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Indian Secondary Steel Sector

Cluster Mapping and Resource Consumption Study

IMPRINT

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Executive summary

The industry sector is the largest consumer of commercial energy in India with a final energy consumption of 328 million tonne (2019-20) accounting for about 56% of total final energy consumption. Within the industry sector, the iron and steel industry is the highest consumers of final energy, accounting for about 17% of total energy consumption in industry sector. The iron and steel sector has an important role in Indian economy, contributing to about 2% to the country's GDP. The Indian steel industry can be classified into primary producers and secondary producers. The primary producers have undertaken a number of steps, in terms of technology upgradation, energy conservation measures, etc. to improve their energy performance. Further, these large producers, whose annual energy consumption are 20,000 tonne of oil equivalent (toe) or above are covered under Perform, Achieve and Trade (PAT) programme under the Energy Conservation Act, 2001 to reduce their specific energy consumption level as set by the Bureau of Energy Efficiency (BEE) on mandatory basis.

A large number of secondary producers have significant scope to improve their energy efficiency through technology upgradation and energy conservation measures in process and utilities. Some of the important secondary steel producers include (1) foundry, (2) forging industry, (3) steel re-rolling mill, (4) sponge iron (direct reduction of iron), (5) electric arc furnace and (6) electric induction furnace sub-sectors. Availability of baseline data is important along with potential energy efficiency measures for improving the performance of these sub-sectors. However, the baseline data on energy consumption of these sub-sectors are not readily available.

A study was undertaken for analysis of energy consumption using secondary data to assess energy consumption, energy performance (specific energy consumption) and GHG emissions. The total energy consumption covering Non-DC units in these secondary steel sub-sectors is estimated to be 11.8 mtoe and the equivalent GHG emissions are 58.2 million tonne CO_2 per year (table 1.0).

Table 1.0: Summary of energy consumption of secondary steel sub-sectors (Non-DC)

S No	Sub-sector	Number of industries		Production (Non-DC) (mtpa)	Energy consumption (Non-DC) (mtoe/yr)	Average SEC (GJ/t)	GHG emissions (mt-CO_2/yr)	Specific GHG emissions (t-CO_2/t)
		Total	Non-DC					
1	Foundry	5,000	5,000	10.1	0.9	3.6	6.6	0.6
2	Forging	705	705	2.4	0.3	5.9	1.6	0.7
3	Steel re-rolling	1,313	1,257	34.1	1.7	2.1	6.5	0.2
4	Sponge iron	333	223	14.1	7.4	22.0	30.0	2.1
5	Electric arc furnace	55	37	0.3	0.1	1.9	0.1	0.4
6	Induction furnace	1,103	1,037	24.9	1.5	2.4	13.4	0.5
	Total	8,509	8,222	85.9	11.8		58.2	

Note: Indicated total number of forging units in four clusters

The total number of industries in different sub-sectors is also given in the table, as reported in different sources. Based on parameters such as total number of units, total energy consumption, etc. twelve clusters/ states in each sub-sector have been short-listed for further deep diving in secondary steel sector (table 2.0).

Table 2.0: Clusters short-listed in secondary steel sub-sector for deep-diving

S No	Sub-sector	Cluster/state	State	Number of Non-DC industries	Production (tpy)	Energy consumption (toe)	GHG emissions (t-CO_2/yr)
1	Foundry	Ahmedabad	Gujarat	450	543,600	46,098	346,435
		Rajkot	Gujarat	700	537,000	51,219	364,703
2	Forging	Rajkot	Gujarat	90	268,548	46,559	183,642
		Ludhiana	Punjab	510	372,000	58,496	281,565
3	Steel re-rolling	Raipur	Chhattisgarh	81	2,747,700	143,290	655,712
		Fatehgarh Sahib (Mandi Gobindgarh)	Punjab	132	2,634,600	129,510	572,245
4	Sponge iron	Odisha	Odisha	51	3,989,000	2,098,521	8,478,741
		Jharkhand	Jharkhand	26	2,413,000	1,269,045	5,127,372
5	Electric arc furnace	Odisha	Odisha	3	631,894	28,639	263,076
		Maharashtra	Maharashtra	4	586,129	26,565	244,023
6	Induction furnace	Fatehgarh Sahib (Mandi Gobindgarh)	Punjab	60	1,593,366	93,180	855,956
		Raipur	Chhattisgarh	34	1,293,437	75,640	694,835

Contents

List of tables

List of figures

List of abbreviations

AEMA	Ahmedabad Engineering Manufacturers Association
AIFI	Association of Indian Forging Industry
BCCI	Belgaum Chambers of Commerce and Industries
BEE	Bureau of Energy Efficiency
BF	Blast Furnace
BFC	Belgaum Foundry Cluster
BOF	Basic Oxygen Furnace
BSSIA	Belgaum Small Scale Industries Association
CF	Cupola Furnace
CO_2	Carbon dioxide
CODISSIA	Coimbatore District Small Industries Association
COSMAFAN	Coimbatore Tiny and Small Foundry Owners Association
COFIOA	The Coimbatore Foundry and Industry Owners Association
DC	Designated Consumer
DRI	Direct Reduced Iron
EAF	Electric Arc Furnace
EC	Energy Conservation
EIF	Electric Induction Furnace
GCV	Gross Calorific Value
GDP	Gross Domestic Product
GEDA	Gujarat Energy Development Agency
GHG	Greenhouse Gases
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GJ	Giga Joule
GLIA	GIDC (Lodhika) Industrial Association
GOSHMA	Gokul Shirgaon Manufacturers Association
IF	Induction Furnace
IIF	Institute of Indian Foundrymen
IGBT	Insulated gate bipolar transistor
JPC	Joint Plant Committee
KEA	Kolhapur Engineering Association
KREDL	Karnataka Renewable Energy Development Limited
LSP	Local service provider
MAKH	Manufacturers Association of Kagal Hatkanangale
MEDA	Maharashtra Energy Development Agency
MoSPI	Ministry of Statistics and Programme Implementation
MPUVNL	M.P. Urja Vikas Nigam Limited
MS	Mild steel
Mtoe	million tonne of oil equivalent
MTPA	Million tonnes per annum
NG	Natural gas
OEM	Original Equipment Manufacturer

PAT	Perform, Achieve and Trade
PEDA	Punjab Energy Development Agency
REA	Rajkot Engineering Association
SAMEEEKSHA	Small and Medium Enterprises Energy Efficiency Knowledge Sharing
SCM	Standard cubic metre
SCR	Silicon controlled rectifier
SMAK	Shiroli Manufacturers Association of Kolhapur
SMAM	Steel Manufacturers Association of Maharashtra
SPV	Special purpose vehicle
SVIA	Shapar Veraval Industrial Association
TERI	The Energy and Resources Institute
TMT	Thermo Mechanically Treated
tpa	Tonnes per annum
TPM	Tonnes per month
tpy	Tonnes per year
toe	tonne of oil equivalent
WHR	Waste heat recovery

Acknowledgements

The Energy and Resources Institute (TERI) expresses its sincere gratitude to the German Development Cooperation, GIZ office, New Delhi for entrusting TERI to work on the project titled ‘Cluster mapping of secondary steel sector in India and identification of minimum two clusters per sub-sector for further deep dive activities’. We express our thanks to the officials of GIZ for their support and guidance in preparation of the cluster mapping report on secondary steel sector in India.

TERI is also thankful to various industry associations, entrepreneurs and sectoral experts in secondary steel sector for sharing their valuable inputs in preparation of this cluster mapping report.

About the project

Background

The project on "Energy Efficiency in Industry and Data" under the energy efficiency component of 'Indo-German Energy Programme' (IGEN-EE) being commissioned by BMZ has the following main objectives: (i) capacity building of selected SDA's to promote energy efficiency in Non-DC industries, (ii) providing Non-DC secondary steel and pulp and paper industries with access to information on key energy efficiency processes and technologies, (iii) institutionalization of peer to peer learning among SDAs and Non-DC secondary steel and pulp and paper industry clusters, and (iv) National Energy Efficiency dialogue for secondary steel and pulp and paper sector between policy makers, research institutions and business associations.

The steel industry in India is one of the most important segments of the manufacturing sector contributing to the infrastructure development, housing and urbanization. Ranking 2nd in the world, the Indian steel industry produced about 99.6 million tonne of crude steel during 2020 and 111.3 million tonne (mt) during 2019 (MoS, Annual report, 2020-21). The consumption of finished steel in the year of 2020 is 88.5 mt and 102.6 mt during the year of 2019. Steel industry contributes about 2% of country's GDP. The total energy consumption of iron & steel sector is estimated to be 54.6 million tonne of oil equivalent (mtoe), which is about 10% of total final energy consumption (MoSPI, 2019).

The Indian steel industry comprises mainly two sectors namely (1) primary steel producers and (2) secondary steel producers. The primary steel producers are large steel industries which are covered under the mandatory programme of PAT (perform, achieve and trade) being implemented by the Bureau of Energy Efficiency (BEE) under the Energy Conservation Act, 2001 to reduce their specific energy consumption level.

The secondary steel sector includes several sub-sectors, namely sponge iron units, electric arc furnace (EAF), electric induction furnace (EIF), foundry, forging, rerolling, galvanized coil/ sheet, alloy steel, pelletizing units, etc. Majority of units in these sub-sectors are SMEs and are not covered under the PAT scheme but as a group, they are large consumers of energy and there exists substantial scope for energy conservation in these sub-sectors. In many cases, the units are located in clusters, which provide a good opportunity to develop deep-dive cluster based programs for efficiency improvements. Literature survey and earlier studies shows that the secondary steel sector is an important sector having significant level of energy consumption based on end product and technology use with a wide bandwidth of 'specific energy consumption' (SEC). Secondary steel sector therefore offers significant energy saving potential by providing suitable technical assistance. In order to draw a road map and initiate and strengthen energy efficiency programmes in secondary steel sector, a mapping study of secondary steel sector was undertaken covering all key MSME clusters in India.

Objectives

The major objectives of the proposed study include the following:

(1) Mapping of clusters under individual sub-sectors of secondary steel sector in India
(2) Identifying and recommending minimum two clusters per sub-sector to be selected for further deep-dive activities

The mapping exercise was undertaken to help in developing a comprehensive database on energy consumption and energy performance of different secondary steel clusters across the country.

Chapter 1

1.0Indian industry sector

1.1 Background

The energy consuming sectors of India include industry, transport, residential, commercial & public services, agriculture/ forestry, non-energy use and non-specified (others). The total final energy consumption of India is estimated to be 587 million tonne of oil equivalent (mtoe) during 2019-2020(P) (MoSPI, 2021). The industry sector, which is an important sector in Indian economy, accounts for about 56% of total final energy consumption. The share of transport, residential, agriculture, commercial & public sectors and other sectors is estimated to be 41% of the total final consumption.

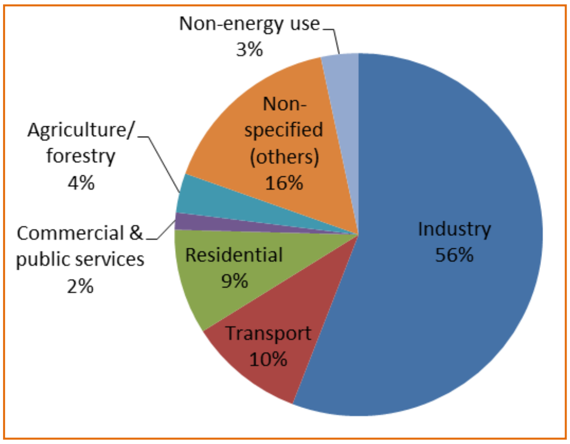


Figure 1.1 Final energy consumption of India (2019-2020P)

1.2 Energy efficiency programmes for large industries

The energy intensive industries are mandated under the Energy Conservation (EC) Act enforced by the Bureau of Energy Efficiency (BEE) to reduce their energy intensities based on their energy consumption levels under the 'perform, achieve and trade' (PAT) scheme. The threshold limit for energy consumption for individual industries in iron & steel sector to qualify as 'Designated Consumer' (DC) under PAT scheme is presently set at 20,000 toe per year (table 1.2).

Table 1.2: Threshold limits of energy intensive industries under PAT scheme

Industry	Energy threshold limit (toe per year)
Aluminium	7,500
Cement	30,000
Chlor alkali	12,000
Fertilizer	30,000
Iron and steel	20,000
Pulp and paper	20,000
Textile	3,000
Petrochemical	100,000
Petroleum refinery	90,000

Source: Bureau of Energy Efficiency

Chapter 2

2.0 Indian steel industry

2.1 Background of iron & steel industry

The iron and steel industry has played a key role in fostering the overall growth process of Indian economy as well as the domestic industry sector. The iron &steel sector is one of the most important sector to Indian economy, contributing to about 2% to the country's GDP (PWC, 2019) and employing around 2.5 million people in steel and allied sectors (Ministry of Steel, 2019).

India is the second-largest steel producer, and third-largest steel consumer at global level (TERI, 2020). The Indian steel industry comprises both primary steel producers and secondary steel producers. It is quite heterogeneous, with a wide range of different sized facilities across the sector. Various technologies/ processes used in Indian steel industry include (1) blast furnace – basic oxygen furnace (BF-BOF), (2) coal-based direct reduction (DR), (3) gas-based DR, (4) electric induction furnace (EIF) and (5) electric arc furnace (EAF). The finishing operations include re-rolling, hot/cold

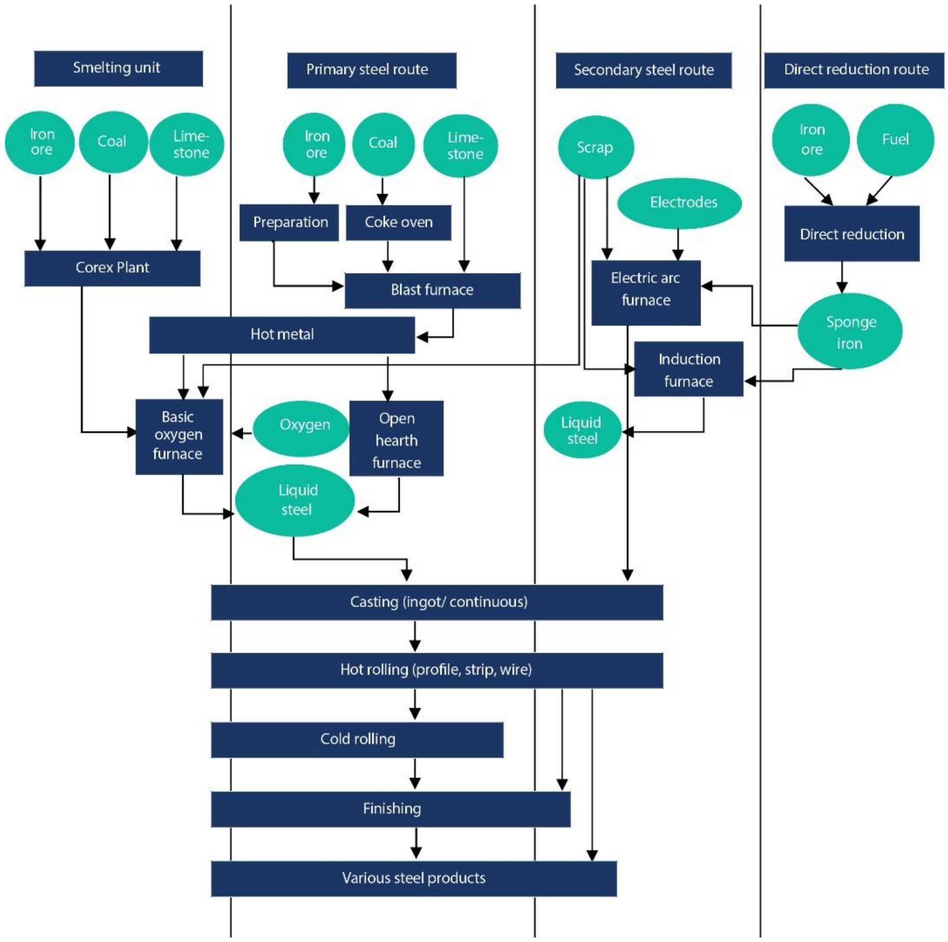


Figure 2.1: Steel production routes

rolling, galvanizing, etc. Different steel production routes followed in Indian steel sector are shown in figure 2.1 (source: Towards Low Carbon Steel Sector, TERI 2020).

2.1.1 Installed capacity and production of iron & steel sub-sector

The installed capacities and number of industries in different sub-sectors of iron & steel industry are shown in table 2.1.1.

Table 2.1.1: Installed capacities of iron & steel sub-sectors

SNo	Sub-sector	Total units	Capacity (mtpa)
1	Foundry	5,000	14.5
2	Forging	705*	3.8
3	Sponge iron	333	52.3
4	Electric arc furnace	55	41.8
5	Induction furnace	1,104	52.2
6	Re-rolling	1,314	91.0

Source: Joint Plant Committee, Association of Indian Forging Industry; Metal casting report

* *From four clusters namely Chennai, Ludhiana, Pune and Rajkot*

2.1.2 Energy consumption of iron and steel sector

The Indian iron & steel industries are the most energy intensive within the industry sector. The steel sector is the highest consumer of energy in the industry sector. The estimated final energy consumption of iron & steel sector is 54.6 million toe (MoSPI, 2019) accounting for about 17% of the industrial energy consumption (figure 2.1.2).

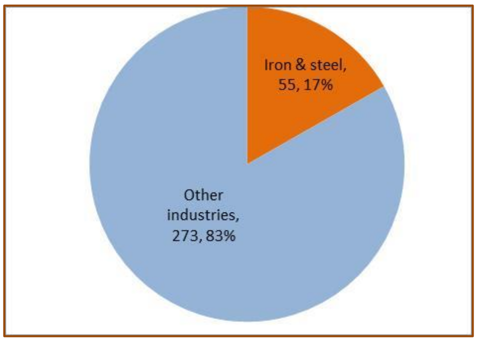


Figure 2.1.2 Share of energy consumption of iron & steel sector

2.2 Secondary steel sector

The secondary steel industries are important within iron & steel sector as these industries are closely involved in various finishing processes to produce final steel products. The different segments within secondary steel sector include pellets (iron ore), sponge iron, electric arc furnace, induction furnace, re-rolling, hot/cold rolling, galvanized sheets, colour coated products, tin plate, and pipes.

2.2.1 Sectoral coverage

The study on secondary steel sector covers the following sub-sectors, which are significant in terms of number of units, production capacities and energy intensity. The study has undertaken analysis of energy consumption and performance of these secondary steel sub-sectors at cluster/ state level.

1. Foundry
2. Forging industry
3. Steel rerolling
4. Sponge iron industry
5. Electric arc furnace
6. Induction furnace

Chapter 3

3.0 Methodology

3.1 Literature review

The project had undertaken detailed review of information and data available in public domain. This covered number of units (operating and closed), range of production capacities in different clusters, capacity utilization, and energy/ specific energy consumption levels for different categories within a cluster. The project also effectively utilized the in-house resources like SAMEEEKSHA (http:\\www.sameeeksha.org) for collation of data and information of relevant sub-sectors studied.

3.2 Data analysis and verification with stakeholders

The data pertaining to different sub-sectors at cluster/state level were collated and an analysis was undertaken for different clusters/states in each sub-sector using standard values and conversion factors for both energy consumption and greenhouse gas (GHG) emissions. The logical assumptions considered for arriving at energy consumption at cluster/sub-sector level are provided under section 4. The energy consumption at cluster level was aggregated at sub-sectoral level as well as sectoral level. Any significant deviation observed in the data and information was verified through discussions with stakeholders at cluster and/or sub-sector level.

3.3 Short-listing clusters for deep diving

The project undertook an exercise of ranking of clusters for each sub-sector based on a number of parameters such as number of units, specific energy consumption, GHG emissions share, variability (technology, fuel use), availability of industrial association and prior/on-going activities on energy efficiency. The short-listed clusters under each sub-sector have been identified for potential deep diving on energy efficiency improvements.

Chapter 4

4.0 Mapping of secondary steel sector

4.1 Introduction

The study focused on collation of secondary data pertaining to number of industries, production, energy type, energy consumption, performance in terms of specific energy consumption and GHG emissions related to six steel sub-sectors namely foundry, forging, steel rerolling, sponge iron, electric arc furnace and induction furnace. The analysis and findings were used to compare performance of different clusters with the objective to identify the most potential clusters in each sub-sector for improving overall performance in secondary steel sector. A set of selection criteria was considered to short-list the clusters for evolving suitable energy efficiency programmes for deep diving.

4.2 Foundry sub-sector

4.2.1 Background

The growth of foundry industries is considered the main factor for industrial growth and the Indian economy. The growth of the manufacturing sector is envisaged to achieve the proposed GDP of 25% from the current around 15% in the next ten years. Most of the industrial activities in diverse sectors use casting products from the foundry, and it is impossible to attain such target without corresponding growth of directly linked industrial sector like foundry in India.

4.2.1.1 Spread of foundry industries

The foundry industries are available mostly around the industrial zones in different states across plain areas of India, which directly need casting products in their business/product manufacturing activities. Out of around 5,000 numbers of foundry industries in India, more than 70% of foundry industries are established within 14 numbers of major foundry clusters in India (table 4.2.1.1a).

Table 4.2.1.1a: Details of major foundry clusters in India

S No	Cluster	Location	Total unit
1	Agra	Uttar Pradesh	80
2	Ahmedabad	Gujarat	450
3	Batala-Jalandhar-Ludhiana	Punjab	450
4	Belgaum	Karnataka	160
5	Coimbatore	Tamil Nadu	535
6	Kolhapur	Maharashtra	300
7	Howrah	West Bengal	330
8	Jaipur	Rajasthan	120

S No	Cluster	Location	Total unit
9	Rajkot	Gujarat	700
10	Samalkha	Haryana	30
11	Shimoga	Karnataka	38
12	Saharanpur	Uttarakhand	102
13	Indore	Madhya Pradesh	46
14	Faridabad	Haryana	340

Source: Cluster profile, SAMEEEKSHA

There are about 30 foundry clusters exist in different states of India (table 4.2.1.1b). Apart from a significant share of foundries existing in known clusters, it is estimated that about 25-30% of total number of foundry units are scattered across the country which are generally smaller in size producing castings for local applications.

Table 4.2.1.1b: Details of scattered foundry industries in India

Sl.No	Area	State
1.	Durgapur	West Bengal
2.	Hyderabad	Andhra Pradesh
3.	Vijayawada	Telangana
4.	Chennai	Tamil Nadu
5.	Salem	Tamil Nadu
6.	Bangalore	Karnataka
7.	Mangalore	Karnataka
8.	Hubli	Karnataka
9.	Bidar	Karnataka
10.	Pune	Maharashtra
11.	Aurangabad	Maharashtra
12.	Sholapur	Maharashtra
13.	Nagpur	Maharashtra
14.	Bhavnagar	Gujarat
15.	Nadiad	Gujarat
16.	Ghaziabad	Uttar Pradesh
17.	Jodhpur	Rajasthan
18.	Ajmer	Rajasthan
19.	Alwar	Rajasthan
20.	Bhiwadi	Rajasthan
21.	Bhilai	Chhattisgarh
22.	Rourkela	Odisha
23.	Panchkula	Haryana
24.	Gurgaon	Haryana
25.	Kaithal	Haryana
26.	Panipat	Haryana
27.	Sonepat	Haryana
28.	Cuttack	Odisha
29.	Muzaffarpur	Bihar

The share of foundry industries in 14 clusters is about 74%, whereas other clusters account for only 26% of the total industries (figure 4.2.1.1).

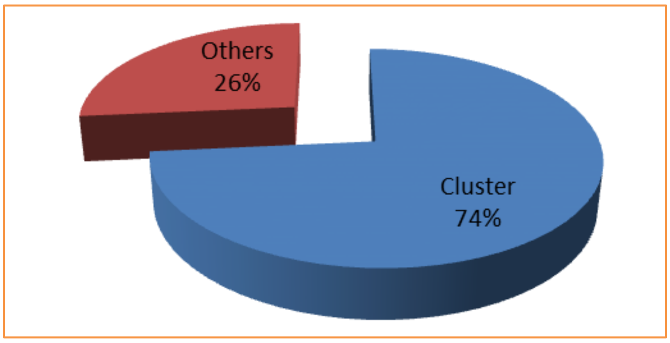


Figure 4.2.1.1: Distribution of Foundry industries

4.2.1.2 Process description and technology use

In the foundry, sand casting, which is also known as the green sand moulding process, is followed in manufacturing ferrous castings. The major steps of the process are mould sand preparation, charge preparation, followed by melting, pouring, knockout, and finishing (figure 4.2.1.2). The process steps are explained below.

