreneurs 6. Facilitates the procurement of machinery and equipment

		7. Conducts market surveys and market development programmes. Make the entrepreneurs well informed of the market intelligence
Associations	**National Level Association**	
	All India Steel Re-Rollers Association (AISRA)	Bhadla Road, Khanna, Punjab, 141401 Tel: +91-7837100415 Mr Vinod Vashishta, President Email: aisramgg@gmail.com
	Steel Rolling Mill Association (SRMA)	Everest Building, Chowringhee Road, Midleton Row, Kolkata – 700071 Tel: +91-3322885697 Shri. Vivek Adukia, Chairman Website: www.srma.co.in
	Mandi Gobindgarh & Ludhiana Cluster	
	Ludhiana Steel Re-Rollers Association	Industrial Area B, Gill Road, Ludhiana Tel: +91-9814082559 Mr K.K. Garg, President Email: kkgarg@sharusteels.com
	Bhavnagar Cluster	
	Bhavnagar (Sihor) Steel Re-Rolling Association	Plot No. 101, GIDC Phase -2, Sihor – 364 240. Dist – Bhavnagar. Gujarat; Shri Hareshbhai K. Patel Tel: 0278-2429573, +919825205053 E-mail: ssrrassociation@yahoo.com
	Jaipur	
	Rajasthan Steel Chambers	R-234, Road No.9, V.K.I. Area, Jaipur - 302013 Tel: 0141-2331308, 2331194, 2332666 Mr Sitaram Aggarwal, President Email: director@manglaispat.com
	Vishwakarma Industries	E-102 (A), Road No.8, V.K.I. Area, Jaipur - 3022013

	Association	Tel: +91-9829389700 Mr Lakhan Goyal, Vice-President Email: goyal_aman555@yahoo.com
	Bagru Industrial Association	Building RIICO Industrial Area Bagru Extension 303007 Tel: +91-9314966007 Mr R.K. Aggarwal, President Email: director@manglaispat.com
	Jalna	
	Steel Manufacturers Association of Maharashtra	5Th Floor, Potia Indl Estate, Darukhana, Mumbai 400010 Shri Anil Goyal - Additional Secretary Tel: 02223726689; Email: sram.1113@rediffmail.com Website: https://www.sramlive.in
	Raipur	
	Chhattisgarh Steel Re-Rollers Association	1st Floor, Sona Tower, Ramsagarpara, Raipur Ho, Raipur, 492001 Mr Banke Bihari (General Secretary) Tele: 9752007701 Email: cgsra@rediffmail.com Website: http://csraraipur.in/

E6: Support Letters from Associations

SSRMA

Unity For Prosperity

SIHOR STEEL RE-ROLLING MILLS ASSOCIATION [REGD.]

Regd. Office : 101, G. I. D. C. Phase-2, SIHOR-364 240 (Gujarat)
Mo. : 9825205053 e-mail:ssrrmassociation@yahoo.com

Dt.01-10-2021

To,
The Sr. Energy Specialist
ICF,
New Delhi 110037.

Subject: Support required from Government for sustainable Growth of rerolling mill cluster situated at Sihor – Bhavnagar Gujarat.

Dear Sir,

We are in response to your workshop regarding subject matter held in Bhavnagar. We have received following suggestions from our stack holders and executive committee, which will be helpful for development of the steel industries in area. At this stage the growth is somewhat stagnant due to various factors.

i. The technology used in our rerolling mills are obsolete and upgradation is required. New energy efficient machinery will not only improve productivity and profitability but will provide better quality with less pollution.

ii. Some pilot projects with full financial assistance from Government agencies are required to be completed with state-of-the-art technology for rerolling mills. The result will lure more unit owners to opt for new technology with above mentioned benefits. Soft loan and special finance with attractive terms should be a part of the package.

iii. For better quality control and energy efficiency, the coal based reheating process should be replaced by clean fuel like LPG or PNG. A network of pipeline should be made in the cluster so that such fuel will be available at competitive rate.

iv. For green energy, solar park should be erected under group captive power scheme under ESCO model so that the unit owner can pay the cost directly from the benefit they received.

v. The Electric Distribution Company should be directed to give special affordable tariff for steel sector so that the units which are now manufacturing steel products only during concessional night tariff for night hours, can increase productivity 3 times without any additional investments. The better tariff is very important as now Bhavnagar will be a hub for vehicle scrap yard along with ship recycling yard.

vi. A full-fledged testing facility with NABL accreditation is required in line with IS specification to test raw material as well as finished product to make our product at par in quality with international standard as lot of export possibilities remains unexplored in steel sector as Gujarat is having three major ports.