Sand preparation: Additives like bentonite, coal dust, water are added with green sand while preparing a batch of the sand mixer. These binders are used to develop the required strength for mould and core preparation. The final sand mixer is used for mould preparation.

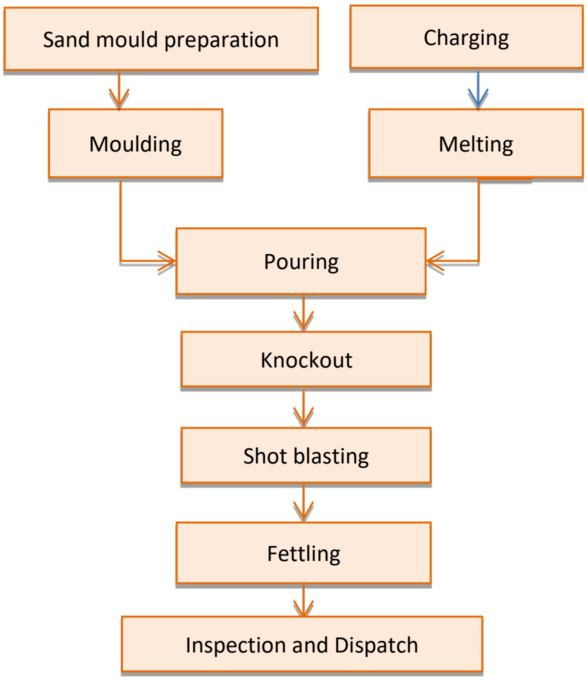


Figure 4.2.1.2: Process flow green sand moulding in foundry

Mould preparation: The mould flask comprises two halves, i.e. cope (upper half) and drag (bottom half). The mould cavity is formed by packing sand around the pattern, which is a replica of the external shape of the desired casting. Most of the moulds are prepared manually except in a few industries where machine moulding is done.

In machine moulding, the machine is usually located below the sand mixer. Sand from a hopper falls into the moulding box and is then pneumatically or hydraulically pressed to make the final mould. High pressure moulding machines can use moulding sand having lower moisture contents, and hence higher mould densities can be achieved. The castings made using machine mould have better dimensional accuracy and better surface finish.

Melting: This is the most energy intensive process across all foundry industries. The melting is done either in a cupola furnace or an induction furnace. Depending upon the target product chemistry, the raw material batch is charged either manually or using a mechanical system. The typical temperature of molten metal for grey iron is about 1,400 °C and for steel grade is 1,650 °C.
Pouring and Casting: The molten metal is poured into sand moulds either manually or using a semi/ automatic pouring system. The poured molten metal takes the shape of the mould.

Knocking out of castings: The moulds are left to cool after which the castings are knocked out from the mould either manually or using a vibratory knock-out machine.

Shot blasting: There are different types of shot-blasting machines available; the most common one is a double door, two shooters type. It has four drives, two for shooters, one for bucket rotating, and one for dust collection. Typical 1 tonne per batch shot blast machine has a total connected load of around 25 kW.

Finishing: The finishing operation involves the removal of runners/risers, shot blasting, and cleaning of castings. This is followed by fettling and machining. In the case of steel casting, heat treatment is also an integral part of finishing operations.

Technologies and equipment

The technology and type of process equipment used in the manufacturing of ferrous casting products are quite similar across all foundry industries. The major technologies and equipment used in process areas and utility sections, including operating energy sources are provided in table 4.2.1.2a.

Table 4.2.1.2a: Technologies and equipment used in foundries

Technology / Equipment	Type of energy
Cupola furnace	Fossil fuel, electricity
Induction furnace	Electricity
Sand mixer	Electricity
Shot blast	Electricity

Cupola furnace
Cupola is a cylindrical metallic shell having refractory lining at the internal surface and is used for melting charge material. The raw material batch is fed into it from the top, and liquid metal is drawn from the bottom either intermittently or continuously, depending on the design feature. Cupola furnaces are mostly operated using coke, but some cupolas are also designed to use natural gas and furnace oil. The capacity of the cupola furnace depends on the inner diameter after refractory lining.

Induction furnace
The induction furnace uses electricity for heating and melting using either silicon controlled rectifier (SCR) or insulated gate bipolar transistor (IGBT) type technology. Heating is done through induction effects, and heating elements are placed in the refractory lining facing charge holding crucible. The capacity of IF depends on the crucible volumetric capacity and designed electric load. IF is the batch type, and the entire liquid metal is tapped on completion of the melting cycle. The melting cycle depends on the crucible capacity. The capacities of melting furnaces used in foundries are largely

depended on the design value. The typical design capacities of furnaces are provided in Table 4.2.1.2b.

Table 4.2.1.2b: Furnace capacities in foundries

Type	Capacity
Cupola furnace	1.5-10.0 tonne per hour
Induction furnace	0.1-2 tonne per batch

The details of some commonly used primary utilities across foundries are provided below.

Sand mixers: It is used for sand preparation in batch. The batch size generally varies between 100 – 500 kg per batch depending upon the requirement. It is connected with two motors; one for mixing and the other for blending. The total load may be 10-30 kW depending upon the mixer capacity.

Shot blast: It is used to remove sand from de-moulded casting. It is batch operated, and capacity depends on design rating.

4.2.1.3 Raw materials, products and production

The raw materials used in foundry industries largely depend on the product chemistries. The base materials are pig iron, iron scrap, steel, borings, and foundry returns. It also uses some alloying elements such as ferro-silicon, ferro-manganese, iron sulphide, silicon carbide, etc., to achieve desired metal chemistries. In special grades and SG iron castings production, the foundry also uses small quantities of other metals like copper and tin. The casting products from foundries covers different metal components for diverse applications segment such as auto industries, railways, sanitary ware, pipe fittings and valves, utilities and engine components and spares, etc.

Indian foundries produce both ferrous and non-ferrous casting products. The ferrous casting includes grey iron, steel grade iron or ductile iron, malleable iron and steel grade castings. Out of these, the grey iron castings contribute the majority share (~76%) of total ferrous castings products (Table 4.2.1.3). Regarding the absolute quantity of finished ferrous casting production, the Indian share is around 10.1 million tonnes (12%) in comparison to the world ferrous casting of 85.6 million tonnes during the year 2019.

Table 4.2.1.3: Details of Indian ferrous casting productions

Casting type	Value (million tonne)
Grey iron	7.7
Ductile iron	1.2
Malleable iron	0.1
Steel grade	1.1
Total	10.1

Source: http://www.foundryinfo-india.org/profile_of_indian.aspx

The share of different ferrous casting production in India is shown in figure 4.2.1.3.

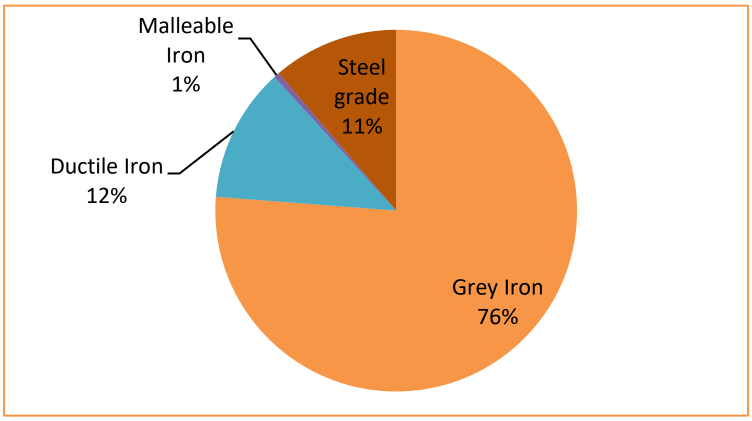


Figure 4.2.1.3: Distribution of ferrous casting productions in India

4.2.1.4 Other countries producing foundry products

The total ferrous casting products at global level are reported to be 86 million tonne during 2019-20 (table 4.2.1.4a). The largest market share of the global foundry market was Asia Pacific region during 2020, which is about 54% followed by Western Europe (18%).

Table 4.2.1.4a: Production of ferrous casting at global level

Casting type	Production (million tonne)
Grey iron	51.2
Ductile iron	23.7
Malleable iron	0.7
Steel grade	10.1
Total	85.6

Source: https://www.globenewswire.com/news-release/2021/02/09/2172270/0/en/Foundries-Global-Market-Report-2021-COVID-19-Impact-and-Recovery-to-2030.html
https://www.thewfo.com/contentfiles/downloads/51.pdf

4.2.1.5 Institutions at the national level

The Institute of Indian Foundrymen (IIF) is the apex body at the national level dealing with foundry industries. The IIF operates with its head office in Kolkata and with other four regional offices at Kolkata (Eastern region), Delhi (Northern Region), Chennai (Southern Region) and Mumbai (Western Region). The institution is also a member of the World Foundrymen Organization (WFO) as well as the Confederation of Indian Industry (CII). Some of the primary roles of IIF are shown in table 4.2.1.5.

Table 4.2.1.5: Roles of Institute of Indian Foundrymen

Organization	Roles
Institute of Indian Foundrymen (IIF)	• Representing Indian foundrymen to the Government of India related to policy and technological updates • Participating in the preparation of standards for foundry materials, products and test methods by the Bureau of Indian Standards.

Organization	Roles
	• Providing opportunities and exposure to its members in domestic and international technological developments/innovations in manufacturing, raw materials, energy, environment, etc., related issues. • Bringing out technical publications and organize events

4.2.1.6 Coverage of clusters

The foundry clusters covered for analysis of energy consumption include Agra, Ahmedabad, Batala, Belgaum, Coimbatore, Kolhapur, Howrah, Jaipur, Rajkot, Samalkha, Shimoga, Saharanpur, Indore, and Faridabad.

4.2.2 Agra Foundry Cluster

4.2.2.1 Cluster background

The foundry industries in the Agra cluster are mainly concentrated in Foundry Nagar, Rambagh and Nunhai. Foundry industries in the Agra cluster use either electricity based induction furnaces (IF) or clean fossil fuel like natural gas fired cupola furnaces (CF) for melting purposes.

Primary raw material

Basic raw materials of the cluster are pig iron, bought out scrap, in-house foundry return and rejected castings

Major products

The primary users of the local castings are diesel generator-set, automotive, and other machinery parts.

Classification of industries

Around 80 foundries units in Agra cluster manufacture annually about 0.1 million tonnes of ferrous casting. Both cupola furnace and induction furnace are in use for the melting process. Considering the melting technology employed and scale of operation, the categorization of industries are provided in table 4.2.2.1.

Table 4.2.2.1: Details of industries

Industry category	Number of Units	Production range (tpm)	Average production (tpy)
Micro (CF)	40	20 - 50	16,800
Small (CF)	10	50 - 100	9,000
Small (IF)	13	50 - 100	11,700
Medium (IF)	15	100 - 500	44,820
Large (IF)	2	500 – 1,500	24,000
Total	80		106,320

Source: (1) Cluster profile report, SAMEEKSHA, (2) Analysis of cluster level secondary data by TERI

A majority of foundries fall under micro category using cupola furnace technology (50%). The share of different categories of industries is provided in figure 4.2.2.1a. The medium category induction furnaces contribute maximum annual casting production, which is around 42% (figure 4.2.2.1b).

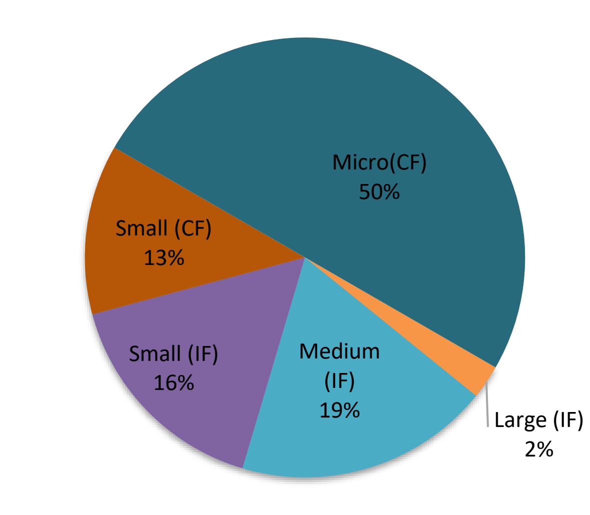


Figure 4.2.2.1a: Share of industries of different categories

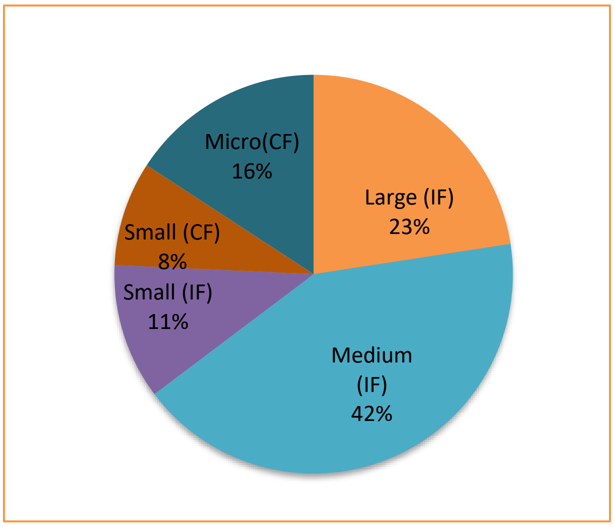


Figure 4.2.2.1b: Share of annual production of different categories

4.2.2.2 Process technology

The details of melting technologies and primary auxiliary equipment used in the Agra foundry cluster are provided in Table 4.2.2.2.

Table 4.2.2.2: Primary technology of Agra foundry cluster

Technology	Purpose
Cupola furnace	All cupola furnaces in Agra foundry cluster use natural gas due to existing environmental regulations. The average natural gas consumption of cupola furnaces is in the range of 55 - 60 SCM per tonne of molten metal.
Induction furnace	Some of the foundries in Agra foundry cluster use induction furnaces to produce castings of cast iron, SG iron and steel. A majority of IF based units use small capacity furnaces. The electricity consumption of induction furnaces varies is about 650 – 700 kWh per tonne of melt.

4.2.2.3 Energy consumption analysis

Foundries in the Agra cluster use both natural gas and electricity. Natural gas (NG) is primarily used in cupola furnaces for producing liquid metal. The energy consumption pattern of the foundry units depends on the melting technology deployed and production capacities. Natural gas is used for melting in CF, and electricity is used in IF. Electricity contributes the majority energy share (86%), and the share of NG is very low (14%). The share of energy consumption of various fuel sources is provided in figure 4.2.2.3a.

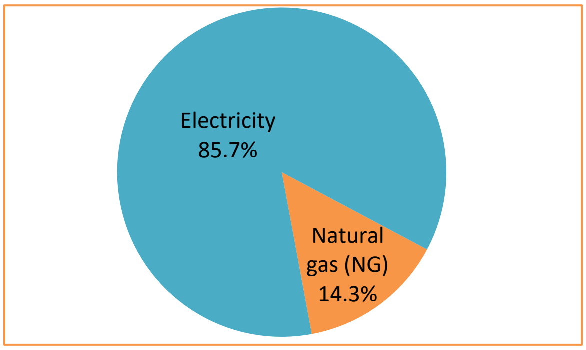


Figure 4.2.2.3a: Share of energy consumption source

The unit level annual energy consumption depends on the annual production range of different industries in the cluster. Table 4.2.2.3a provides the unit level annual energy consumption of different categories of industries in the Agra foundry cluster.

Table 4.2.2.3a: Details of unit level annual energy consumption

Fuel type	Unit	Energy consumption per plant				
		Large (IF)	Medium (IF)	Small (IF)	Small (CF)	Micro (CF)
Natural gas	Sm³/year	12,000	4,800	1,200	51,000	24,000
Graphite	tonne/year	-	-	-	34	16
Electricity	mil kWh/year	13.8	3.7	0.9	0.03	0.01

The cluster level annual energy consumption by individual category of industries is provided in table 4.2.2.3b.

Table 4.2.2.3b: Details cluster level annual energy consumption

Fuel type	Unit	Large (IF)	Medium (IF)	Small (IF)	Small (CF)	Micro (CF)
Natural gas (NG)	mil Sm³/year	0.02	0.1	0.02	0.5	1.0
Graphite	tonne/year	-	-	-	340	640
Electricity	mil kWh/year	28	56	12	0.3	0.6
Thermal energy	toe/year	21	63	13	723	1,362
Electrical energy	toe/year	2,374	4,837	1,006	26	48
Total energy	toe/year	2,394	4,900	1,020	749	1,410

The medium category induction furnace consumes the maximum share of cluster level energy consumption, which is around 47%. The distribution of cluster level energy consumption by different categories of industries is provided in figure 4.2.2.3b.

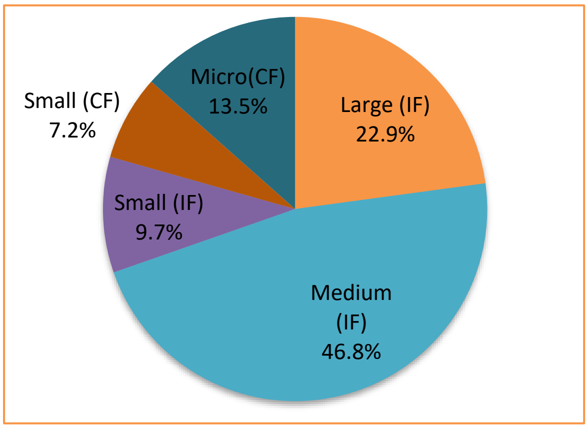


Figure 4.2.2.3b: Distribution of cluster level energy consumption

The total energy consumption in the cluster is estimated to be 10,474 toe per year. The equivalent GHG emissions are estimated to be 84,707 tonne CO_2 per year (Table 4.2.2.3c).

Table 4.2.2.3c: Energy consumption of Agra foundry cluster

Energy source	Unit	Energy consumption		GHG emissions
		Quantity	Equivalent (toe/year)	(Tonne CO_2/year)
Natural gas	million Sm^3/year	1.6	1,384	2,726
Graphite	tonne/year	980	799	2,925
Electricity	mil kWh/year	96	8,291	79,056
		Total	10,474	84,707

4.2.2.4 Performance analysis of foundry industries

The average specific energy consumption among different categories of foundry industries in the Agra cluster varies in the range of 3.5 – 4.6 GJ per tonne of casting production. This variation is largely due to the type of energy use, the energy efficiency of technology employed, quality of product and its chemistries, etc. The details of performance in terms of specific energy consumption incurred by different categories of industries are shown in table 4.2.2.4.

Table 4.2.2.4: Performance of foundry industries in Agra cluster

TYPE	SEC- Thermal (GJ/tonne)	SEC- Electrical (kWh/tonne)	SEC- Cluster (GJ/tonne)
Large (IF)	0.04	1,150	4.2
Medium (IF)	0.1	1,255	4.6
Small (IF)	0.05	1,000	3.6
Small (CF)	3.4	33	3.5
Micro (CF)	3.4	33	3.5
Minimum	0.04	33	3.5
Maximum	3.4	1,255	4.6

Note: SEC variations depend on process parameters

The specific energy consumption (SEC) of medium category induction furnaces is the highest, estimated to be 4.6 GJ per tonne (Figure 4.2.2.4). The cluster level SEC is estimated to be 4.1 GJ per tonne of casting.

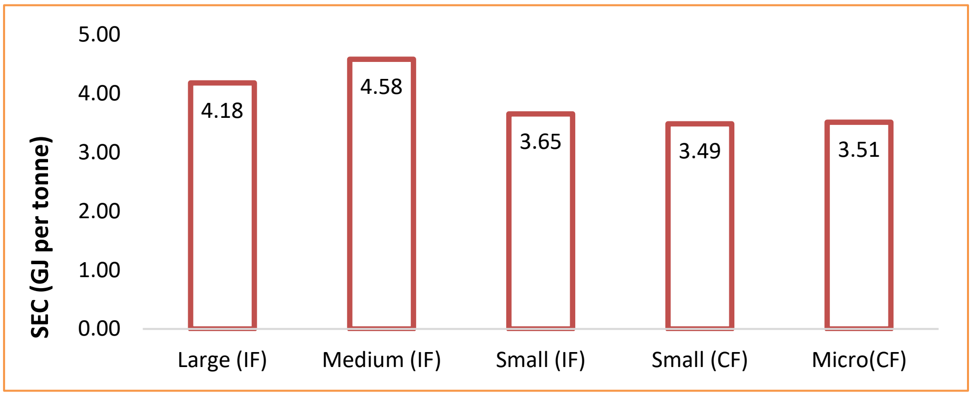


Figure 4.2.2.4: Variation of SEC among different category of industries

4.2.2.5 Relevant institutions for Agra foundry industries

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to foundry industries in the Agra cluster are given in table 4.2.2.5.

Table 4.2.2.5: Institutions involved in Agra foundry cluster

Institution/ organization	Contact details	Objectives and roles
Agra Iron Founder's Association (AIFA)	88, North Vijay Nagar Colony, Agra 282004 Tel: 0562 215 2744	Addresses regulatory issues and welfare of the member industries
The Institute of Indian Foundrymen (IIF) Agra Chapter	Process & Product Development Centre Foundry Nagar, Agra - 282 006 Tel: 0562 234 4673 email: tcppdcagra@dcmsme.gov.in http://www.ppdcagra.dcmsme.gov.in/contact.html	Organizes awareness workshops and plant visits on a regular basis for its members
Process and Product Development Centre (PPDC)	Foundry Nagar, Agra – 282006 Tel: 0562 234 4673 email: tcppdcagra@dcmsme.gov.in http://www.ppdcagra.dcmsme.gov.in/contact.html	Offers services such as testing, product development, and training and consultancy
Uttar Pradesh New and Renewable Energy Development Agency (UPNEDA)	Vibhuti Khand, Gomti Nagar, Lucknow – 226010, Uttar Pradesh Tel: 0522 272 0652 email: compneda@rediffmail.com http://upneda.org.in/Index.aspx	State Designated Agency (SDA) to coordinate, regulate and enforce efficient use of energy and its conservation

Cluster development activities

A dedicated 'foundry nagar' in Agra houses a number of foundry units, which have been relocated from city premises.

4.2.2.6 Other information

BEE has initiated an energy and resource mapping study of Agra foundry cluster, which is under implementation.

4.2.2.7 Summary of findings

The summary of findings of the Agra foundry cluster is provided in table 4.2.2.7.

Table 4.2.2.7: Summary of findings of Agra foundry cluster

Parameter	Unit	Value
Number of units		80
Annual production	tonne per year	106,320
Total energy consumption	toe per year	10,474
SEC – Overall	GJ per tonne	4.1
GHG emissions	tonne CO_2 per year	84,707
Specific GHG emissions	tonne CO_2 per tonne casting	0.8
Other relevant information	On-going energy and resource mapping study under implementation by BEE	

4.2.3 Ahmedabad Foundry Cluster

4.2.3.1 Cluster background

The foundry units in the Ahmedabad cluster use coke fire cupolas and induction furnaces. These units are located in industrial estates of GIDC like Naroda industrial estate, Odhav Industrial Estate, Vatva Industrial Estate, Tribhuvan Industrial Estate, and Rakhial Industrial Estate. Melting operation and casting production mainly depends on the demand as most of these castings are supplied to OEMs of various industrial segments. Generally, smaller cupola-based foundries typically conduct melting 4 – 10 days in a month, while a few larger foundry units operate on daily basis.

Primary raw material

The basic raw materials of the cluster are pig iron, bought-out scrap, in-house foundry return and rejected castings, and additives such as ferro-silicon, ferro-manganese and limestone.

Major products

The primary users of the local castings are the textile sectors (~50% of total production). Castings for other sectors include agriculture machinery (~10%), sanitary (~10%), pump and valve body (~20%), etc.