Conte...2..

SIHOR
STEEL RE-ROLLING MILLS
ASSOCIATION [REGD.]

Unity For Prosperity

Regd. Office : 101, G. I. D. C. Phase-2, SIHOR-364 240 (Gujarat)
Mo. : 9825205053 e-mail:ssrrmassociation@yahoo.com

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vii. A skill development center is required to give training to local workers to operate latest machineries and get them ready to adopt world class work practice.

viii. The Government should encourage the local supplier to have updated technology and better work practice to provide services at local level and generate employment for youth of this area.

We hope that your recommendation to Government will open doors of a new era of steel industries in Bhavnagar,

With Regards.

For Sihor Steel Rerolling Mills Association

Haresh Patel
(President).

THE JALNA STEEL MANUFACTURES ASSOCIATION
C/O PLOT NO C-1 TO C-11, ADDITIONAL MIDC PHASE-I, JALNA
Mail ID: gcklika@gmail.com,kalikajalna@gmail.com Mobile No: 9823088661

7th December 2021

To,
Rudhi Pradhan,
Senior Energy Specialist,
ICF Consulting India Pvt. Ltd.
2nd Floor, Caddie Commercial Tower, Aerocity, Delhi - 110037

Ref : Meeting at Jalna steel cluster

Dear Sir,
During your visit to Jalna steel cluster and sub sequent meeting we had with all the stake holder, we have derived at following points for implementing to enhance operational efficiency and marketability of the cluster.

1) We at Jalna steel industry are basically recycler of steel through Induction furnace route. We consume lot of electric energy to operate our induction furnaces. Jalna steel industry as a whole consume @300 Million KWh per month. Cost of electricity is major component in our cost of conversion. We are interested in sourcing solar energy for our operation, subject to net cost of that solar energy is below Rs 5/KWH at our meter end. We request you to kindly pursue with department of energy to formulate and draft a policy where in big ticket investor in solar energy can be attracted to set up their solar park and supply electric energy to us. We are looking for long term association (@20 years) for such arrangement.

2) We since long trying to in-corporate industry-based curriculum in engineering colleges, for which we have designed one tailor made curriculum for 'Post Graduate Diploma In Rolling Mill Technology'. We tried our level best to get nod of AICTE for allowing engineering colleges in our vicinity to grant them permission to run such courses. Somehow our efforts didn't convert into outcomes. We would like Ministry of Steel to look into the matter and expedite the process.

3) As you are aware steel industry is energy guzzling industry and bears burnt of high fuel cost. Though the industry has been rolling hot billet directly from Continuous casting machine, still 10/15% of billet need to be fed by reheating furnaces. Presently these furnaces are fired using pulverized coal which can be easily shifted to CNG/PNG. Shendra MIDC which is 40 Kms from our cluster is under completion of gas pipeline. We request your good office to kindly pursue with the concerned department and extend the said pipeline to Jalna MIDC phase 1,2 and 3.

THE JALNA STEEL MANUFACTURES ASSOCIATION

C/O PLOT NO C-1 TO C-11, ADDITIONAL MIDC PHASE-I, JALNA
Mail ID: gcklika@gmail.com,kalikajalna@gmail.com Mobile No: 9823088661

4) Steel production from the scrap is less energy and emission intensive. As per national vehicular scrappage policy, the vehicle which fails the fitness test needs to be scrapped and deregistered. To enhance the availability of the scrap please provide deregistration authorization facility of scrapped vehicles and scrap processing centers in the cluster.

Looking forward to seeing effective action on above prayers of ours. This will help in reducing the energy and emission intensity, upskilling the workforce for the sustainability of the steel rerolling sector.