Classification of industries

Around 450 foundries units in the cluster manufacture annually about 0.5 million tonne of ferrous casting. Based on melting technology and scale of operation, the categorization of industries is provided in table 4.2.3.1.

Table 4.2.3.1: Details of industries

Industry category	Number of Units	Production range (tpm)	Average production (tonne/year)
Large (IF)	30	500 - 600	198,000
Medium (IF)	70	100 - 200	88,200
Medium (CF)	150	100 - 200	162,000
Small (CF)	100	50 - 150	72,000
Micro (CF)	50	40 - 60	15,000
Micro (PF)	50	20 - 50	8,400
Total	450		543,600

Source: (1) Cluster profile report, SAMEEKSHA, (2) Analysis of cluster level secondary data by TERI

The majority of the industries are cupola furnaces consisting of micro, small and medium (~77%) category. The share of different categories of industries is provided in figure 4.2.3.1a. The medium category induction furnaces contribute maximum annual casting production, which is around 42% (figure 4.2.3.1b).

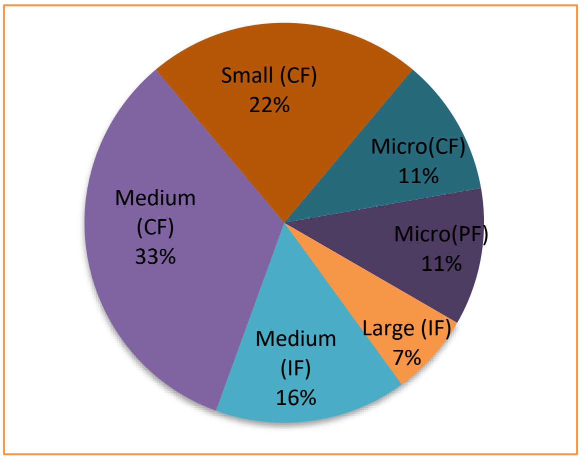


Figure 4.2.3.1a: Share of industries of different categories

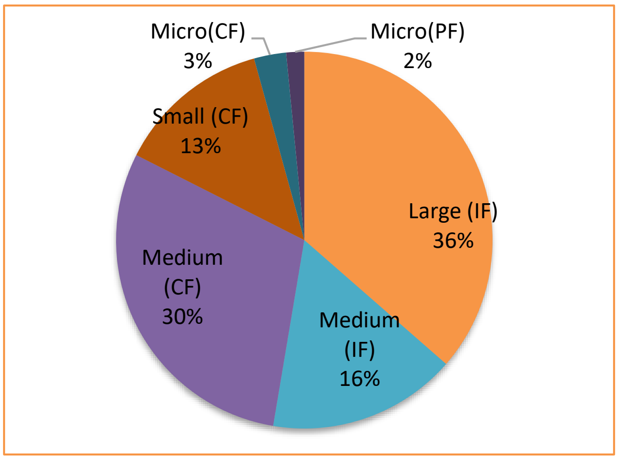


Figure 4.2.3.1b: Share of annual production of different categories

4.2.3.2 Process technology

The details of melting technologies and major auxiliaries used in the cluster are provided in table 4.2.3.2.

Table 4.2.3.2: Primary technology of Ahmedabad foundry cluster

Technology	Purpose
Cupola furnace	All CFs in the cluster are coke fired. The average percentage of coke consumption on metal is in the range of 10.2 to 17.9%.
Pit furnace	These are operated by micro units and use coke. Generally, the units operate furnaces once a week for melting.
Induction furnace	IFs are mostly used for producing higher grade casting, and most of them operate on daily basis. The majority of these furnaces are smaller capacity with an average 100 to 600 tonne per month production. The SEC varies in the range of 658 – 863 kWh per tonne of melt.

4.2.3.3 Energy consumption analysis

The foundry units in Ahmedabad cluster use coke, natural gas and electricity. Coke is primarily used in cupola furnaces for producing liquid metal. The energy consumption pattern of the foundry units depends on the melting technology deployed and production capacities. The electricity consumption accounts for a major share of 58% followed by coke (39%). The energy consumption share of NG is about 3%, mainly used for core heating and operating backup power generators (figure 4.2.3.3a).

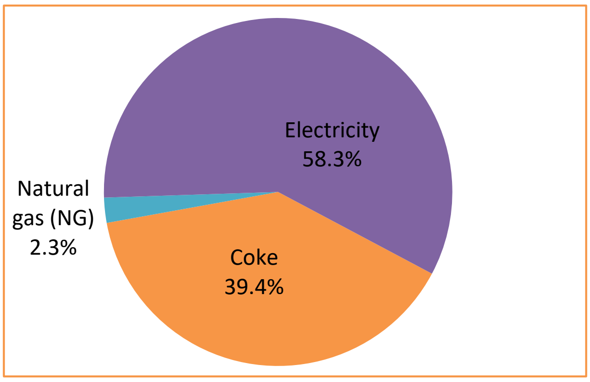


Figure 4.2.3.3a: Share of energy consumption source

Table 4.2.3.3a provides unit level energy consumption of different categories of industries in the cluster.

Table 4.2.3.3a: Unit level energy consumption

Fuel type	Unit	Energy consumption per plant					
		Large (IF)	Medium (IF)	Medium (CF)	Small (CF)	Micro (CF)	Micro (PF)
Coke	tonne/year	-	-	110	100	45	30
Natural gas	Sm^3/year	14,916	2,848	2,441	1,627	678	380
Electricity	kWh/year	6,200,000	1,450,000	150,000	20,000	6,000	3,500

The cluster level annual energy consumption by individual category of industries is provided in table 4.2.3.3b.

Table 4.2.3.3b: Details cluster level annual energy consumption

Fuel type	Unit	Large (IF)	Medium (IF)	Medium (CF)	Small (CF)	Micro (CF)	Micro (PF)
Coke	tonne/year	-	-	16,500	10,000	2,250	1,500
Natural gas	mil Sm^3/year	0.4	0.2	0.4	0.2	0.03	0.02
Electricity	mil kWh/year	186	101	22	2	0.3	0.2
Thermal	toe/year	391	174	10,220	6,142	1,379	916
Electrical	toe/year	15,996	8,729	1,935	172	26	15
Total	toe/year	16,387	8,903	12,155	6,314	1,405	932

The large category induction furnace consumes the maximum share of cluster level energy consumption, which is around 35% ((figure 4.2.3.3b).

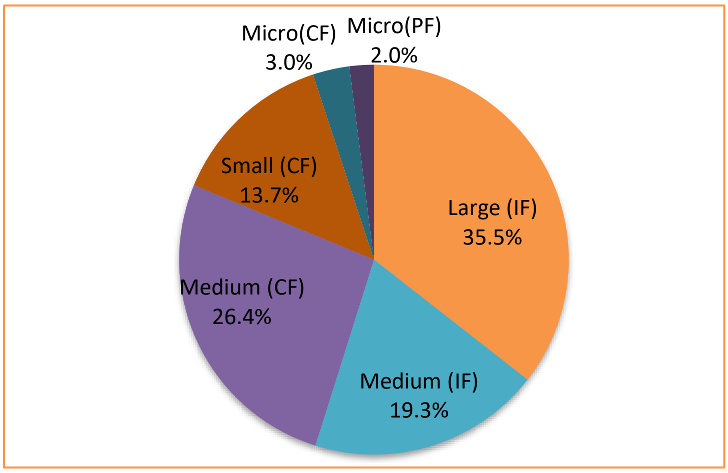


Figure 4.2.3.3b: Distribution of cluster level energy consumption

The total energy consumption in the cluster is estimated to be 46,098 toe per year. The equivalent GHG emissions are estimated to be 346,435 tonne CO_2 per year (Table 4.2.3.3c).

Table 4.2.3.3c: Energy consumption of Ahmedabad foundry cluster

Energy source	Unit	Energy consumption Quantity	Equivalent (toe/year)	GHG emissions (tonne CO_2/year)
Coke	tonne/year	30,250	18,150	88,088
Natural gas	mil Sm^3/year	1.2	1,075	2,117
Electricity	mil kWh/year	312	26,873	256,229
		Total	46,098	346,435

4.2.3.4 Performance analysis of foundry industries

The average specific energy consumption among different categories of foundry industries in the cluster varies in the range of 3.1 – 4.6 GJ per tonne of casting production. This variation is largely due to the type of energy use, the energy efficiency of technology employed, quality of product and its chemistries, etc. The details of performance in terms of SEC of different categories of industries are shown in table 4.2.3.4.

Table 4.2.3.4: Performance of foundry industries in Ahmedabad cluster

TYPE	SEC-Thermal (GJ/tonne)	SEC- Electrical (kWh/tonne)	SEC- Cluster (GJ/tonne)
Large (IF)	0.1	939	3.5
Medium (IF)	0.1	1,151	4.2
Medium (CF)	2.6	139	3.1
Small (CF)	3.6	28	3.7
Micro (CF)	3.8	20	3.9
Micro (PF)	4.6	21	4.6
Minimum	0.1	20	3.1
Maximum	4.6	1,151	4.6

Note: SEC variations depend on process parameters

The micro category pit furnace consumes maximum energy for producing per tonne of casting, which is estimated to be 4.6 GJ per tonne (Figure 4.2.3.4).

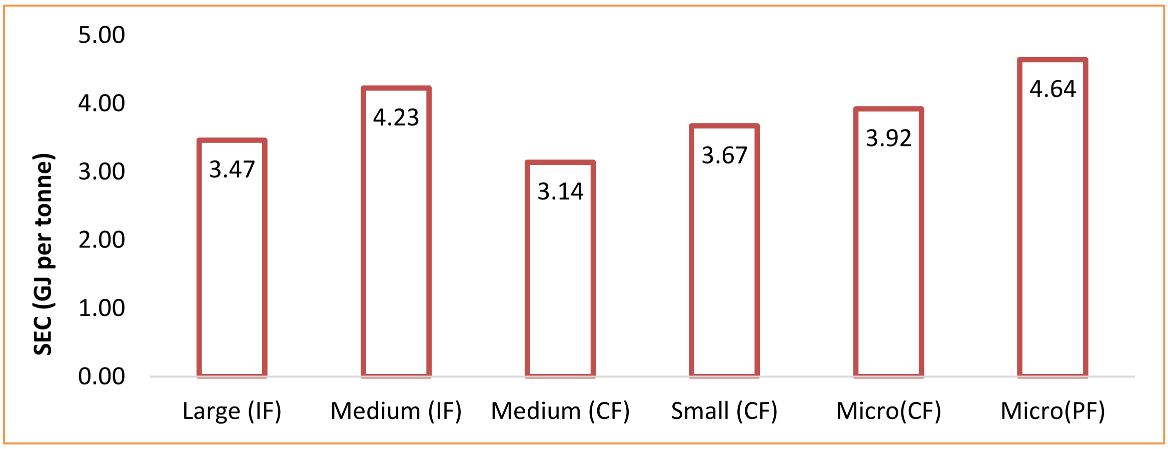


Figure 4.2.3.4: Variation of SEC among the different categories of industries

The cluster level specific energy consumption considering total annual production in the cluster and the total energy consumption is estimated to be around 3.5 GJ per tonne of casting production.

4.2.3.5 Relevant institutions for Ahmedabad foundry industries

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to foundry industries in the Ahmedabad cluster are given in table 4.2.3.5.

Table 4.2.3.5: Institutions involved in Ahmedabad cluster

Institution/ organization	Contact details	Objectives and roles
Ahmedabad Engineering Manufacturers Association (AEMA)	Lal Bunglow, Amrut Industrial Estate, Dudheshwar, Ahmedabad, Gujarat 380004 Tel: 079 2562 2961 Email: aema1959@gmail.com http://aema1959.com/	• Close coordination with Bureau of Indian Standards and other regulatory bodies
The Institute of Indian Foundrymen (IIF) Ahmedabad Chapter	The Komer Building, 2nd Floor, Satellite Road, Surendra Mangaldas Rd, Ambawadi, Ahmedabad, Gujarat 380015 Email: info@iiffc.org http://www.iifafc.org/	• Promote education, research, training, and development to Indian foundrymen • Serves as a nodal point of reference between the customers and suppliers of the Indian foundry industry on a global scale
Gujarat Energy Development Agency (GEDA)	4th floor, Block No. 11 & 12, Udyog Bhavan, Sector-11, Gandhinagar – 382017, Gujarat. Tel: 079-23257251,54 email : info@geda.org.in http://www.geda.org.in	• State Designated Agency (SDA) to coordinate, regulate and enforce efficient use of energy and its conservation

Cluster development activities

The foundry industries in Ahmedabad have proactively initiated various approaches as mentioned below.

(i) A 'special purpose vehicle' (SPV) was set up in Changodha as an industrial park to relocate about 175 foundries, of which 20 foundries have already relocated and started operation.
(ii) A 'Centre for Foundry Education and Research' has been set up in Odhav Industrial Estate.
(iii) Ahmedabad Engineering and Servicing Society procure molasses in bulk for foundry for micro and small foundries.
(iv) UNIDO-BEE has initiated a local service provider (LSP) project for deep drive implementation, which is on-going.

4.2.3.6 Summary of findings

The summary of findings of the Ahmedabad foundry cluster is provided in table 4.2.3.6.

Table 4.2.3.6: Summary of findings of Ahmedabad foundry cluster

Parameter	Unit	Value
Number of units		450
Annual production	tonne per year	543,600
Total energy consumption	toe per year	46,098
SEC – Overall	GJ per tonne	3.5
GHG emissions	tonne CO_2 per year	346,435
Specific GHG emissions	tonne CO_2 per tonne casting	0.6
Other relevant information	UNIDO-BEE LSP project is on-going focusing on energy efficiency and capacity building of LSP in the cluster	

4.2.4 Batala-Jalandhar-Ludhiana Foundry Cluster

4.2.4.1 Cluster background

The foundry cluster in Punjab is widely famous as Batala-Jalandhar-Ludhiana foundry cluster due to the proximity of these areas and similarity in types of casting products. It is one of the major foundry clusters in India manufacturing casting products for catering to agricultural appliances, tractor industries, diesel engines, lathe machines, etc. The majority of the foundry industries are micro, small, and medium categories. Traditionally melting is to be done using a coke fire cupola furnace, but in the recent past, industries have started using induction heating furnaces for manufacturing higher grades of castings. Generally, smaller cupola-based foundries typically conduct melting 4-10 days in a month. A few large foundry units operate on daily basis using either a cupola or induction furnace.

Primary raw material

Basic raw materials of the cluster are pig iron, bought out scrap, in-house foundry return and rejected castings, Ferro-silicon, Ferro-manganese, and limestone.

Major products

The primary users of the local castings are tractor industries. Other castings include agriculture machinery, automotive/oil engine, pump/fans, machine tools, diesel engine components, manhole covers, sewing machine stands, and valve bodies, etc.

Classification of industries

Around 450 foundries units in the cluster manufacture annually about 250,200 tonnes of ferrous casting. Both cupola furnace and induction furnace are used for melting process. Considering the melting technology employed and scale of operation, the categorization of industries are provided in table 4.2.4.1.

Table 4.2.4.1: Details of industries

Industry category	Number of Units	Production range (tpm)	Average production (tonne/year)
Large (IF)	15	200 - 300	27,000
Medium (IF)	50	100 - 200	54,000
Small (IF)	100	20 - 100	50,400
Medium (CF)	35	100 - 200	37,800
Small (CF)	100	50 - 100	36,000
Micro(CF)	100	10 - 50	36,000
Micro(FO)	50	10 - 20	9,000
TOTAL	450		250,200

Source: (1) Cluster profile report, SAMEEKSHA, (2) Analysis of cluster level secondary data by TERI

The majority of the industries are cupola furnaces consisting of micro, small, and medium (>52%). The share of different categories of industries is provided in figure 4.2.4.1a. The cumulatively induction furnaces contribute maximum annual casting production, which is around 53% (figure

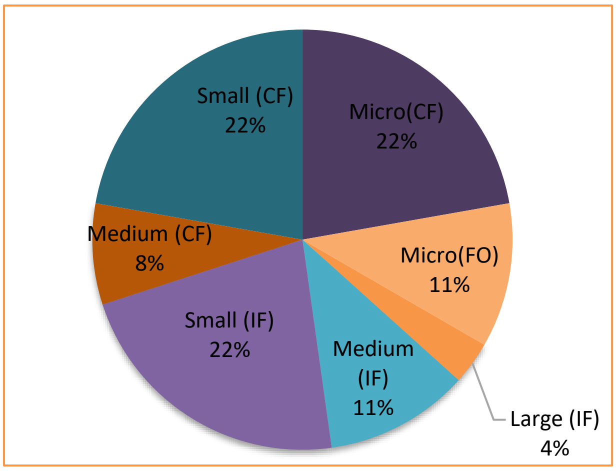


Figure 4.2.4.1a: Share of industries of different categories

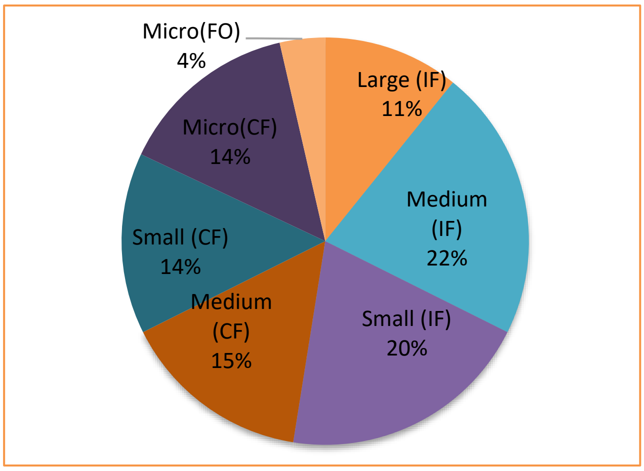


Figure 4.2.2.1b: Share of the annual production of different categories

4.2.4.1b).

4.2.4.2 Process technology

The details of melting technologies and primary auxiliary equipment used in the cluster are provided in table 4.2.4.2.

Table 4.2.4.2: Primary technology of Batala foundry cluster

Technology	Purpose
Cupola furnace	All CFs in the cluster are coke-fired. The average percentage of coke consumption on metal is in the range of 10.2 to 19.4%
Rotary furnace	These are operated by micro units using furnace oil, and generally, these are very inefficient furnaces. The average 140 kg of furnace oil consumed per tonne melt.
Induction furnace	IFs are mostly used for producing higher grade casting, and most of them operate on daily basis. The majority of these furnaces are smaller capacity with an average 20 to 300 tonne per month production, and electricity consumption varies in the range of 500-714 kWh per tonne of melt.

4.2.4.3 Energy consumption analysis

Details of energy use

Foundries in these clusters use coke, furnace oil, and electricity. Coke is primarily used in cupola furnaces for producing liquid metal. The captive backup power generator is operated using diesel during the failure of grid supply.

Energy consumption pattern

The energy consumption pattern of the foundry units depends on melting technology deployed and production capacities. Coke is used for melting in CF, and electricity is used in IF. The coke contributes the majority energy share (47%), next is electricity (47%), and the share of FO is very low (6%) which is mainly used for rotary furnace and core heating. The share of energy consumption from different sources is provided in figure 4.2.4.3a.

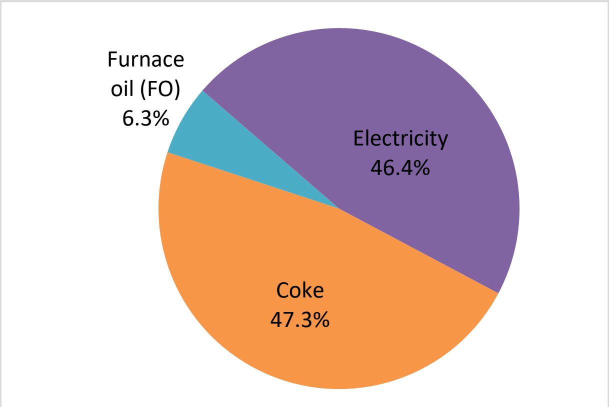


Figure 4.2.4.3a: Share of energy consumption source

The unit level annual energy consumption depends on the annual production range of different industries in the cluster. Table 4.2.4.3a provides the unit level annual energy consumption of different categories of industries in the cluster.

Table 4.2.4.3a: Details of unit level annual energy consumption

Fuel type	Unit	Energy consumption per plant						
		Large (IF)	Medium (IF)	Small (IF)	Medium (CF)	Small (CF)	Micro (CF)	Micro (FO)
Coke	tonne/year	-	-	-	110	50	70	-
Furnace oil	tonne/year	-	-	-	-	-	-	25
Electricity	kWh/year	1,200,000	800,000	450,000	100,000	15,000	4,500	3,500

The cluster level annual energy consumption by individual category of industries is provided in table 4.2.4.3b.

Table 4.2.4.3b: Details cluster level annual energy consumption

Fuel type	Unit	Large (IF)	Medium (IF)	Small (IF)	Medium (CF)	Small (CF)	Micro(CF)	Micro(FO)
Coke	tonne/year	-	-	-	3,850	5,000	7,000	-
Furnace oil	tonne/year	-	-	-	-	-	-	1,260
Electricity	mil kWh/year	18	40	45	3.5	1.5	0.4	0.2
Thermal	toe/year	-	-	-	2,310	3,000	4,200	1,267
Electrical	toe/year	1,548	3,440	3,870	301	129	38	15
Total	toe/year	1,548	3,440	3,870	2,611	3,129	4,238	1,282

The cupola furnace based industries consume the maximum share of cluster level energy consumption, which is around 50%. The distribution of cluster level energy consumption by different categories of industries is provided in figure 4.2.4.3b.

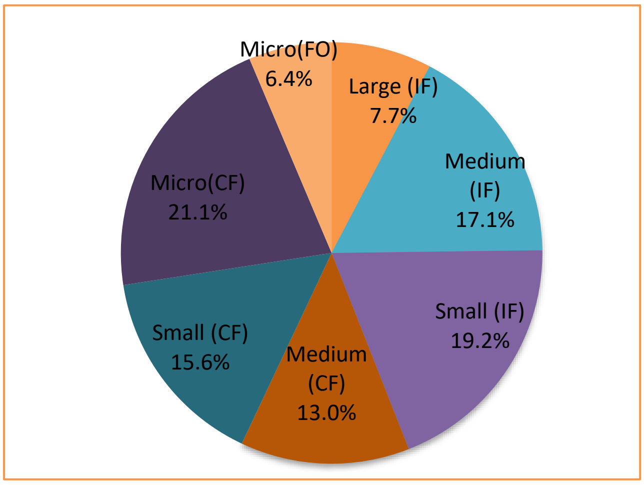


Figure 4.2.4.3b: Distribution of cluster level energy consumption

The total energy consumption in the cluster is estimated to be 20,119 toe per year. The equivalent GHG emissions are estimated to be 139,136 tonne CO_2 per year (Table 4.2.4.3c).

Table 4.2.4.3c: Energy consumption of Batala foundry cluster

Energy source	Unit	Energy consumption		GHG emissions
		Quantity	Equivalent (toe/year)	(tonne CO_2/year)
Coke	tonne/year	15,850	9,510	46,155
Furnace oil	tonne/year	1,260	1,267	3,909
Electricity	mil kWh /year	109	9,342	89,073
		Total	20,119	139,136

4.2.4.4 Performance analysis of foundry industries

The average specific energy consumption among different categories of foundry industries in the cluster varies in the range of 3.1-4.6 GJ per tonne of casting production. This variation is largely due to the type of energy use, the energy efficiency of technology employed, quality of product and its chemistries, etc. The details of performance in terms of SEC of different categories of industries are shown in table 4.2.4.4.

Table 4.2.4.4: Performance of foundry industries in Batala cluster

TYPE	SEC- Thermal (GJ/tonne)	SEC- Electrical (kWh/tonne)	SEC- Cluster (GJ/tonne)
Large (IF)	-	667	2.4
Medium (IF)	-	741	2.7
Small (IF)	-	893	3.2
Medium (CF)	2.6	93	2.9
Small (CF)	3.5	42	3.6
Micro(CF)	4.9	12	4.9
Micro(FO)	5.9	19	6.0
Minimum	-	12	2.4
Maximum	5.9	893	6.0

Note: SEC variations depend on process parameters

The micro category rotary furnace consumes maximum energy for producing per tonne of casting, which is estimated to be 6.0 GJ per tonne (Figure 4.2.4.4).

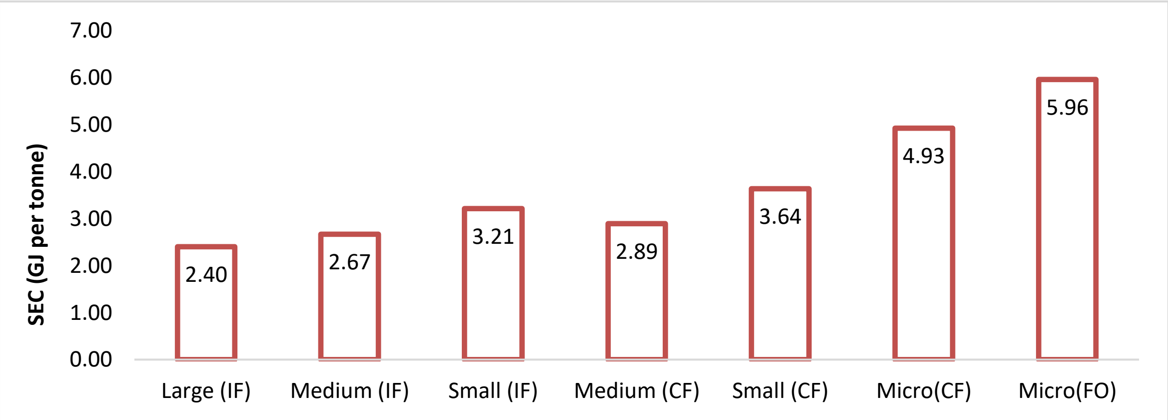


Figure 4.2.4.4: Variation of SEC among different category of industries

The cluster level specific energy consumption considering total annual production in the cluster and the total energy consumption is estimated to be around 3.4 GJ per tonne of casting production.

4.2.4.5 Relevant institutions for Batala foundry industries

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to foundry industries in this cluster are given in table 4.2.2.5.

Table 4.2.4.5: Institutions involved in the cluster

Institution/ organization	Contact details	Objectives and roles
Batala Foundry Men Association, Batala	Association of Batala Small Industries GT Road, Esskay Building Batala, Punjab-143 505 Tel: 0187 1242963 Email: rashtriya@rediffmail.com	• Close coordination with Bureau of Indian Standards and other regulatory bodies
Bharat Foundrymen Association, Gurdaspur	GT Road Gurdaspur-143 505	
The Institute of Indian Foundrymen (IIF) Batala Chapter	Hind Metal & Allied Industries 25-BF, Industrial Estate E- Batala - 143 505 email: batala@indianfoundry.org	• Promotes education, research, training, and development to Indian foundrymen • Nodal point of reference between the customers and suppliers of the Indian foundry industry on a global scale
Punjab Energy Development Agency (PEDA)	Solar Passive Complex, Plot No. 1-2, Sector 33-D, Chandigarh - 160 034 Tel: 0172 266 3382 Email: ceo@peda.gov.in https://www.peda.gov.in/	State Designated Agency (SDA) to coordinate, regulate and enforce efficient use of energy and its conservation

4.2.4.6 Other information

There is no specific energy efficiency related studies carried out in the past. BEE has initiated a project to carry out an energy and resource mapping study for the foundry sector in which Batala is one of the target clusters for detailed study. This project is under implementation.

4.2.4.7 Summary of findings

The summary of findings related to this foundry cluster is provided in table 4.2.4.7.

Table 4.2.4.7: Summary of findings of Batala foundry cluster

Parameter	Unit	Value
Number of units		450
Annual production	tonne per year	250,200
Total energy consumption	toe per year	20119
SEC – Overall	GJ per tonne	3.4
GHG emissions	tonne CO_2 per year	139,136
Specific GHG emissions	tonne CO_2 per tonne of casting	0.6
Other relevant information	On-going energy and resource mapping study under implementation by BEE	

4.2.5 Belgaum Foundry Cluster

4.2.5.1 Cluster background

The majority of the units in Belgaum are located in three industrial estates: (1) Udyambag Industrial Estate, (2) BEMCIEL (Belgaum Manufacturers Cooperative Industrial Estate Limited), and (3) Macche Industrial Estate. Apart from these industrial estates, a few foundry industries are also operating in Honga Industrial estate and in Navage area. The majority of the foundry industries are micro, small, and medium categories. Generally, smaller cupola-based foundries typically conduct melting 4 – 10 days in a month. A few large foundry units operate on a daily basis.

Primary raw material

Basic raw materials of the cluster are pig iron, bought-out scrap, in-house foundry return, and rejected castings, Ferro-silicon, Ferro-manganese, and limestone.

Major products

The primary users of the local castings are the OEM from heavy industries like Kirloskar Brothers Limited (Pune), Bharat Heavy Electricals Limited (Bangalore), and Machine Tools Limited (Bengaluru). Other castings include agriculture machinery, automotive /oil engine, pumps, fans, machine tools, diesel engine components, and valve body, etc.

Classification of industries

Around 160 foundries units in the cluster manufacture annually about 211,500 tonnes of ferrous casting. Both cupola furnace (CF) and induction furnace (IF) are in use for the melting process. Considering the melting technology employed and scale of operation, the categorization of industries are provided in table 4.2.5.1.

Table 4.2.5.1: Details of industries

Industry category (-)	No of Units (-)	Production range (TPM)	Average production (tonne/year)
Large (IF)	10	600 - 700	78,000
Medium (IF)	20	300 - 400	42,000
Small (IF)	60	150 - 250	72,000

Industry category (-)	No of Units (-)	Production range (TPM)	Average production (tonne/year)
Small (CF)	10	100 - 150	6,000
Micro (CF)	60	50 - 100	13,500
Total	160		211,500

Source: (1) Cluster profile report, SAMEEKSHA, (2) Analysis of cluster level secondary data by TERI

The majority of the industries are micro and small category and medium (>82%). The share of different categories of industries is provided in figure 4.2.5.1a. Cumulatively induction furnaces contribute maximum annual casting production, which is around 53% (figure 4.2.5.1b).

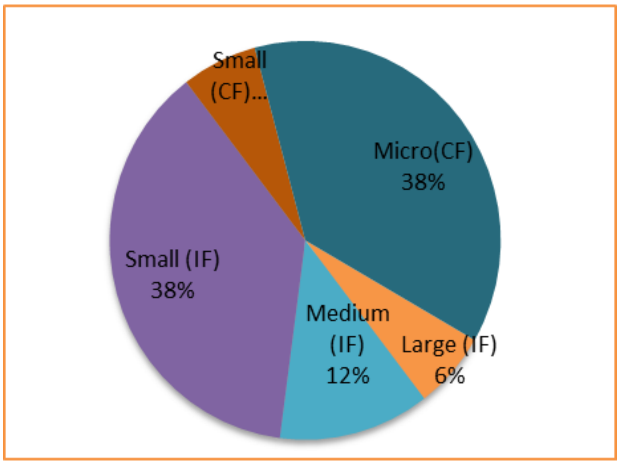


Figure 4.2.5.1a: Share of industries of different categories

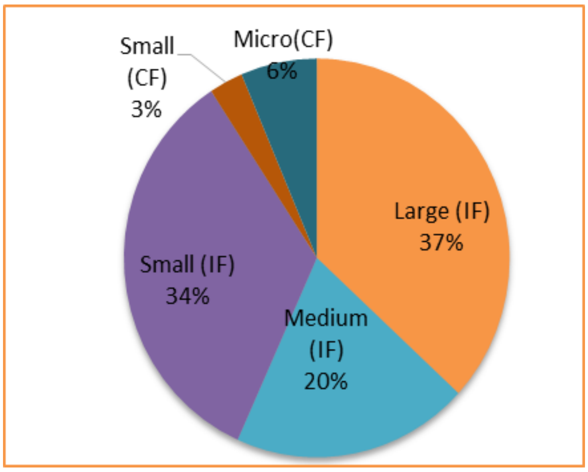


Figure 4.2.2.1b: Share of the annual production of different categories

4.2.5.2 Process technology

The details of melting technologies and major auxiliaries used in the cluster are provided in table 4.2.5.2.

Table 4.2.5.2: Primary technology of Belgaum foundry cluster

Technology	Purpose
Cupola furnace (CF)	All CFs in the cluster are coke fired. The average percentage of coke consumption on metal is in the range of 10 to 11 %.
Induction furnace (IF)	IFs are mostly used for producing higher grade casting, and most of them operate on a daily basis. The majority of these furnaces are smaller capacity with an average 150 to 250 tonne per month production. The electricity consumption varies in the range of 700-900 kWh per tonne of melt.

4.2.5.3 Energy consumption analysis

Details of energy use

Foundries in these clusters use either coke or electricity in melting. Coke is primarily used in cupola furnaces for producing liquid metal. The captive backup power generator is operated using diesel during the failure of grid supply.

Energy consumption pattern

The energy consumption pattern of the foundry units depends on the melting technology deployed and production capacities. The electricity contributes the majority energy share (>93%). The share of energy consumption from a different source is provided in figure 4.2.5.3a.

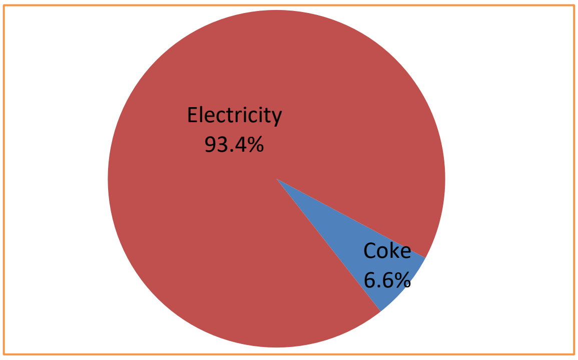


Figure 4.2.5.3a: Share of energy consumption source

Unit level energy consumption

The unit level annual energy consumption depends on the annual production range of different industries in the cluster. Table 4.2.5.3a provides the unit level annual energy consumption of different categories of industries in the cluster.

Table 4.2.5.3a: Details of unit level annual energy consumption

Fuel type	Unit	Energy consumption per plant				
		Large (IF)	Medium (IF)	Small (IF)	Small (CF)	Micro (CF)
Coke	tonne/year	-	-	-	60	25
Electricity	kWh/year	7,300,000	2,300,000	1,450,000	18,000	3,500

The cluster level annual energy consumption by individual category of industries is provided in table 4.2.5.3b.

Table 4.2.5.3b: Details cluster level annual energy consumption

Fuel type	Unit	Large (IF)	Medium (IF)	Small (IF)	Small (CF)	Micro (CF)
Coke	tonne/year	-	-	-	600	1,500
Electricity	mil kWh/year	73	46	87	0.2	0.2
Thermal	toe/year	-	-	-	360	900
Electrical	toe/year	6,278	3,956	7,482	15	18
Total	toe/year	6,278	3,956	7,482	375	918

The induction furnace based industries consume the most share of cluster level energy consumption, which is more than 90%. The distribution of cluster level energy consumption by different categories of industries is provided in figure 4.2.5.3b.

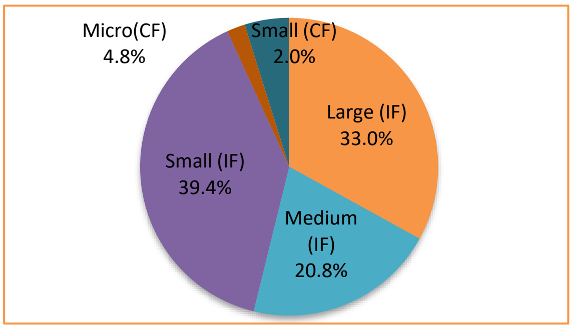


Figure 4.2.5.3b: Distribution of cluster level energy consumption

The total energy consumption in the cluster is estimated to be 19,010 toe per year. The equivalent GHG emissions are estimated to be 175,355 tonne CO_2 per year (Table 4.2.5.3c).

Table 4.2.5.3c: Energy consumption of Belgaum foundry cluster

Energy source	Unit	Energy consumption		GHG emissions
		Quantity	Equivalent (toe/year)	(tonne CO_2/year)
Coke	tonne/year	2,100	1,260	6,115
Electricity	mil kWh/year	206	17,750	169,240
		Total	19,010	175,355

4.2.5.4 Performance analysis of foundry industries

The average specific energy consumption among different categories of foundry industries in the cluster varies in the range of 3.1-4.6 GJ per tonne of casting production. This variation is largely due to the type of energy use, the energy efficiency of technology employed, quality of product and its chemistries, etc. The details of performance in terms of specific energy consumption incurred by different categories of industries are shown in table 4.2.5.4.

Table 4.2.5.4: Performance of foundry industries in Belgaum cluster

TYPE	SEC- Thermal (GJ/tonne)	SEC- Electrical (kWh/tonne)	SEC- Cluster (GJ/tonne)
Large (IF)	-	936	3.4
Medium (IF)	-	1,095	3.9
Small (IF)	-	1,208	4.3
Small (CF)	2.5	30	2.6
Micro(CF)	2.8	16	2.8
Minimum	-	16	2.6
Maximum	2.8	1,208	4.3

Note: SEC variations depend on process parameters

The small induction category furnace consumes maximum energy for producing per tonne of casting, which is estimated to be 4.35 GJ per tonne (Figure 4.2.5.4).

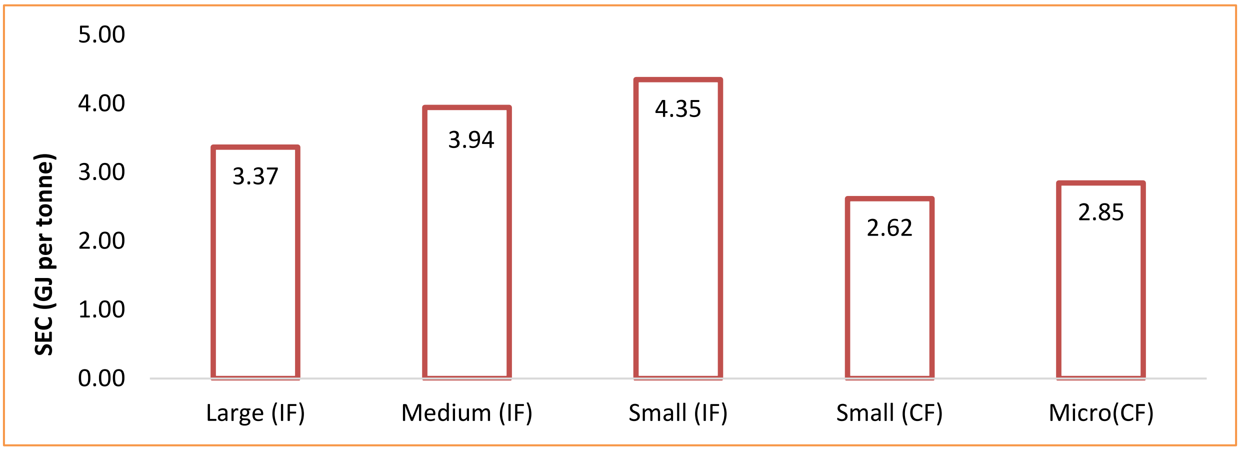


Figure 4.2.5.4: Variation of SEC among the different categories of industries

The cluster level specific energy consumption considering total annual production in the cluster and the total energy consumption is estimated to be around 3.8 GJ per tonne of casting production.

4.2.5.5 Relevant institutions for Belgaum foundry industries

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to foundry industries in this cluster are given in table 4.2.5.5.

Table 4.2.5.5: Institutions involved in Belgaum foundry cluster

Institution/ organization	Contact details	Objectives and roles
Belgaum Chambers of Commerce and Industries (BCCI)	Khanapur Road, Udyambag, Belagavi, Karnataka 590008 Tel: 0831 244 0417 email: info@belgaumchamber.com/ https://belgaumchamber.com/	• Addressing regulatory issues related to foundry industries in the cluster
Belgaum District Small Scale Industries Association (BSSIA)	Plot No. 41, BEMCIEL, Khanapur Road, Udyambag, Belgaum 590008 Tel: 0831 244 2802 Email: facebook.com/BDSSIA http://www.bdssia.com	
Belgaum Foundry Cluster (BFC)	Plot No.1, Angol Industrial Area, Udyambag, Belagavi, Karnataka 590008 Tel: 0831 244 3392 Email: bgmfoundrycluster@gmail.com, http://www.bfcindia.co.in	
The Institute of Indian Foundrymen (IIF) Belgaum Chapter	A.K.P Foundries Pvt. Ltd. R.S. No. 689, Udyambag, Belgaum – 590008 Tel: 0831 244 0164/420 2766 email: belgaum@indianfoundry.org	• Promote education, research, training, and development to Indian foundrymen • Nodal point of reference between the customers

Institution/ organization	Contact details	Objectives and roles
		and suppliers of the Indian foundry industry on a global scale
Karnataka Renewable Energy Development Limited(KREDL)	39, Shanthi Gruha, Bharath Scouts & Guides Building, Palace Road, Bengaluru – 560 001, Karnataka. Tel: 080 2220 7851 email: kredl09ec@gmail.com http://www.kredlinfo.in	• State Designated Agency (SDA) to coordinate, regulate and enforce efficient use of energy and its conservation

4.2.5.6 Other information

UNIDO, in association with BEE, has initiated a project to promote energy conservation measures and capacity building of local service providers. This project is under implementation.

4.2.5.7 Summary of findings

The summary of findings related to this foundry cluster is provided in table 4.2.5.7.

Table 4.2.5.7: Summary of findings of Belgaum foundry cluster

Parameter	Unit	Value
Number of units		160
Annual production	tonne per year	211,500
Total energy consumption	toe per year	19,010
SEC – Overall	GJ per tonne	3.8
GHG emissions	tonne CO_2 per year	175,355
Specific GHG emissions	tonne CO_2 per tonne of casting	0.8
Other relevant information	Cluster level initiative by UNIDO is under implementation	

4.2.6 Coimbatore Foundry Cluster

4.2.6.1 Cluster background

Coimbatore foundry cluster has great demand for casting products from diverse industries like textile, spinning, pump and motor body manufacturers, major automobile manufacturing units such as Hyundai, Honda, Leyland, Allwyn Nissan, Pricol, L&T, LMW and Mahindra, etc., from surrounding major industrial hubs. The majority of foundries in the Coimbatore cluster are small in capacity and typically conduct melting 4 – 10 days in a month using coke based cupola. The foundry industries are scattered both within and outside the city. Some of the areas with a larger concentration of foundry industries are Arasur, Annur, Avinashi Road, Ganapathy, Kanuvai, Manikkampalayam, Mettupalayam, Peelamedu and SIDCO Industrial Estate.

Primary raw material

The raw material compositions for manufacturing castings largely depend on the desired chemistry; however, base raw materials for different industries in the cluster are the same, which include pig iron, steel, boring, bought out scrap, in-house foundry return and rejected castings, and alloys (ferro-silicon, ferro-manganese, iron sulphide, silicon carbide, etc.). In addition, small quantities of other metals like copper and tin are added for special grades and SG iron castings.

Major products

Most of the foundries in the cluster are of captive type, i.e. they produce castings for use in the end-products being manufactured by the OEM for different end-use applications like textile, spinning, pump and motor manufacturers, automobile industries, a few to name.

Classification of industries

Around 535 foundries units in the cluster are manufacturing0.6 million tonne per year of ferrous casting. Both cupola furnace (CF) and induction furnace (IF) are in use for the melting process. Considering the melting technology employed and scale of operation, the categorization of industries are provided in table 4.2.6.1.

Table 4.2.6.1: Details of industries

Industry category	Number of units	Production range (tpm)	Average production (tonne/year)
Large (IF)	15	500-1,500	180,000
Medium (IF)	70	100-500	252,000
Small (IF)	50	50-100	45,000
Small (CF)	50	20-50	21,000
Micro (CF)	350	15-25	84,000
Total	535		582,000

Source: (1) Cluster profile report, SAMEEKSHA, (2) Analysis of cluster level secondary data by TERI

The majority of the industries are micro and small category and medium (>84%). The share of different categories of industries is provided in figure 4.2.6.1a. Cumulatively induction furnaces contribute maximum annual casting production, which is more than 80% (figure 4.2.6.1b).

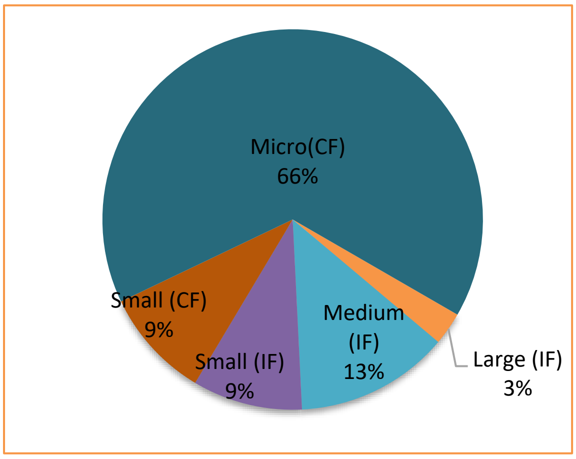


Figure 4.2.6.1a: Share of industries of different categories

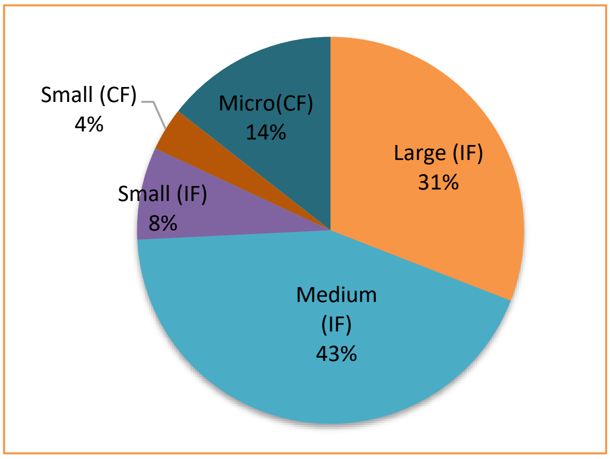


Figure 4.2.6.1b: Share of the annual production of different categories

4.2.6.2 Process technology

The details of melting technologies and major auxiliaries used in the cluster are provided in Table 4.2.6.2.

Table 4.2.6.2: Primary technology of Coimbatore foundry cluster

Technology	Purpose
Cupola furnace	All CFs in the cluster are coke fired. The average percentage of coke consumption on metal is in the range of 10.7-12.5%.
Induction furnace	IFs are mostly used for producing higher grade casting, and most of them operate on a daily basis. The majority of these furnaces are smaller capacity with an average 100 to 1000 tonne per month production. The electricity consumption varies in the range of 600-900 kWh per tonne of melt.

4.2.6.3 Energy consumption analysis

Foundries in these clusters use either coke or electricity in melting. Coke is primarily used in cupola furnaces for producing liquid metal. The energy consumption pattern of the foundry units depends on the melting technology deployed and production capacities. The electricity contributes the majority energy share (>82%). The share of energy consumption from a different source is provided in figure 4.2.6.3a.

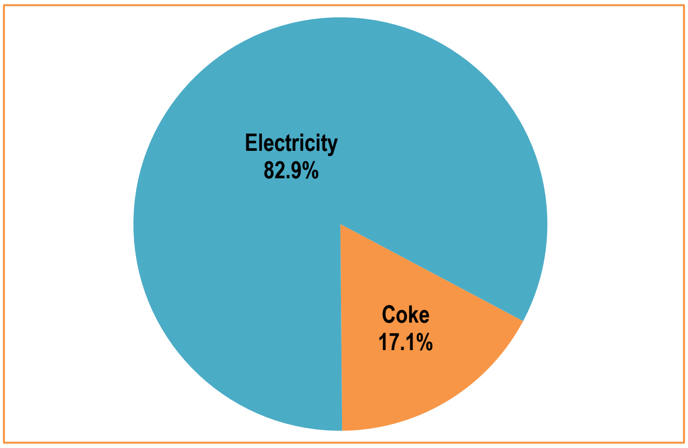


Figure 4.2.6.3a: Share of energy consumption source

The unit level annual energy consumption depends on the annual production range of different industries in the cluster. Table 4.2.2.3a provides the unit level annual energy consumption of different categories of industries in the cluster.