Regards,

Nitin Kabra
For,
Jalna Steel Manufacturers' Association

E7: Technology Penetration level over the years

Table 60: Moderate Scenario

Measures	Incremental Penetration of EE Technologies from the present level			
	2023	2025	2027	2030
Installation of VFD on CCM (Continuous Casting Machine) pump to optimize the pressure and flow	10%	20%	30%	40%
Installation of Oxygen and CO sensor to optimize the excess air of the furnace	5%	10%	15%	20%
Installation/ Overhauling of the recuperator to reduce the flue gas heat loss	10%	20%	30%	40%
Installation of VFD in the compressor to eliminate the no-load power consumption	10%	20%	30%	40%
Installation of automation and temperature control system in the reheating furnace	5%	10%	15%	20%
Installation of Energy Monitoring System (EMS) to optimize the power consumption in a different section of the Plant	5%	10%	15%	20%
Replacement of the existing compressor with energy efficient (low specific power consumption) compressor	5%	10%	15%	20%
Replacement of the multiple cooling water pumps with single energy efficient pump with VFD	10%	20%	30%	40%
Improvement in the efficiency of Induction Furnace by using proper grade and quality ramming mass	5%	10%	15%	20%
Overhauling of the furnace with proper insulation lining	10%	20%	30%	40%
Installation of the Scrap processing unit to reduce melting cycle time and energy consumption in the induction furnace	2%	4%	6%	8%
Installation of Solar PV Panels				
Replacement of SCR based induction furnace with energy-efficient IGBT based induction furnace	2%	4%	6%	8%
Implementation of continuous casting and direct rolling to eliminate the requirement of reheating furnace	2%	4%	6%	8%
Installation of Universal spindles & couplings	5%	10%	15%	20%
Installation of Sintering panel to preheat the ramming mass	1%	2%	3%	4%

Installation of Y- roller table/tilting table in 3-Hi mill stands of rolling mills	2%	4%	6%	8%
Fuel shifting from coal to PNG	1%	2%	3%	4%
Installation of regenerative burners in the PNG fired reheating furnace	0%	0%	0%	0%
Installation of Crop length optimization to enhance the yield	1%	2%	3%	4%
Installation of The membrane-based oxygen-enriched combustion	1%	2%	3%	4%
Installation of energy-efficient roller motor for each rolling strand	2%	4%	6%	8%
Installation of Anti friction roller bearings	1%	2%	3%	4%
Installation of energy efficient furnace with top and bottom firing	0%	0%	0%	0%

Table 61: Energy Efficient Scenario

Measures	Incremental Penetration of EE Technologies from the present level			
	2023	2025	2027	2030
Installation of VFD on CCM (Continuous Casting Machine) pump to optimize the pressure and flow	15%	30%	45%	60%
Installation of Oxygen and CO sensor to optimize the excess air of the furnace	10%	20%	30%	40%
Installation/ Overhauling of the recuperator to reduce the flue gas heat loss	15%	30%	40%	50%
Installation of VFD in the compressor to eliminate the no-load power consumption	20%	30%	40%	50%
Installation of automation and temperature control system in the reheating furnace	10%	20%	30%	40%
Installation of Energy Monitoring System (EMS) to optimize the power consumption in a different section of the Plant	10%	20%	30%	40%
Replacement of the existing compressor with energy efficient (low specific power consumption) compressor	7%	15%	22%	30%
Replacement of the multiple cooling water pumps with single energy efficient pump with VFD	15%	20%	40%	50%
Improvement in the efficiency of Induction Furnace by using proper grade and quality ramming mass	10%	15%	20%	25%

Overhauling of the furnace with proper insulation lining	15%	30%	40%	50%
Installation of Scrap processing unit to reduce melting cycle time and energy consumption in the induction furnace	4%	8%	12%	16%
Installation of Solar PV Panels	15%	25%	35%	50%
Replacement of SCR based induction furnace with energy-efficient IGBT based induction furnace	7%	15%	22%	30%
Implementation of continuous casting and direct rolling to eliminate the requirement of reheating furnace	7%	15%	22%	30%
Installation of Universal spindles & couplings	7%	15%	22%	30%
Installation of Sintering panel to preheat the ramming mass	2%	4%	6%	8%
Installation of Y- roller table/tilting table in 3-Hi mill stands of rolling mills	4%	8%	12%	16%
Fuel shifting from coal to PNG	2%	4%	6%	8%
Installation of regenerative burners in the PNG fired reheating furnace	1%	2%	3%	4%
Installation of Crop length optimization to enhance the yield	2%	4%	6%	8%
Installation of The membrane-based oxygen-enriched combustion	4%	8%	15%	25%
Installation of energy-efficient roller motor for each rolling strand	4%	6%	8%	10%
Installation of Anti friction roller bearings	2%	4%	6%	8%
Installation of the energy-efficient furnace with top and bottom firing	1%	2%	3%	4%

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