Table 4.2.2.3a: Details of unit level annual energy consumption

Fuel type	Unit	Energy consumption per plant				
		Large (IF)	Medium (IF)	Small (IF)	Small (CF)	Micro (CF)
Coke	tonne/year	-	-	-	45	30
Electricity	kWh/year	10,300,000	3,150,000	1,100,000	12,000	3,000

The cluster level annual energy consumption by individual category of industries is provided in table 4.2.6.3b.

Table 4.2.6.3b: Details cluster level annual energy consumption

Fuel type	Unit	Large (IF)	Medium (IF)	Small (IF)	Small (CF)	Micro (CF)
Coke	tonne/year	0	0	0	2,250	10,500
Electricity	mil kWh/year	154	220	55	0.6	1.0
Thermal	toe/year	0	0	0	1,350	6,300
Electrical	toe/year	13,287	18,963	4,730	52	90
Total	toe/year	13,287	18,963	4,730	1,402	6,390

The induction furnace based industries consume the maximum share of cluster level energy consumption, which is more than 82%. The distribution of cluster level energy consumption by different categories of industries is provided in figure 4.2.6.3b.

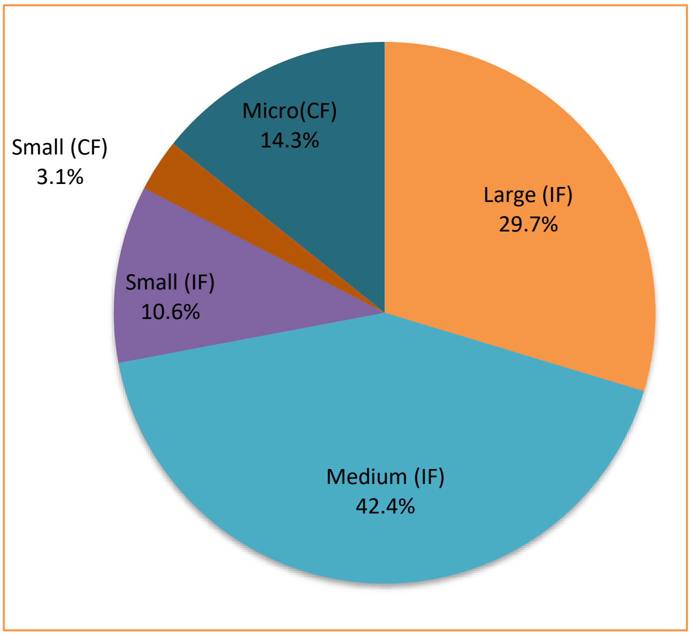


Figure 4.2.6.3b: Distribution of cluster level energy consumption

The total energy consumption in the cluster is estimated to be 44,772 toe per year. The equivalent GHG emissions are estimated to be 391,081 tonne CO_2 per year (table 4.2.6.3c).

Table 4.2.6.3c: Energy consumption of Coimbatore foundry cluster

Energy source	Unit	Energy consumption		GHG emissions
		Quantity	Equivalent (toe/year)	(tonne CO_2/year)
Coke	tonne/year	12,750	7,650	37,128
Electricity	mil kWh/year	432	37,122	353,953
		Total	44,772	391,081

4.2.6.4 Performance analysis of foundry industries

The average specific energy consumption among different categories of foundry industries in the cluster varies in the range of 2.8 – 4.4 GJ per tonne of casting production. This variation is largely due to the type of energy use, the energy efficiency of technology employed, quality of product and its chemistries, etc. The details of performance in terms of specific energy consumption incurred by different categories of industries are shown in table 4.2.6.4.

Table 4.2.6.4: Performance of foundry industries in Coimbatore cluster

Type	SEC- Thermal (GJ/tonne)	SEC- Electrical (kWh/tonne)	SEC- Cluster (GJ/tonne)
Large (IF)	-	858	3.1
Medium (IF)	-	875	3.1
Small (IF)	-	1222	4.4
Small (CF)	2.7	29	2.8
Micro(CF)	3.1	12	3.2
Minimum	-	12	2.8
Maximum	3.1	1222	4.4

Note: SEC variations depend on process parameters

The small induction category furnace consumes maximum energy for producing per tonne of casting, which is estimated to be 4.4 GJ per tonne (Figure 4.2.6.4).

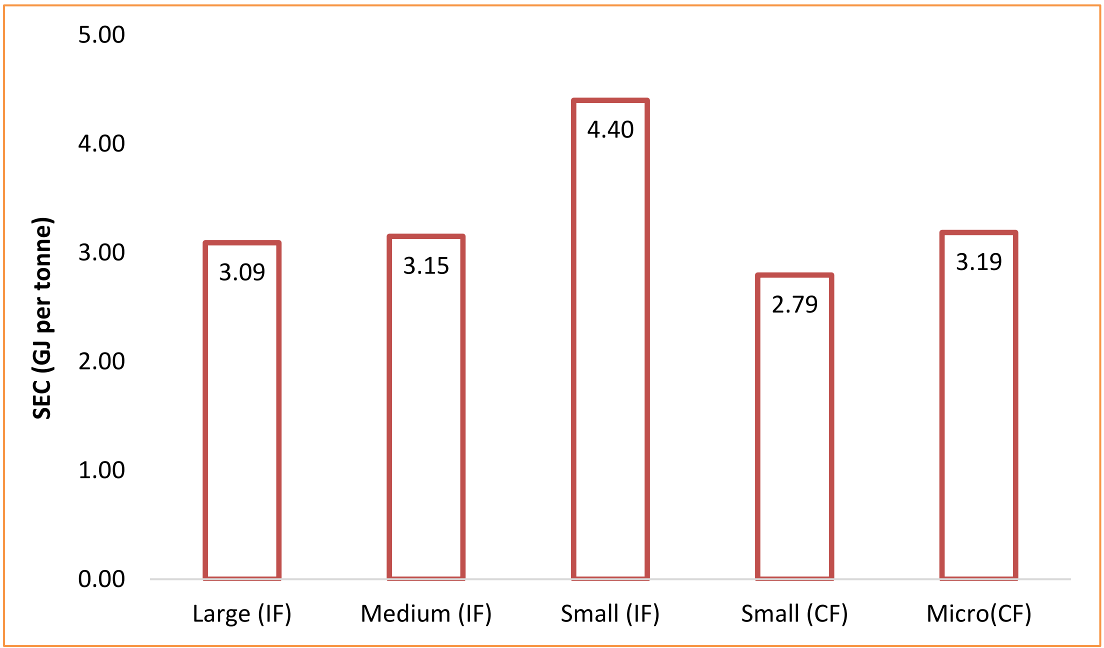


Figure 4.2.6.4: Variation of SEC among the different categories of industries

The cluster level specific energy consumption considering total annual production in the cluster and the total energy consumption is estimated to be around 3.2 GJ per tonne of casting production.

4.2.6.5 Relevant institutions for Coimbatore foundry industries

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to foundry industries in this cluster are given in table 4.2.6.5.

Table 4.2.6.5: Institutions involved in Coimbatore foundry cluster

Institution/ organization	Contact details	Objectives and roles
Coimbatore Industrial Infrastructure Association (COINDIA)	Coindia, 340-342, Avarampalayam, K R Puram, Coimbatore, Tamil Nadu 641006 Tel: 0422 427 3775 email: info@coindia.in https://www.coindia.in/	• Most of the foundry industries are member of one or more association. • Work in close coordination with each other for the benefits of the cluster and other regulatory issues related to foundry industries
Southern India Engineering Manufacturers' Association (SIEMA)	41, Race Course Rd, Race Course, Gopalapuram, Coimbatore, Tamil Nadu 641018 Tel: 0422222 0014, 4514014 email: siema@siema.org https://www.siema.org/index.php	
Coimbatore District Small Industries Association (CODISSIA)	G.D.Naidu Towers, Post Bag No.3827, Huzur Road, Coimbatore 641 018 Tel: 0422 2221582, 2222409 email: info@codissia.com https://www.codissia.com/index.php	
Coimbatore Tiny and Small Foundry Owners Association (COSMAFAN)	Hem Garden Road, Off, Avinashi Rd, Peelamedu, Tamil Nadu 641004 Tel: 0422 2562863	• Represents small foundry industries and established one foundry park for their members
The Coimbatore Foundry and Industry Owners Association (COFIOA)	No 14 A R R Naidu Industrial Estate, Trichy Road, Singanallur, Coimbatore – 641005 Tel: 0422 227 0854	• Represents small and micro scale foundry units in the cluster focusing on welfare activities and grievances redressal
The Institute of Indian Foundrymen (IIF) - Coimbatore Chapter	CPC (P) Ltd 207, Mettupalayam Road Coimbatore - 641030 coimbatore@indianfoundry.org	• Promotes education, research, training, and development to Indian foundrymen • Nodal point of reference between the customers and suppliers of the Indian foundry industry on a global scale

Institution/ organization	Contact details	Objectives and roles
Chief Electrical Inspector to Govt of Tamil Nadu	Electrical Inspectorate Department Government of Tamil Nadu Thiru Vi.Ka. Industrial Estate, Guindy, Chennai-600 032 Tel: 044 2250 0184 http://www.tnei.tn.gov.in/	State Designated Agency (SDA) to coordinate, regulate and enforce efficient use of energy and its conservation

4.2.6.6 Other information

There is a project under implementation with support from BEE focusing on cluster mapping covering energy and resource consumption) and UNIDO in association with BEE to promote energy conservation measures and capacity building of local service providers.

4.2.6.7 Summary of findings

The summary of findings related to this foundry cluster is provided in table 4.2.6.7.

Table 4.2.6.7: Summary of findings of Coimbatore foundry cluster

Parameter	Unit	Value
Number of units		535
Annual production	tonne per year	582,000
Total energy consumption	toe per year	44,772
SEC – Overall	GJ per tonne	3.2
GHG emissions	tonne CO_2 per year	391,081
Specific GHG emissions	tonne CO_2 per tonne of casting	0.7
Other relevant information	Cluster level initiative by BEE and UNIDO is under implementation	

4.2.7 Kolhapur Foundry Cluster

4.2.7.1 Cluster background

Kolhapur is a hub for industry, comprising mainly of automotive, foundries, engineering spares, sugar industries, and textile mills. Out of eight industrial estates in Kolhapur, three are Maharashtra Industrial Development Corporations (MIDC), and six are corporate industrial estates. These industrial estates include (i) Shiroli MIDC, (ii) Gokul Shirgaon MIDC, (iii) Kagal 5-star MIDC, (iv) Kolhapur city, (v) Ichalkaranji industrial estate, (vi) Jaisingpur industrial area, (vii) Laxmi industrial area and (viii) Hatkanagale industrial area.

Kolhapur has several large manufacturing companies like Kirloskar Oil Engines, Vardhaman Textiles, Raymond Textiles, Menon Group, Gokul Milk, Eurotex, etc. The foundry industries in Kolhapur are dispersed across various industrial estates and primarily manufacture ferrous (iron) castings covering both SG iron and grey-iron castings to cater to the requirement of OEMs from the automotive sector along with other sectors such pumps/valves, sugar, textiles, etc. The cluster also exports castings to several countries and catering to numerous industries.

Primary raw material

The base raw materials for the foundry industries in the cluster are the same across all units, which include pig iron, steel, boring, bought out scrap, in-house foundry return, and rejected castings. The use of alloying elements such as ferro-silicon, ferro-manganese, iron sulphide, silicon carbide, etc., depends on the target chemistries of the castings. In addition, small quantities of other metals like copper and tin are added for special grades and SG iron castings.

Major products

Most of the foundries in the cluster are of captive type i.e., they produce castings for use in the end-products being manufactured by the OEM for different end-use applications like textile, spinning, sugar mills, agricultural appliances, pump, valves and motor body manufacturers, automobile industries a few to name.

Classification of industries

About 300 foundries units in the cluster manufacture a total of about 613,500 tonnes of ferrous casting per year. Both cupola furnace and induction furnace are used for melting process. Considering the melting technology employed and scale of operation, the categorization of industries are provided in table 4.2.7.1.

Table 4.2.7.1: Details of industries

Industry category	No of Units	Production range (tpm)	Average production (tonne/year)
Large (IF)	10	1000-1500	150,000
Medium (IF)	75	200-400	270,000
Small (IF)	115	50-100	103,500
Small (CF)	100	50-100	90,000
TOTAL	300		613,500

Source: (1) Cluster profile report, SAMEEKSHA, (2) Analysis of cluster level secondary data by TERI

The small and medium sized foundries (including cupola and induction furnace) account for about 97% of the total number of units (figure 4.2.7.1a). Cumulatively induction furnaces contribute maximum annual casting production, which is more than 85% (figure 4.2.7.1b).

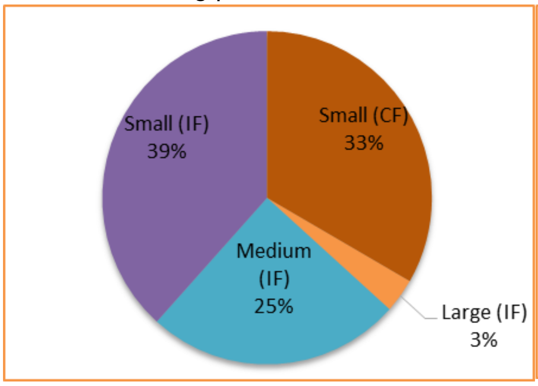


Figure 4.2.7.1a: Share of industries of different categories

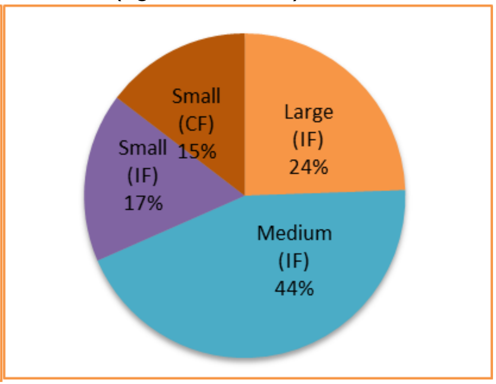


Figure 4.2.7.1b: Share of the annual production of different categories

4.2.7.2 Process technology

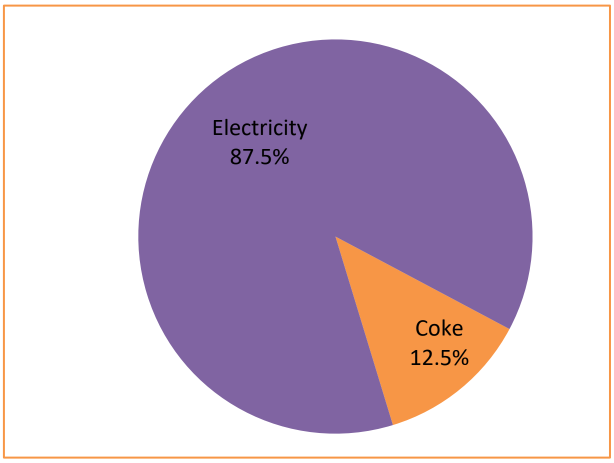
The details of melting technologies and primary auxiliary equipment used in the cluster are provided in Table 4.2.7.2.

Table 4.2.7.2: Primary technology of Kolhapur foundry cluster

Technology	Purpose
Cupola furnace	All CFs in the cluster are coke fired. The average percentage of coke consumption on metal is around 11.1 %.
Induction furnace	IFs are mostly used for producing higher grade casting, and most of them operate on a daily basis. The furnace melting capacity depends on design capacity, and it varies in the cluster with an average 100 to 1500 tonne per month production, and electricity consumption varies in the range of 625 – 800 kWh per tonne of melt.

4.2.7.3 Energy consumption analysis

Foundries in these clusters use either coke or electricity in melting. Coke is primarily used in cupola furnaces for producing liquid metal. The energy consumption pattern of the foundry units depends on the melting technology deployed and production capacities. The electricity contributes the majority energy share (>87%). The share of energy consumption from a different source is provided in figure



4.2.7.3a.

Figure 4.2.7.3a: Share of energy consumption source

The unit level annual energy consumption depends on the annual production range of different industries in the cluster. Table 4.2.7.3a provides the unit level annual energy consumption of different categories of industries in the cluster.

Table 4.2.7.3a: Details of unit level annual energy consumption

Fuel type	Unit	Energy consumption per plant			
		Large (IF)	Medium (IF)	Small (IF)	Small (CF)
Coke	tonne/year	-	-	-	100
Electricity	kWh/year	12,500,000	3,500,000	850,000	25,000

The cluster level annual energy consumption by individual category of industries is provided in table 4.2.7.3b.

Table 4.2.7.3b: Details cluster level annual energy consumption

Fuel type	Unit	Large (IF)	Medium (IF)	Small (IF)	Small (CF)
Coke	tonne/year	-	-	-	10,000
Electricity	mil kWh/year	125	262	98	2.5

Thermal	toe/year	-	-	-	6,000
Electrical	toe/year	10,750	22,575	8,406	215
Total	toe/year	10,750	22,575	8,406	6,215

The IF based foundries account for about 67% of total energy consumption at cluster level (figure 4.2.7.3b).

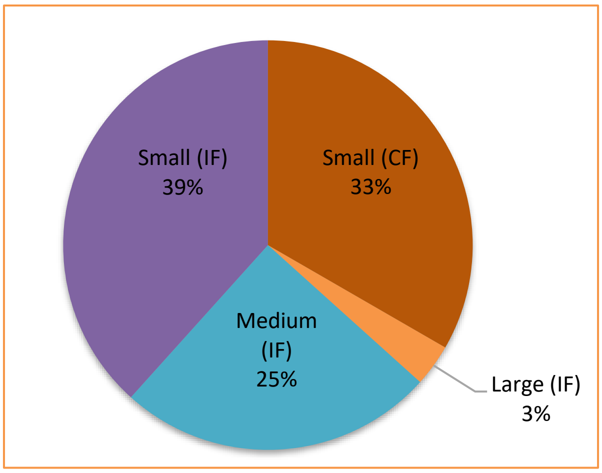


Figure 4.2.7.3b: Distribution of cluster level energy consumption

The total energy consumption in the cluster is estimated to be 47,947 toe per year. The equivalent GHG emissions are estimated to be 429,075 tonne CO_2 per year (Table 4.2.7.3c).

Table 4.2.7.3c: Energy consumption of Kolhapur foundry cluster

Energy source	Unit	Energy consumption Quantity	Equivalent (toe/year)	GHG emissions (tonne CO_2/year)
Coke	tonne/year	10,000	6,000	29,120
Electricity	mil kWh/year	488	41,947	399,955
		Total	47,947	429,075

4.2.7.4 Performance analysis of foundry industries

The average specific energy consumption among different categories of foundry industries in the cluster varies in the range of 3.1 – 4.6 GJ per tonne of casting production. This variation is largely due to the type of energy use, the energy efficiency of technology employed, quality of product and its chemistries, etc. The details of performance in terms of specific energy consumption incurred by different categories of industries are shown in table 4.2.7.4.

Table 4.2.7.4: Performance of foundry industries in Kolhapur cluster

TYPE	SEC- Thermal (GJ/tonne)	SEC- Electrical (kWh/tonne)	SEC- Cluster (GJ/tonne)
Large (IF)	-	833	3.0
Medium (IF)	-	972	3.5
Small (IF)	-	944	3.4

TYPE	SEC- Thermal (GJ/tonne)	SEC- Electrical (kWh/tonne)	SEC- Cluster (GJ/tonne)
Small (CF)	2.8	28	2.9
Minimum	-	28	2.9
Maximum	2.8	972	3.5

Note: SEC variations depend on process parameters

The small induction category furnace consumes maximum energy for producing per tonne of casting, which is estimated to be 3.4 GJ per tonne (Figure 4.2.7.4).

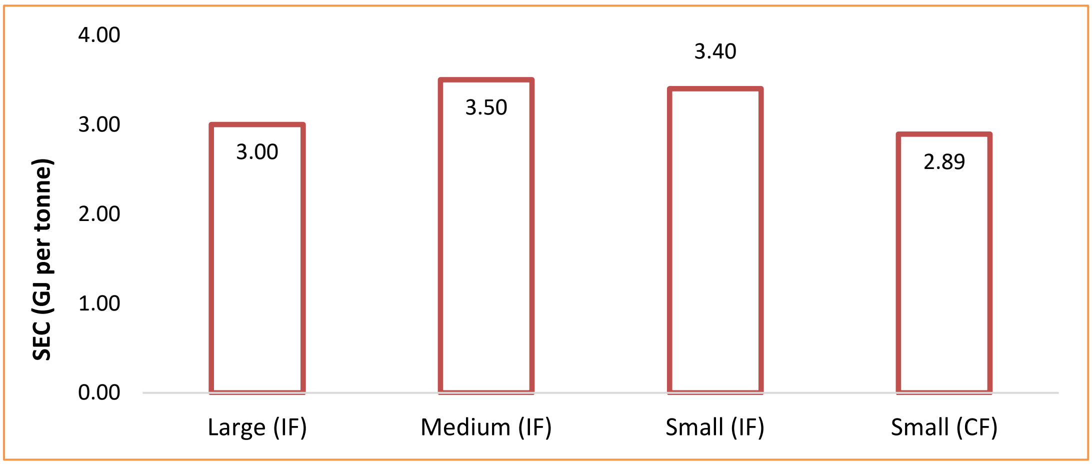


Figure 4.2.7.4: Variation of SEC among the different categories of industries

The cluster level specific energy consumption considering total annual production in the cluster and the total energy consumption is estimated to be around 3.3 GJ per tonne of casting production.

4.2.7.5 Relevant institutions for Kolhapur foundry industries

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to foundry industries in this cluster are given in table 4.2.7.5.

Table 4.2.7.5: Institutions involved in Kolhapur foundry cluster

Institution/ organization	Contact details	Objectives and roles
The Kolhapur Engineering Association (KEA)	1243/46-47, E Ward, Madhawrao Karajgar Road, Shivaji Udyam Nagar, Kolhapur Tel: 0231-2654652 kprenggasso@gmail.com https://www.keaindia.org/	• The most of the foundry industries in the cluster are the member of one or more association. • They work in close coordination with each other for the benefits of the cluster and other regulatory issues related to foundry industries
Gokul Shirgaon Manufacturers Association (GOSHMA)	P-5, MIDC Area , Gokul Shirgaon, Kolhapur - 416234 Tel: 0231 267 2470	
Shiroli Manufacturers Association of Kolhapur (SMAK)	P-12, MIDC, Shiroli, Kolhapur, Maharashtra 416112 Tel: 0230 246 8001	

Institution/ organization	Contact details	Objectives and roles
Manufacturers Association of Kagal Hatkanangale (MAKH)	Plot No P4, Raymond Circle, Kagal, Kolhapur - 416216 Tel: 9226 391 314	
Ichalkaranji Engineering Association	Plot no. 367, The Ichalkaranji Co-operative Industrial Estate, Khanjire nagar, Shahapur, Industrial Estate, Ichalkaranji, Maharashtra 416115 Tel: 0230 244 1855	
The Institute of Indian Foundrymen (IIF) Kolhapur Chapter	Rajarampuri email: kolhapur@indianfoundry.org	• It is one of the vibrant chapters in promoting education, research, training, and development to Indian foundrymen and serve as a nodal point of reference between the customers and suppliers of the Indian foundry industry on a global scale
Maharashtra Energy Development Agency (MEDA)	MHADA Commercial Complex, 2nd Floor, Opp. Tridal Nagar, Yerwada, Pune – 411 006, Maharashtra. Tel: 02026614403, 26641393 http://www.mahaurja.com	State Designated Agency (SDA) to coordinate, regulate and enforce efficient use of energy and its conservation

4.2.7.6 Other information

There is no on-going initiative by development agencies or the Central Government department. In the past, the cluster has established SPV for setting testing, training, and sand reclamation facilities.

4.2.7.7 Summary of findings

The summary of findings related to this foundry cluster is provided in table 4.2.7.7.

Table 4.2.7.7: Summary of findings of Kolhapur foundry cluster

Parameter	Unit	Value
Number of units		300
Annual production	tonne per year	613,500
Total energy consumption	toe per year	47,947
SEC – Overall	GJ per tonne	3.27
GHG emissions	tonne CO_2 per year	429,075
Specific GHG emissions	tonne CO_2 per tonne casting	0.7
Other relevant information	No on-going cluster level initiative is under implementation	

4.2.8 Howrah Foundry Cluster

4.2.8.1 Cluster background

There are more than 300 foundries located in the Howrah cluster, except a few mostly use coke based cupola furnaces. Foundry units are located around the city and are mainly concentrated at Liluah, Salkia, Benaras Road, Belgachia, Dasnagar, Balitikuri, Jangalpur and Santragachi. Some of the major foundries in the cluster include Kiswok Industries, Calcutta Ferrous, Bharat Engineering Works, Crescent Foundry, Shree Uma Foundry, R B Aggarwalla and CO, Gobin Steel Industries, RBA Ferro, Kejriwal castings, etc.

Primary raw material

The base raw materials for the foundry industries in the cluster are the same across all units, which include pig iron, steel, boring, bought out scrap, in-house foundry return and rejected castings. The use of alloying elements such as ferro-silicon, ferro-manganese, iron sulphide, silicon carbide, etc., depends on the target chemistries of the castings. In addition, small quantities of other metals like copper and tin are added for special grades and SG iron castings.

Major products

Most of the foundries in the cluster are of captive type, i.e., they produce castings for use in the end-products being manufactured by the OEM for different end-use applications. The primary products of the cluster include automobile components, railway components, earthmoving components, valves and other engineering components, manhole cover and frames, counterweights, flywheel housing, steel grating, and pipe fittings.

Classification of industries

There are 330 foundries in the cluster manufacturing annually about 811, 200 tonne of ferrous casting. Both cupola furnace (CF) and induction furnace (IF) are in use for the melting process. Considering the melting technology employed and scale of operation, the categorization of industries are provided in table 4.2.8.1.

Table 4.2.8.1: Details of industries

Industry category	No of Units	Production range (tpm)	Average production (tonne/year)
Micro (CF)	150	30-70	90,000
Small (CF)	100	100-150	120,000
Medium (CF)	50	400-600	300,000
Large (CF)	20	500-1500	240,000
Small (IF)	4	100-200	7,200
Medium (IF)	6	500-1000	54,000
Total	330		811,200

Source: (1) Cluster profile report, SAMEEKSHA, (2) Analysis of cluster level secondary data by TERI

The majority of the industries operate coke based cupola furnaces (>95%). The share of different categories of industries is provided in figure 4.2.8.1a. Cumulatively, cupola furnaces contribute maximum share (>92%) of annual production of castings (figure 4.2.8.1b).

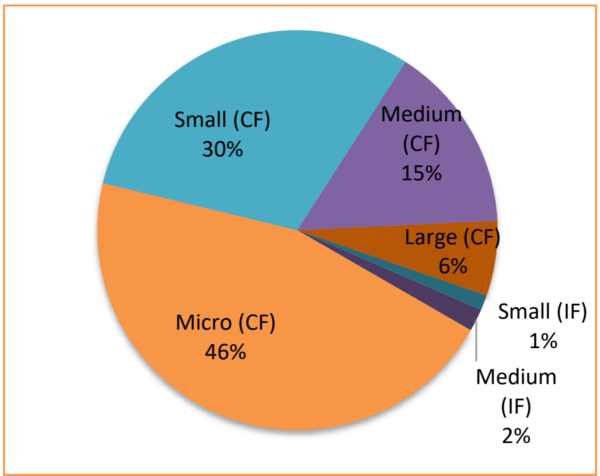


Figure 4.2.8.1a: Share of industries of different categories

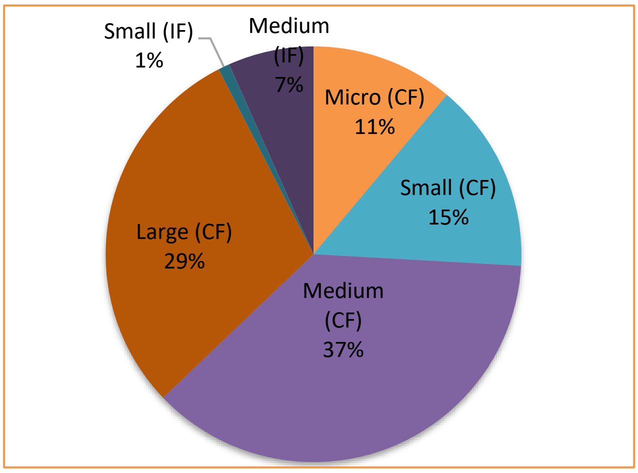


Figure 4.2.8.1b: Share of the annual production of different categories

4.2.8.2 Process technology

The details of melting technologies and primary auxiliary equipment used in the cluster are provided in table 4.2.8.2.

Table 4.2.8.2: Process technologies in Howrah foundry cluster

Technology	Purpose
Cupola furnace (CF)	The cupola furnace uses coke. The average coke consumption across the different categories of the units is around 12.5 to 15.8 %.
Induction furnace (IF)	Induction furnace uses electricity to produce high grade castings. The furnace melting capacity varies in the range of 100 to 1500 tonne per month, and electricity consumption varies in the range of 635-725 kWh per tonne of melt.

4.2.8.3 Energy consumption analysis

Foundries in these clusters use either coke or electricity in melting. Coke is primarily used in cupola furnaces for producing liquid metal. The energy consumption pattern of the foundry units depends on the melting technology deployed and production capacities. The coke contributes the majority energy share (>87%). The share of energy consumption from a different source is provided in figure 4.2.8.3a.

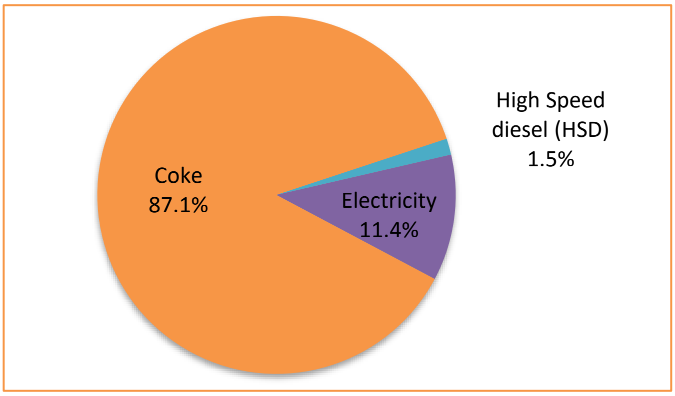


Figure 4.2.8.3a: Share of energy consumption source

The unit level annual energy consumption depends on the annual production range of different industries in the cluster. Table 4.2.8.3a provides the unit level annual energy consumption of different categories of industries in the cluster.

Table 4.2.8.3a: Details of unit level annual energy consumption

Fuel type	Unit	Energy consumption per plant					
		Micro (CF)	Small (CF)	Medium (CF)	Large (CF)	Small (IF)	Medium (IF)
Coke	tonne/year	80	150	950	1,700	-	-
HSD	kL/year	1	2	10	20	-	-
Electricity	kWh/year	6,000	35,000	100,000	700,000	1,740,000	11,437,500

The cluster level annual energy consumption by individual category of industries is provided in table 4.2.8.3b.

Table 4.2.8.3b: Details cluster level annual energy consumption

Fuel type	Unit	Micro (CF)	Small (CF)	Medium (CF)	Large (CF)	Small (IF)	Medium (IF)
Coke	tonne/year	12,000	15,000	47,500	34,000	-	-
HSD	kL/year	150	200	500	400	-	-
Electricity	mil kWh/year	0.9	3.5	5	14	7.0	69
Thermal	toe/year	7,331	9,175	28,937	20,750	0	0
Electrical	toe/year	77	301	430	1,204	599	5,902
Total	toe/year	7,408	9,476	29,367	21,954	599	5,902

The cupola furnace based industries consume the maximum share of cluster level energy consumption, which is more than 90%. The distribution of cluster level energy consumption by different categories of industries is provided in figure 4.2.8.3b.

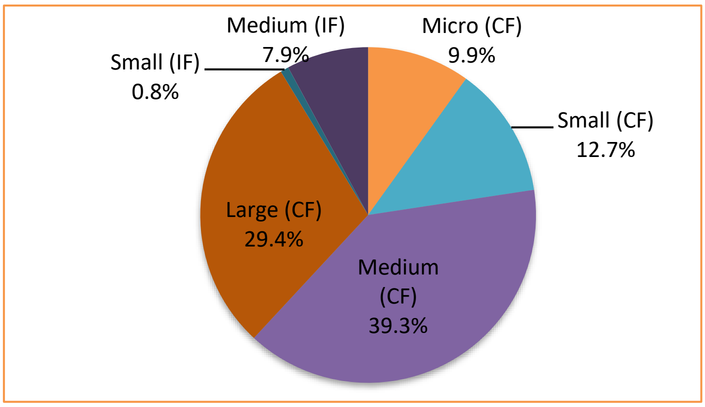


Figure 4.2.8.3b: Distribution of cluster level energy consumption

The total energy consumption in the cluster is estimated to be 74,705 toe per year. The equivalent GHG emissions are estimated to be 400,289 tonne CO_2 per year (Table 4.2.8.3c).

Table 4.2.8.3c: Energy consumption of Howrah foundry cluster

Energy source	Unit	Energy consumption		GHG emissions (tonne CO_2/year)
		Quantity	Equivalent (toe/year)	
Coke	tonne/year	108,500	65,100	315,952
HSD	kL/year	1,250	1,092	3,170
Electricity	mil kWh /year	99	8,513	81,168
Total			74,705	400,289

4.2.8.4 Performance analysis of foundry industries

The average specific energy consumption among different categories of foundry industries in the cluster varies in the range of 3.3-4.6 GJ per tonne of casting production. This variation is largely due to the type of energy use, the energy efficiency of technology employed, quality of product and its chemistries, etc. The details of performance in terms of specific energy consumption incurred by different categories of industries are shown in table 4.2.8.4.

Table 4.2.8.4: Performance of foundry industries in Howrah cluster

TYPE	SEC- Thermal (GJ/tonne)	SEC- Electrical (kWh/tonne)	SEC- Cluster (GJ/tonne)
Micro (CF)	3.4	10	3.4
Small (CF)	3.2	29	3.3
Medium (CF)	4.0	17	4.1
Large (CF)	3.6	58	3.8
Small (IF)	-	967	3.5
Medium (IF)	-	1,271	4.6
Minimum	-	10	3.3
Maximum	4.0	1,271	4.6

Note: SEC variations depend on process parameters

The medium induction category furnace consumes maximum energy for producing per tonne of casting, which is estimated to be 4.6 GJ per tonne (Figure 4.2.8.4).

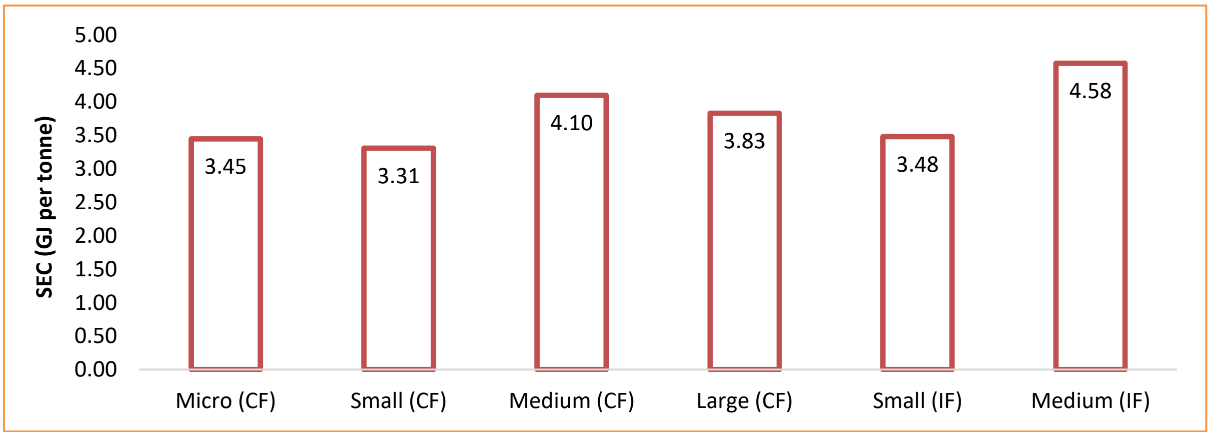


Figure 4.2.8.4: Variation of SEC among the different categories of industries

The cluster level specific energy consumption considering total annual production in the cluster and the total energy consumption is estimated to be around 3.9 GJ per tonne of casting production.

4.2.8.5 Relevant institutions for Howrah foundry industries

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to foundry industries in this cluster are given in table 4.2.8.5.

Table 4.2.8.5: Institutions involved in Howrah foundry cluster

Institution/ organization	Contact details	Objectives and roles
Indian Foundry Association (IFA)	4, India Exchange Place, 7th floor, Kolkata- 700001 Tel: 03322206790 email: info@ifa.org.in	• The IFA is a national association, affiliated to the Indian Chamber of Commerce
Howrah Foundry Association (HFA)	Das Nagar, C E O Building, Howrah-711105 Tel: 033 2653 5658 email: hfdcluster@gmail.com	• HFA is the state level association for foundries. Most of micro and small scale cupola foundries are the member of HFA
The Institute of Indian Foundrymen (IIF) Kolkata Chapter	Calcutta Greens, Phase - I. HIGB 1/8 1050/2, Survey Park Kolkata - 700 075 Tel: 033 2667 1160 email: kolkata@indianfoundry.org	• Promotes education, research, training, and development to Indian foundrymen • Nodal point of reference between customers and suppliers of the Indian foundry industry on a global scale
West Bengal State Electricity Distribution Company Limited - WBSDA	Vidyut Bhawan, 4th Floor, Block-DJ, Sector II, Bidhanagar (Salt Lake), Kolkata-700 091 https://www.wbsedcl.in/irj/go/km/docs/internet/new_website/WBSDA_New.html	• State Designated Agency (SDA) to coordinate, regulate and enforce efficient use of energy and its conservation

4.2.8.6 Other information

There is a project under implementation with support from BEE focusing on cluster mapping covering energy and resource consumption) and UNIDO in association with BEE to promote energy conservation measures and capacity building of local service providers.

4.2.8.7 Summary of findings

The summary of findings related to this foundry cluster is provided in table 4.2.8.7.

Table 4.2.8.7: Summary of findings of Howrah foundry cluster

Parameter	Unit	Value
Number of units		330
Annual production	tonne per year	811,200
Total energy consumption	toe per year	74,705
SEC – Overall	GJ per tonne	3.9
GHG emissions	tonne CO_2 per year	400,289
Specific GHG emissions	tonne CO_2 per tonne casting	0.5
Other relevant information	On-going cluster mapping initiative under implementation by BEE. UNIDO, in association with BEE, is also implementing a project in the cluster.	

4.2.9 Jaipur Foundry Cluster

4.2.9.1 Cluster background

In Jaipur cluster, foundry units are mainly located in Vishwakarma, Jhotwara, Jetpura industrial areas. Few foundries are being established around Kaladera industrial area, RIICO, and Sarna Dungar industrial area.

Primary raw material

The base raw materials for the foundry industries in the cluster are the same across all units, which include pig iron, steel, boring, bought out scrap, in-house foundry return, and rejected castings. The use of alloying elements such as ferro-silicon, ferro-manganese, iron sulphide, silicon carbide, etc., depends on the target chemistries of the castings. In addition, small quantities of other metals like copper and tin are added for special grades and SG iron castings.

Major products

The major products produced are cast iron detachable joints, sanitary & pipe fittings, automobile components, agricultural implements, engine & machine parts, and grinding media.

Classification of industries

Out of total installed 120 foundries units in the cluster, 113 foundry industries are operational and manufacture annually about 211, 800 tonnes of ferrous casting. Both cupola furnace (CF) and induction furnace (IF) are in use for the melting process. Considering the melting technology employed and scale of operation, the categorization of industries are provided in table 4.2.9.1.

Table 4.2.9.1: Details of industries

Industry category	Number of units	Production range (tpm)	Average production (tonne/year)
Medium (IF)	20	400-600	120,000
Small (IF)	10	100-200	18,000
Small (CF)	20	100-200	36,000
Micro(CF)	63	40-60	37,800
Total	113		211,800

Source: (1) Cluster profile report, SAMEEKSHA, (2) Analysis of cluster level secondary data by TERI

The majority of the industries operate coke based cupola furnaces (74%). The share of different categories of industries is provided in figure 4.2.9.1a. Cumulatively, induction furnaces contribute maximum casting production (65%) as shown in figure 4.2.9.1b.

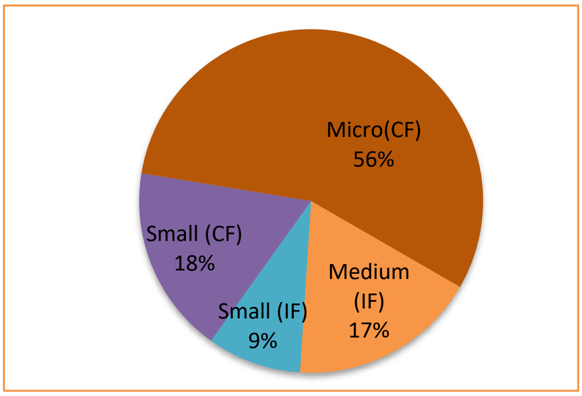


Figure 4.2.9.1a: Share of industries of different categories

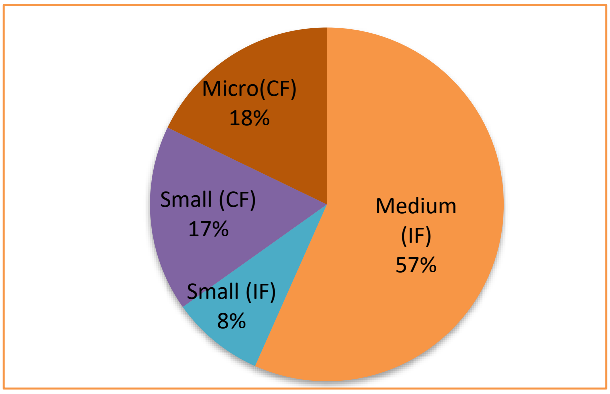


Figure 4.2.9.1b: Share of the annual production of different categories

4.2.9.2 Process technology

The details of melting technologies and primary auxiliary equipment used in the cluster are provided in Table 4.2.9.2.

Table 4.2.9.2: Primary technology of Jaipur foundry cluster

Technology	Purpose
Cupola furnace (CF)	All CFs in the cluster are coke fired. The average percentage of coke consumption on metal across the different categories of industries is around 12.2 to 13.3%.
Induction furnace (IF)	IFs are mostly used for producing higher grade casting, and most of them operate on a daily basis. The furnace melting capacity varies in the range of 150 to 500 tonne per month. The electricity consumption is 889 – 933 kWh per tonne of melt.

4.2.9.3 Energy consumption analysis

Foundries in these clusters use either coke or electricity in melting, depending upon the melting technology employed. Coke is primarily used in cupola furnaces for producing liquid metal. LPG is used for applications such as core heating, ladle preheating, gas cutting, etc. The energy consumption pattern of the foundry units depends on the melting technology deployed and production capacities. Electricity contributes the majority energy share (70%). The share of energy consumption from a different source is provided in figure 4.2.9.3a.

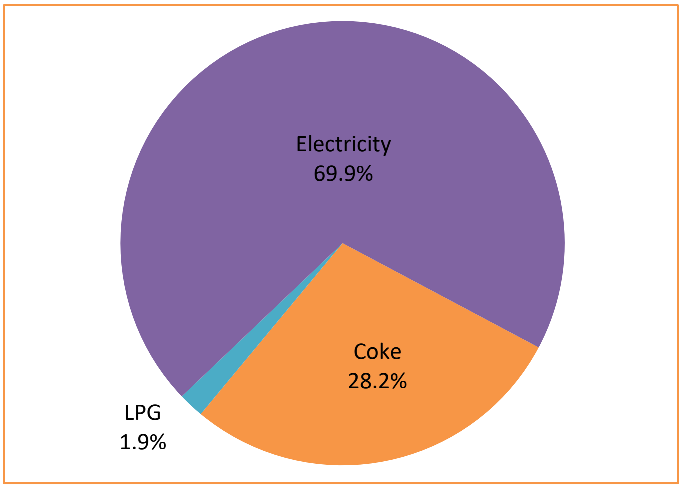


Figure 4.2.9.3a: Share of energy consumption source

The unit level annual energy consumption depends on the annual production range of different industries in the cluster. Table 4.2.9.3a provides the unit level annual energy consumption of different categories of industries in the cluster.

Table 4.2.9.3a: Details of unit level annual energy consumption

Fuel type	Unit	Energy consumption per plant			
		Medium (IF)	Small (IF)	Small (CF)	Micro (CF)
Coke	tonne/year	-	-	220	80
LPG	tonne/year	15	3	-	-
Electricity	kWh/year	7,000,000	2,000,000	85,000	20,000

The cluster level annual energy consumption by individual category of industries is provided in table 4.2.9.3b.

Table 4.2.9.3b: Details cluster level annual energy consumption

Fuel type	Unit	Medium (IF)	Small (IF)	Small (CF)	Micro (CF)
Coke	tonne/year	-	-	4400	5040
LPG	tonne/year	300	30	-	-
Electricity	mil kWh/year	140	20	1.7	1.3
Thermal	toe/year	339	339	2,640	3,024
Electrical	toe/year	12,040	1,720	146	108
Total	toe/year	12,379	1,754	2,786	3,132

The induction furnace based industries consume the maximum share of cluster level energy consumption, which is more than 70%. The distribution of cluster level energy consumption by different categories of industries is provided in figure 4.2.9.3b.

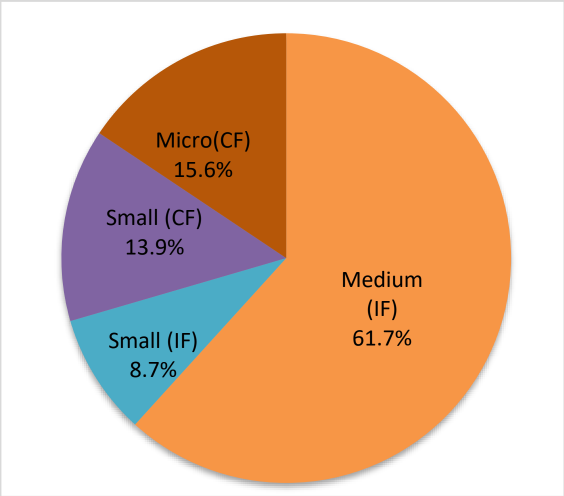


Figure 4.2.9.3b: Distribution of cluster level energy consumption

The total energy consumption in the cluster is estimated to be 20,051 toe per year. The equivalent GHG emissions are estimated to be 162,102 tonne CO_2 per year (Table 4.2.9.3c).

Table 4.2.9.3c: Energy consumption of Jaipur foundry cluster

Energy source	Unit	Energy consumption		GHG emissions
		Quantity	Equivalent (toe/year)	(tonne CO_2/year)
Coke	tonne/year	9,440	5,664	27,489
LPG	tonne/year	330	373	985
Electricity	million kWh/ year	163	14,015	133,627
Total			20,051	162,102

4.2.9.4 Performance analysis of foundry industries

The average specific energy consumption among different categories of foundry industries in the cluster varies in the range of 3.2 – 4.3 GJ per tonne of casting production. This variation is largely due to the type of energy use, the energy efficiency of technology employed, quality of product and its chemistries, etc. The details of performance in terms of specific energy consumption incurred by different categories of industries are shown in table 4.2.9.4.

Table 4.2.9.4: Performance of foundry industries in Jaipur cluster

Type	SEC- Thermal (GJ/tonne)	SEC- Electrical (kWh/tonne)	SEC- Cluster (GJ/tonne)
Medium (IF)	0.1	1,167	4.3
Small (IF)	0.1	1,111	4.1
Small (CF)	3.1	47	3.2
Micro (CF)	3.3	33	3.5
Minimum	0.1	33	3.2
Maximum	3.3	1,167	4.3

Note: SEC variations depend on process parameters

The medium induction category furnace consumes maximum energy for producing per tonne of casting, which is estimated to be 4.3 GJ per tonne (Figure 4.2.9.4).The cluster level specific energy consumption considering total annual production in the cluster and the total energy consumption is estimated to be around 4.0 GJ per tonne of casting production.

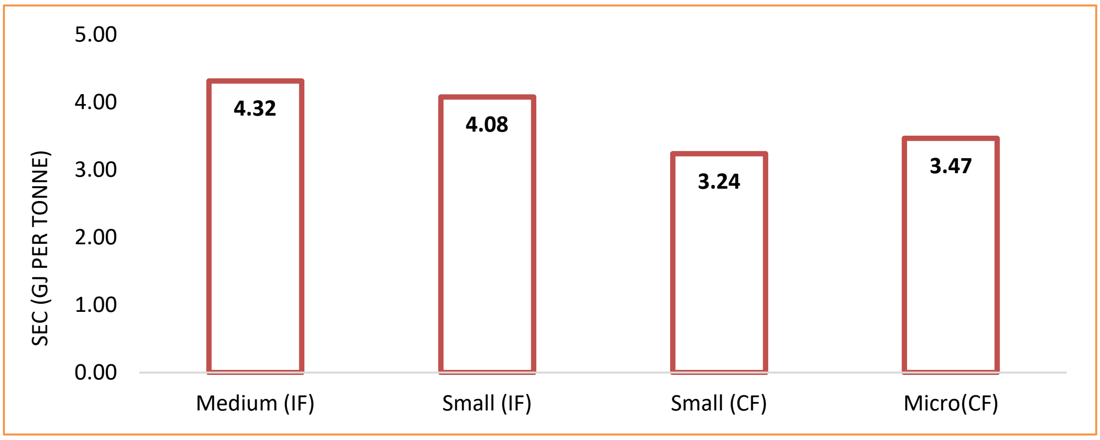


Figure 4.2.9.4: Variation of SEC among the different categories of industries

4.2.9.5 Relevant institutions for Jaipur foundry industries

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to foundry industries in this cluster are given in table 4.2.9.5.

Table 4.2.9.5: Institutions involved in Jaipur foundry cluster

Institution/ organization	Contact details	Objectives and roles
Vishwakarma Industries Association Jaipur	Association Bhawan, Road No.1, Vishwakarma Industrial Area, Jaipur Tel: 141-2331244 email: info@vkiassociation.com	• Welfare of member industries and grievances redressal
The Institute of Indian Foundrymen (IIF) Jaipur Chapter	Malaviya National Institute of Technology D-27, Staff Colony Jaipur - 302 017 email: bks.sharmaaa@gmail.com	• It is one of the vibrant chapters in promoting education, research, training, and development to Indian foundrymen and serve as a nodal point of reference between the customers and suppliers of the Indian foundry industry on a global scale
Rajasthan Renewable Energy Corporation Ltd (RRECL), Jaipur	E-166, Yudhishthir Marg, C-Scheme, Jaipur – 302 005, Rajasthan Tel: 0141 222 9055 https://energy.rajasthan.gov.in/content/raj/energy-department/rrecl/en/home.html	State Designated Agency (SDA) to coordinate, regulate and enforce efficient use of energy and its conservation

4.2.9.6 Other information

There is a project under implementation with support from BEE focusing on cluster mapping covering energy and resource consumption

4.2.9.7 Summary of findings

The summary of findings related to this foundry cluster is provided in table 4.2.9.7.

Table 4.2.9.7: Summary of findings of Jaipur foundry cluster

Parameter	Unit	Value
Number of units		120
Annual production	tonne per year	211,800
Total energy consumption	toe per year	20,051
SEC – Overall	GJ per tonne	4.0
GHG emissions	tonne CO_2 per year	162,102
Specific GHG emissions	tonne CO_2 per tonne casting	0.7
Other relevant information	There are project under implementation with support from BEE focusing on cluster mapping covering energy and resource consumption.	

4.2.10 Rajkot Foundry Cluster

4.2.10.1 Cluster background

Rajkot, in the state of Gujarat, is one of the largest clusters of MSMEs (micro, small and medium enterprises) in the country. The cluster is spread within Rajkot and neighbouring Metoda and Shapar industrial areas. Some of the larger geographical concentrations of foundry units include Aji and surrounding Bamanbore, Kuvadwa and Manda Dungar, Shapar and surrounding Atika, Samrat and Vavdi, and GIDC Lodhika (Metoda) areas.

Primary raw material

The base raw materials for the foundry industries in the cluster are the same across all units, which include pig iron, steel, boring, bought out scrap, in-house foundry return and rejected castings. The use of alloying elements such as ferro-silicon, ferro-manganese, iron sulphide, silicon carbide, etc., depends on the target chemistries of the castings. In addition, small quantities of other metals like copper and tin are added for special grades and SG iron castings.

Major products

Most of the foundries in Rajkot produce castings for OEMs (original equipment manufacturers) in diverse engineering sectors like automotive, pump sets, electric motors, air compressors, machine tools, agricultural machines, electrical transmission, and so on.

Classification of industries

About 700 foundry industries are operational and manufacture annually about 537,000 tonnes of ferrous casting. Both cupola furnace (CF) and induction furnace (IF) are used for the melting process. Considering the melting technology employed and scale of operation, the categorization of industries are provided in table 4.2.10.1.

Table 4.2.10.1: Details of industries

Industry category	Number of Units	Production range (tpm)	Average production (tonne/year)
Large (IF)	10	300-400	29,400
Medium (IF)	50	100-200	54,000
Small (IF)	200	50-150	144,000
Medium (CF)	100	100-150	90,000
Small (CF)	200	50-150	144,000
Micro (CF)	130	50-100	70,200
Micro (FO)	10	30-60	5,400
Total	700		537,000

Source: (1) Cluster profile report, SAMEEKSHA, (2) Analysis of cluster level secondary data by TERI

The majority of the industries operate coke based cupola furnaces (62%). The share of different categories of industries is provided in figure 4.2.10.1a. The cumulatively coke fired cupola furnaces contribute maximum annual casting production, which is about 57% (figure 4.2.10.1b).

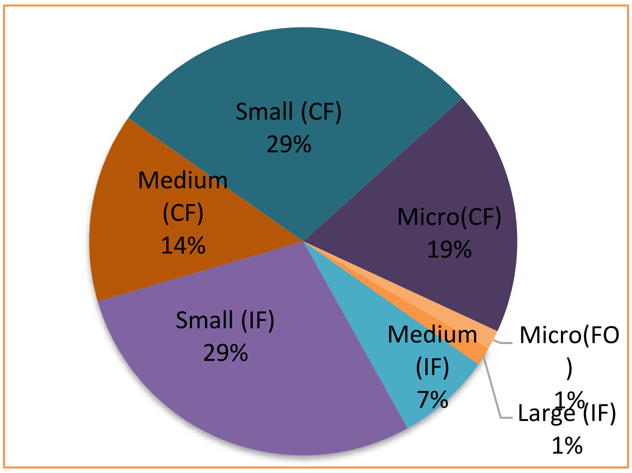


Figure 4.2.10.1a: Share of industries of different categories

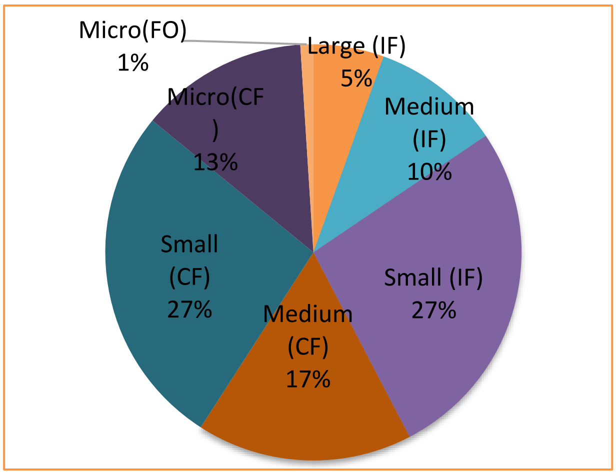


Figure 4.2.2.1b: Share of the annual production of different categories

4.2.10.2 Process technology

The details of melting technologies and primary auxiliary equipment used in the cluster are provided in table 4.2.10.2.

Table 4.2.10.2: Primary technology of Rajkot foundry cluster

Technology	Purpose
Cupola furnace (CF)	All CFs in the cluster are coke fired. The average percentage of coke consumption on metal across the different categories of industries is around 11.1 to 16.7%.
Induction furnace (IF)	IFs are mostly used for producing higher grade casting, and most of them operate on a daily basis. The melting capacity ranges from 50 to 400 tonne per month, and electricity consumption varies in the range of 631 – 1000 kWh per tonne of melt.

4.2.10.3 Energy consumption analysis

Foundries in these clusters use either coke or electricity in melting, depending upon the melting technology employed. Coke is primarily used in cupola furnaces for producing liquid metal. The energy consumption pattern of the foundry units depends on the melting technology deployed and production capacities. Both electricity and coke contribute the equal energy share by each source (49%). The share of energy consumption from a different source is provided in figure 4.2.10.3a.

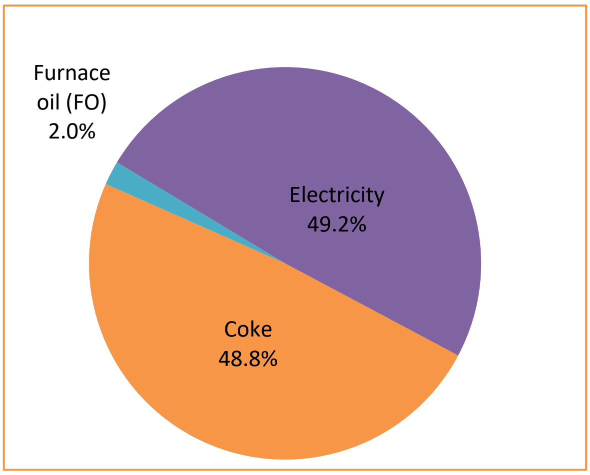


Figure 4.2.10.3a: Share of energy consumption source

The unit level annual energy consumption depends on the annual production range of different industries in the cluster. Table 4.2.10.3a provides the unit level annual energy consumption of different categories of industries in the cluster.

Table 4.2.10.3a: Details of unit level annual energy consumption

Fuel type	Unit	Energy consumption per plant						
		Large (IF)	Medium (IF)	Small (IF)	Medium (CF)	Small (CF)	Micro (CF)	Micro (FO)
Coke	tonne/year	-	-	-	100	100	90	-
Furnace oil	tonne/year							101
Electricity	kWh/year	2,650,000	1,300,000	900,000	150,000	25,000	10,000	6,000

The cluster level annual energy consumption by individual category of industries is provided in table 4.2.10.3b.

Table 4.2.10.3b: Details cluster level annual energy consumption

Fuel type	Unit	Large (IF)	Medium (IF)	Small (IF)	Medium (CF)	Small (CF)	Micro (CF)	Micro (FO)
Coke	tonne/year	-	-	-	10,000	20,000	11,700	-
Furnace oil	tonne/year	-	-	-	-	-	-	1,008
Electricity	mil kWh/ year	26	65	180	15	5	1.3	0.1
Thermal	toe/year	0	0	0	6,000	12,000	7,020	1,013
Electrical	toe/year	2,279	5,590	15,480	1,290	430	112	5.2
Total	toe/year	2,279	5,590	15,480	7,290	12,430	7,132	1,019

The cupola furnace based industries consume the maximum share of cluster level energy consumption, which is more than 52%. The distribution of cluster level energy consumption by different categories of industries is provided in figure 4.2.10.3b.

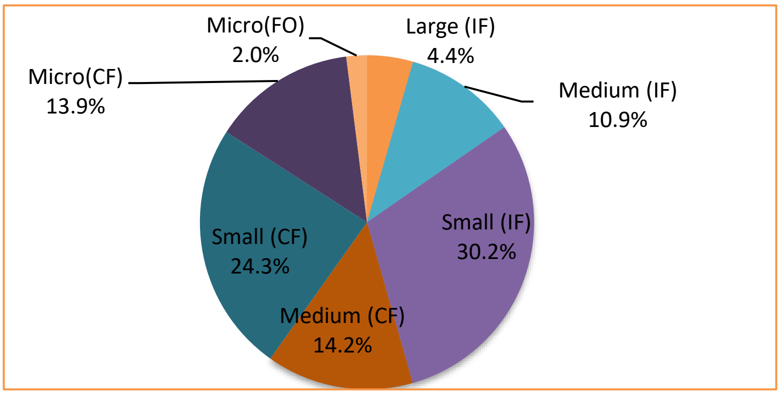


Figure 4.2.10.3b: Distribution of cluster level energy consumption

The total energy consumption in the cluster is estimated to be 51,219 toe per year. The equivalent GHG emissions are estimated to be 364,703 tonne CO_2 per year (Table 4.2.10.3c).

Table 4.2.10.3c: Energy consumption of Rajkot foundry cluster

Type	Unit	Energy consumption		GHG emissions
		Quantity	Equivalent (toe/year)	(tonne CO_2/year)
Coke	tonne/year	41,700	25,020	121,430
Furnace oil	tonne/year	1,008	1,013	3,127
Electricity	mil kWh/yr	293	25,186	240,145
Total			51,219	364,703

4.2.10.4 Performance analysis of foundry industries

The average specific energy consumption among different categories of foundry industries in the cluster varies in the range of 3.2 – 7.9 GJ per tonne of casting production. This variation is largely due to the type of energy use, the energy efficiency of technology employed, quality of product and its chemistries, etc. The details of performance in terms of specific energy consumption incurred by different categories of industries are shown in table 4.2.10.4.

Table 4.2.10.4: Performance of foundry industries in Rajkot cluster

TYPE	SEC- Thermal (GJ/tonne)	SEC- Electrical (kWh/tonne)	SEC- Cluster (GJ/tonne)
Large (IF)	-	901	3.2
Medium (IF)	-	1,204	4.3
Small (IF)	-	1,250	4.5
Medium (CF)	2.8	167	3.4
Small (CF)	3.5	35	3.6
Micro(CF)	4.2	18	4.2
Micro(FO)	7.9	11	7.9
Minimum	-	11	3.2
Maximum	7.9	1,250	7.9

Note: SEC variations depend on process parameters

The micro category furnaces consume maximum energy for producing per tonne of casting, which is estimated to be 4.25 GJ per tonne for cupola based micro units and 7.9 GJ per tonne for FO fired micro units (figure 4.2.2.4).

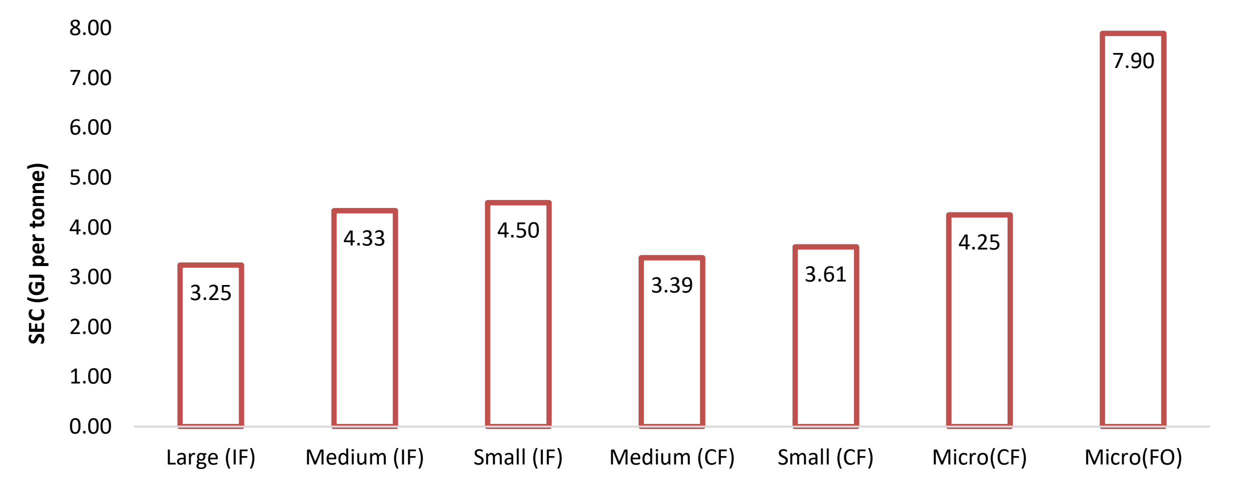


Figure 4.2.10.4: Variation of SEC among the different categories of industries

The cluster level specific energy consumption considering total annual production in the cluster and the total energy consumption is estimated to be 4.0 GJ per tonne of casting production.

4.2.10.5 Relevant institutions for Rajkot foundry industries

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to foundry industries in this cluster are given in table 4.2.10.5.

Table 4.2.10.5: Institutions involved in Rajkot foundry cluster

Institution/ organization	Contact details	Objectives and roles
Rajkot Engineering Association (REA)	Bhaktinagar Railway Station Bhaktinagar Industrial Estate, Gujarat 360002 Tel: 0281 236 2235 email: info@reaindia.com https://www.reaindia.com/	• The REA is one of the most proactive Cluster level associations in the Rajkot. The primary objective is to provide support to members for promotion and development of manufacturing activities. • The association also supplies raw materials like pig iron to its members on 'no-profit-no-loss' basis.
GIDC (Lodhika) Industrial Association (GLIA)	Centre of Excellence Plot No.G-105/A-1 Almighty Gate, Kalavad Road, Metoda, Gujarat-360021 Tel: 0287 287 699 email: glia.lodhika@gmail.com https://gidclodhika.com/	• Industrial promotional, Development & maintenance of infrastructure of the estate, industrial training, environmental, social and Educational

Institution/ organization	Contact details	Objectives and roles
Aji GIDC Industries Association	Plot no 121, GIDC, Rajkot, Gujarat-360002 Tel: 0281 238 9050 email: info@ajigidc.com http://www.ajigidc.com/directory.php	• Around 80 foundry industries in this estate are members of this association. Welfare of member industries and grievances redressal
Shapar Veraval Industrial Association (SVIA)	Shapar Veraval industrial Association, Nr. Shapar Veraval Bus Station National Highway 27, Veraval - Shapar, Tal, :Kotda Sangani, Gujarat 360024 Tel: 02827253364 email : svia2400@gmail.com, svia24@rediffmail.com http://sviarajkot.com/	• Around 300 foundry industries in this estate are members of this association.
The Institute of Indian Foundrymen (IIF), Rajkot Chapter	Prabhukrupa Industries 10-Aji Vasahat, 80 Ft. Road, Adwin Diesel Street, Rajkot – 360 003 Tel: 0281 2387276 email: rajkot@indianfoundry.org	• Promoting research, training, and development and serve as a nodal point of reference between the customers and suppliers of the Indian foundry industry on a global scale • It works closely with REA and is also located within the association premises.
Gujarat Energy Development Agency (GEDA), Ahmedabad	4th floor, Block No. 11 & 12, Udyog Bhavan, Sector-11, Gandhinagar – 82017, Gujarat Tel: 079-23257251,54 email : info@geda.org.in http://www.geda.org.in	• State Designated Agency (SDA) to coordinate, regulate and enforce efficient use of energy and its conservation

4.2.10.6 Other information

TERI has carried out a project on energy efficiency improvements in Rajkot foundry cluster. BEE has recently initiated a study on energy and resource mapping of the foundry cluster

4.2.10.7 Summary of findings

The summary of findings related to this foundry cluster is provided in table 4.2.10.7.

Table 4.2.10.7: Summary of findings of Rajkot foundry cluster

Parameter	Unit	Value
Number of units		700
Annual production	tonne per year	537,000
Total energy consumption	toe per year	51,219
SEC – Overall	GJ per tonne	4.0
GHG emissions	tonne CO_2 per year	364,703
Specific GHG emissions	tonne CO_2 per tonne casting	0.7
Other relevant information	No on-going cluster level initiative under implementation.	

4.2.11 Samalkha Foundry Cluster

4.2.11.1 Cluster background

Samalkha is a small town in the district of Panipat (Haryana). The major industrial estates in Samalkha include HSIDC (Haryana State Industrial & Infrastructure Development Corporation Ltd) industrial estate, but the majority of foundries are located in and around GT Road.

Primary raw material

The base raw materials for the foundry industries in the cluster are the same across all units, which include pig iron, steel, boring, bought out scrap, in-house foundry return, and rejected castings. The use of alloying elements such as ferro-silicon, ferro-manganese, iron sulphide, silicon carbide, etc., depends on the target chemistries of the castings.

Major products

A large number of small size foundries in the cluster are engaged in the production of chaff cutter and Kutti machines. The product of all the units is almost similar, but it is sold with different local brand names. The other products in the cluster include low end automotive machineries parts such as motor casings, impellers, and submersible pump parts.

Classification of industries

About 30 foundry industries are operational and manufacture annually about 36,480 tonnes of ferrous casting. Only cupola furnaces (CF) are in use for the melting process. Considering the melting technology employed and scale of operation, the categorization of industries are provided in table 4.2.11.1.

Table 4.2.11.1: Details of industries

Industry category	Number of units	Production range (tpm)	Average production (tonne/year)
Micro	8	20-60	4,800
Small	22	100-140	31,680
TOTAL	30	-	36,480

Source: (1) Cluster profile report, SAMEEKSHA, (2) Analysis of cluster level secondary data by TERI

The majority of the industries are coke based small scale cupola furnaces (73%). The share of different categories of industries is provided in figure 4.2.11.1a. Cumulatively coke fired small scale cupola furnaces contribute maximum annual casting production, which is about 87 % (figure 4.2.11.1b).

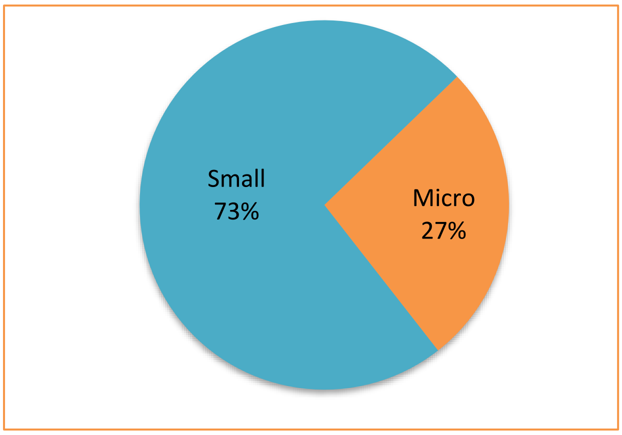


Figure 4.2.11.1a: Share of industries of different categories

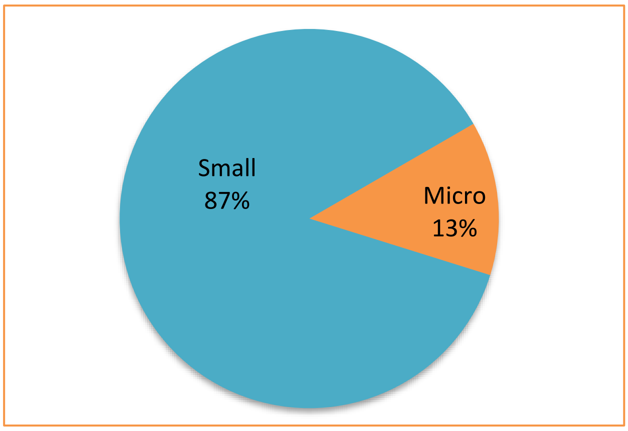


Figure 4.2.11.1b: Share of the annual production of different categories

4.2.11.2 Process technology

The details of melting technologies and major auxiliaries used in the cluster are provided in Table 4.2.11.2.

Table 4.2.11.2: Primary technology of Samalkha foundry cluster

Technology	Purpose
Cupola furnace	All CFs in the cluster are coke fired. The average coke consumption on metal across the different categories of industries is about 12.5%.

4.2.11.3 Energy consumption analysis

Details of energy use

Foundries in these clusters use only coke fired cupola technology is employed in melting. The captive backup power generator is operated using diesel during the failure of grid supply.

Energy consumption pattern

The energy consumption pattern of the foundry units depends on operating practices of cupola furnaces and production capacities. The share of energy consumption from a different source is provided in figure 4.2.11.3a.

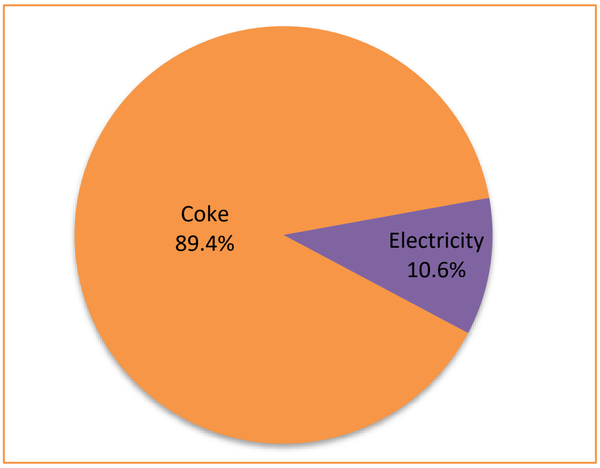


Figure 4.2.11.3a: Share of energy consumption source

The unit level annual energy consumption depends on the annual production range of different industries in the cluster. Table 4.2.11.3a provides the unit level annual energy consumption of different categories of industries in the cluster.

Table 4.2.11.3a: Details of unit level annual energy consumption

Type	Unit	Energy consumption per plant	
		Micro (CF)	Small (CF)
Coke	tonne/year	75	180
Electricity	kWh/year	60,000	150,000

The cluster level annual energy consumption by individual category of industries is provided in table 4.2.11.3b.

Table 4.2.11.3b: Details cluster level annual energy consumption

Fuel type	Unit	Micro	Small
Coke	tonne/year	600	3,960
Electricity	mil kWh/year	0.5	3.3
Thermal	toe/year	360	2,376
Electrical	toe/year	413	284
Total	toe/year	401	2,660

The small category cupola furnace based industries consume the maximum share of cluster level energy consumption, which is more than 86%. The distribution of cluster level energy consumption by different categories of industries is provided in figure 4.2.11.3b.

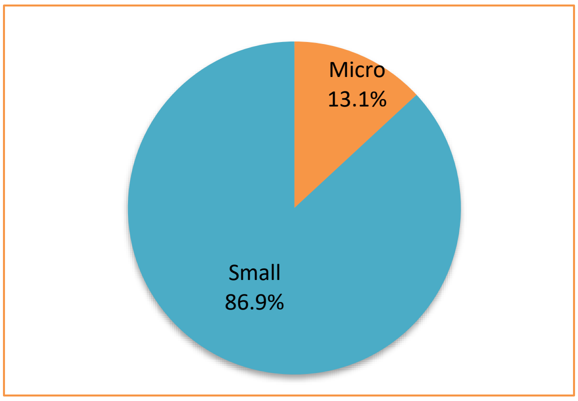


Figure 4.2.11.3b: Distribution of cluster level energy consumption

The total energy consumption in the cluster is estimated to be 3,061 toe per year. The equivalent GHG emissions are estimated to be 16,378 tonne CO_2 per year (table 4.2.11.3c).

Table 4.2.11.3c: Energy consumption of Samalkha foundry cluster

Type	Unit	Energy consumption		GHG emissions
		Quantity	Equivalent (toe/year)	(tonne CO_2/ year)
Coke	tonne/year	4,560	2,736	13,279
Electricity	mil kWh/yr	3.8	325	3,100
Total			3,061	16,378

4.2.11.4 Performance analysis of foundry industries

The average specific energy consumption among different categories of foundry industries in the cluster varies in the range of 3.5 – 3.52 GJ per tonne of casting (figure 4.2.11.4). The details of performance in terms of specific energy consumption incurred by different categories of industries are shown in table 4.2.11.4.

Table 4.2.11.4: Performance of foundry industries in Samalkha cluster

Type	SEC- Thermal (GJ/tonne)	SEC- Electrical (kWh/tonne)	SEC- Cluster (GJ/tonne)
Micro	3.1	100	3.5
Small	3.1	104	3.5
Minimum	3.1	100	3.5
Maximum	3.1	104	3.5

Note: SEC variations depend on process parameters

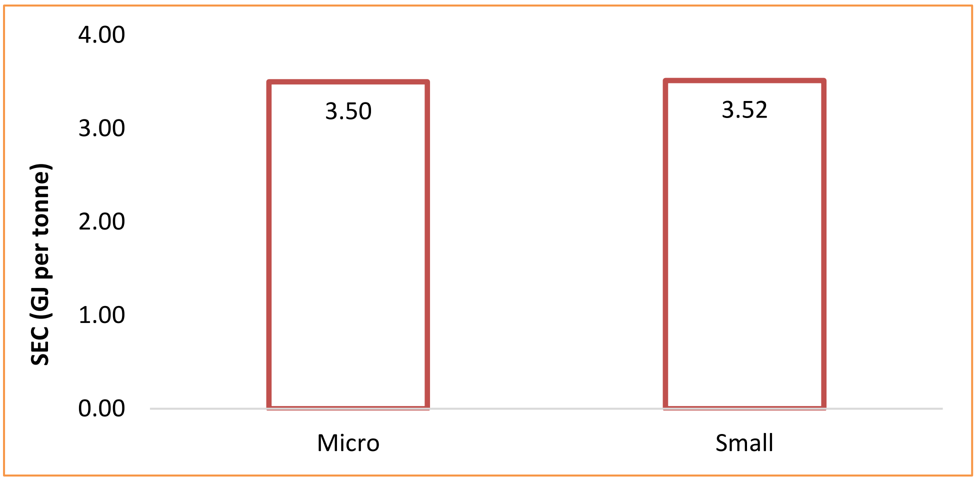


Figure 4.2.11.4: Variation of SEC among the different categories of industries

The cluster level specific energy consumption considering total annual production in the cluster and the total energy consumption is estimated to be around 3.51 GJ per tonne of casting production.

4.2.11.5 Relevant institutions for Samalkha foundry industries

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to foundry industries in this cluster are given in table 4.2.11.5.

Table 4.2.11.5: Institutions involved in Samalkha foundry cluster

Institution/ organization	Contact details	Objectives and roles
Samalkha Industries Association (SIA)	G.T. Road Samalkha, Distt Panipat, Haryana-132115 Tel: 094162 02438 email: info@samalkhaindustrialassociation.com http://www.samalkhaindustrialassociation.com/contactus.html	• Apex body for organizing events or conducting any programs in the cluster. • SIA deals with local issues faced by industries
Department of New & Renewable Energy, Haryana (HAREDA)	Akshay Urja Bhawan, Plot No-1, Sector 17, Opp Agarwal Bhavan, Panchkula, Haryana 134109 Tel: 0172 258 7233 https://hareda.gov.in/	State Designated Agency (SDA) to coordinate, regulate and enforce efficient use of energy and its conservation

4.2.11.6 Other information

There was no cluster level initiative reported to be undertaken in the cluster.

4.2.11.7 Summary of findings

The summary of findings related to this foundry cluster is provided in table 4.2.11.7.

Table 4.2.11.7: Summary of findings of Samalkha foundry cluster

Parameter	Unit	Value
Number of units		30
Annual production	tonne per year	36,480
Total energy consumption	toe per year	3,061
SEC – Overall	GJ per tonne	3.51
GHG emissions	tonne CO_2 per year	16,378
Specific GHG emissions	tonne CO_2 per tonne casting	0.4
Other relevant information	No cluster level on-going initiatives under implementation.	

4.2.12 Shimoga Foundry Cluster

4.2.12.1 Cluster background

Foundry units are located in three industrial areas around the city: Machenahalli, Mandli Kallur, and Sagar road. Major castings buyers from the cluster are Cummins, Kirloskar, KSB, BEML, Godrej, Escorts, Emerson, etc.

Primary raw material

The base raw materials for the foundry industries in the cluster are the same across all units, which include pig iron, steel, boring, bought out scrap, in-house foundry return, and rejected castings. The use of alloying elements such as ferro-silicon, ferro-manganese, iron sulphide, silicon carbide, etc., depends on the target chemistries of the castings. In addition, small quantities of other metals like copper and tin are added for special grades and SG iron castings.

Major products

Foundries cater to the OEM of the automobile, oil engines, compressor, mining and earth moving equipment, roads and infrastructure building machinery, general engineering parts, valves and pumps etc. Major products include valves and pumps, earthmoving & mining, machine tools, railways and automobiles.

Classification of industries

Out of the total installed 50 foundries units in the cluster, only 38 foundry industries are operational and manufacture annually about 56,760 tonnes of ferrous casting. Only induction furnaces (IF) are in use for the melting process. Considering the melting technology employed and scale of operation, the categorization of industries are provided in table 4.2.12.1.

Table 4.2.12.1: Details of industries

Industry category	Number of units	Production range (tpm)	Average production (tonne/year)
Large (Steel IF)	2	500-900	16,800
Medium (Steel IF)	9	150-250	21,600
Small (Steel IF)	4	50-90	3,360
Small (Iron IF)	15	50-90	12,600
Micro (Iron IF)	8	20-30	2,400
Total	38		56,760

Source: (1) Cluster profile report, SAMEEKSHA, (2) Analysis of cluster level secondary data by TERI

The majority of the industries are producing grey iron products (60%). The share of different categories of industries is provided in figure 4.2.12.1a. Cumulatively, ductile castings contribute maximum annual casting production (74 %) as shown in figure 4.2.12.1b.

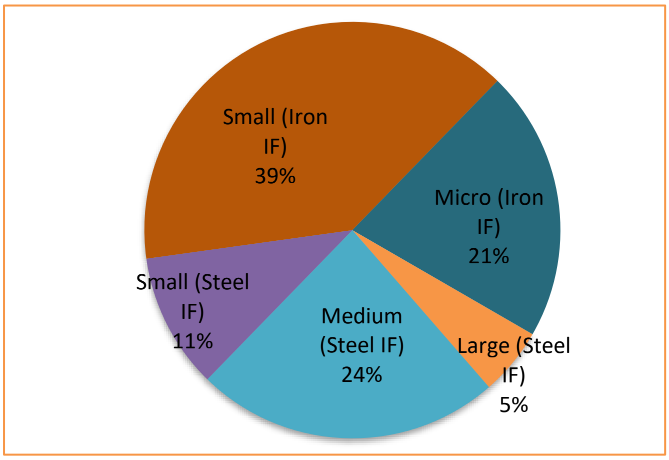


Figure 4.2.12.1a: Share of industries of different categories

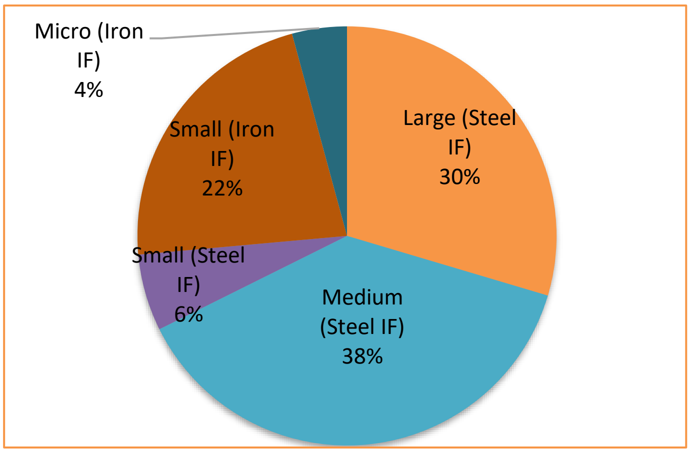


Figure 4.2.12.1b: Share of the annual production of different categories

4.2.12.2 Process technology

The details of melting technologies and primary auxiliary equipment used in the cluster are provided in Table 4.2.12.2.

Table 4.2.12.2: Primary technology of Shimoga foundry cluster

Technology	Purpose
Induction furnace	Induction furnaces are mostly used for producing higher grade casting, and most of them operate on a daily basis. The furnace melting capacity varies in the range of 300 to 8400 tonne per year, and the electricity consumption varies about 750 – 1100 kWh per tonne of melt.

4.2.12.3 Energy consumption analysis

Details of energy use

Foundries in these clusters use electricity in melting for producing liquid metal. LPG is used to meet assorted thermal energy requirements in the plant.

Energy consumption pattern

The energy consumption pattern of the foundry units depends on the melting technology deployed and production capacities. Electricity contributes the majority energy share (93%). The share of energy consumption from a different source is provided in figure 4.2.12.3a.

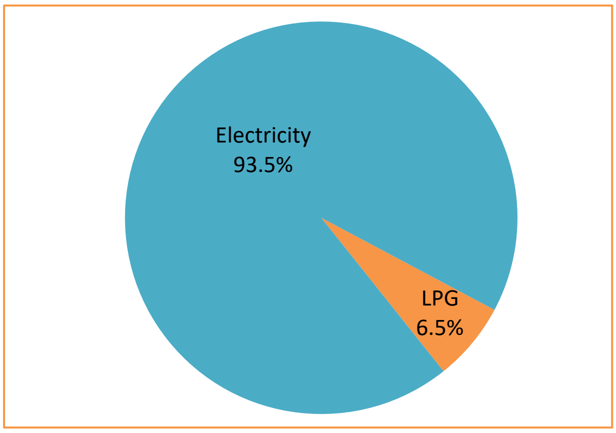


Figure 4.2.12.3a: Share of energy consumption source

The unit level annual energy consumption depends on the annual production range of different industries in the cluster. Table 4.2.12.3a provides the unit level annual energy consumption of different categories of industries in the cluster.

Table 4.2.12.3a: Details of unit level annual energy consumption

Fuel type	Unit	Energy consumption per plant				
		Large (Steel IF)	Medium (Steel IF)	Small (Steel IF)	Small (Iron IF)	Micro (Iron IF)
LPG	tonne/year	20	12	10	8	5
Electricity	kWh/year	9,000,000	2,600,000	1,100,000	1,100,000	415,000

The cluster level annual energy consumption by individual category of industries is provided in table 4.2.12.3b.

Table 4.2.12.3b: Details cluster level annual energy consumption

Fuel type	Unit	Large (Steel IF)	Medium (Steel IF)	Small (Steel IF)	Small (Iron IF)	Micro (Iron IF)
LPG	tonne/year	40	108	40	120	40
Electricity	mil kWh/year	18	23	4.4	16	3.3
Thermal	toe/year	45	122	45	136	45
Electrical	toe/year	1,548	2,012	378	1,419	285
Total	toe/year	1,593	2,134	424	1,555	331

The induction furnace based industries producing ductile castings consume the maximum share of cluster level energy consumption (68%). The distribution of cluster level energy consumption by different categories of industries is provided in figure 4.2.12.3b.

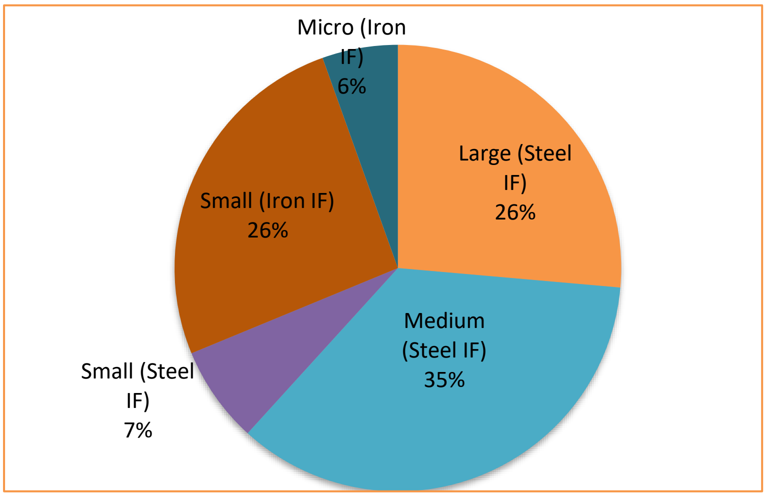


Figure 4.2.12.3b: Distribution of cluster level energy consumption

The total energy consumption in the cluster is estimated to be 6,036 toe per year. The equivalent GHG emissions are estimated to be 54,847 tonne CO_2 per year (table 4.2.12.3c).

Table 4.2.12.3c: Energy consumption of Shimoga foundry cluster

Type	Unit	Energy consumption		GHG emissions
		Quantity	Equivalent (toe/year)	(tonne CO_2/year)
LPG	tonne/year	348	393	1,039
Electricity	mil kWh/year	66	5,643	53,808
Total			6,036	54,847

4.2.12.4 Performance analysis of foundry industries

The average specific energy consumption among different categories of foundry industries in the cluster varies in the range of 4.0 – 5.8 GJ per tonne of casting production. This variation is largely due to the type of energy use, the energy efficiency of technology employed, quality of product and its chemistries, etc. The details of performance in terms of SEC accounted by different categories of industries are shown in table 4.2.12.4.

Table 4.2.12.4: Performance of foundry industries in Shimoga cluster

TYPE	SEC- Thermal (GJ/tonne)	SEC- Electrical (kWh/tonne)	SEC- Cluster (GJ/tonne)
Large (Steel IF)	0.1	1,071	4.0
Medium (Steel IF)	0.2	1,083	4.1
Small (Steel IF)	0.6	1,309	5.3
Small (Iron IF)	0.4	1,309	5.2
Micro (Iron IF)	0.8	1,383	5.8
Minimum	0.1	1,071	4.0
Maximum	0.8	1,383	5.8

Note: SEC variations depend on process parameters

The micro scale grey iron casting producing induction category furnace consumes maximum energy for producing per tonne of casting, which is estimated to be 5.8 GJ per tonne (Figure 4.2.12.4).

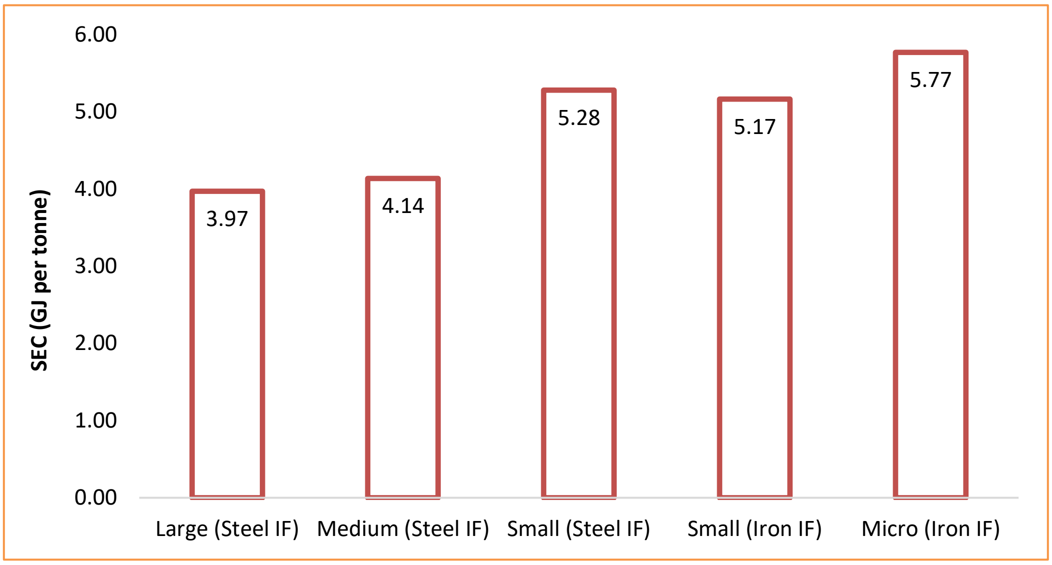


Figure 4.2.12.4: Variation of SEC among different category of industries

The cluster level specific energy consumption considering total annual production in the cluster and the total energy consumption is estimated to be around 4.4 GJ per tonne of casting production.

4.2.12.5 Relevant institutions for Shimoga foundry industries

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to foundry industries in this cluster are given in table 4.2.12.5.

Table 4.2.12.5: Institutions involved in Shimoga foundry cluster

Institution/ organization	Contact details	Objectives and roles
Machenahalli Industries Association, Shimoga	Udyama Bhavan, Shivamogga-Bhadravathi KIADB Industrial Area, Machenahalli, Shivamogga Shimoga, Karnataka 577222	• Welfare activities of member units and grievances redressal
Karnataka Renewable Energy Development Limited (KREDL)	39, Shanthi Gruha, Bharath Scouts & Guides Building, Palace Road, Bangalore – 560 001, Tel: 080 2220 7851 email: kredlmd@gmail.com https://kredlinfo.in/Index_eng	State Designated Agency (SDA) to coordinate, regulate and enforce efficient use of energy and its conservation

4.2.12.6 Other information

There is no project under implementation in the cluster.

4.2.12.7 Summary of findings

The summary of findings related to this foundry cluster is provided in table 4.2.12.7.

Table 4.2.12.7: Summary of findings of Shimoga foundry cluster

Parameter	Unit	Value
Number of units		38
Annual production	tonne per year	56,760
Total energy consumption	toe per year	6,036
SEC – Overall	GJ per tonne	4.4
GHG emissions	tonne CO_2 per year	54,847
Specific GHG emissions	tonne CO_2 per tonne casting	1.0
Other relevant information	No project under implementation in the cluster	

4.2.13 Saharanpur Foundry Cluster

4.2.13.1 Cluster background

Foundry is one of the industrial sectors, and most of these plants are concentrated in the industrial estate of Delhi Road Saharanpur, Mandi samiti road industrial area, and Gagalheri. The Delhi road industrial estate is the oldest industrial estate among all of these. A large number of small size foundries in the cluster are engaged in the production of hand pumps. Comparatively large foundries produce castings for sewing machines.

Primary raw material

The base raw materials include pig iron, steel, boring, bought-out scrap, in-house foundry return, and rejected castings. Limited alloying elements such as ferro-silicon, ferro-manganese, iron sulphide, silicon carbide, etc., are also used depending on the target chemistries of the castings.

Major products

The major products produced are grey iron castings such as hand pumps, sanitary & pipe fittings, agricultural implements, sewing machines, engine & machine parts, and grinding media.

Classification of industries

Out of more than 100 installed foundries units in the cluster, about 52 foundry industries are operational and manufacture annually about 20, 970 tonnes of ferrous casting. Both cupola furnace (CF) and induction furnace (IF) are in use for the melting process. Considering the melting technology employed and scale of operation, the categorization of industries are provided in table 4.2.13.1.

Table 4.2.13.1: Details of industries

Industry category	Number of units	Production range (tpm)	Average production (tonne/year)
Small (IF)	2	50-150	1,920
Medium (CF)	10	50-150	9,600
Small (CF)	15	30-50	7,200
Micro(CF)	25	5-10	2,250
TOTAL	52		20,970

Source: (1) Cluster profile report, SAMEEKSHA, (2) Analysis of cluster level secondary data by TERI

The majority of the industries operate coke based cupola furnaces (96%). The share of different categories of industries is provided in figure 4.2.2.1a. Cumulatively cupola furnaces contribute maximum annual casting production, which is about 91 % (figure 4.2.13.1b).

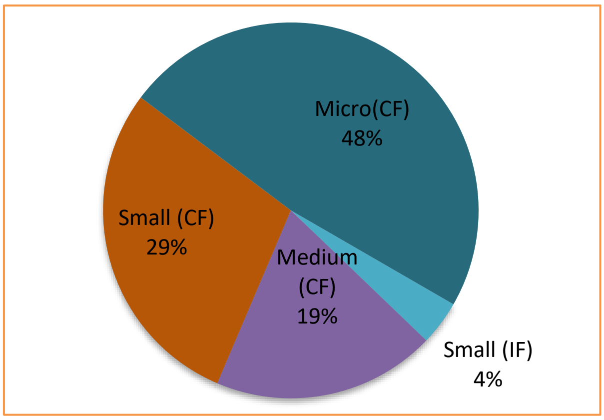


Figure 4.2.13.1a: Share of industries of different categories

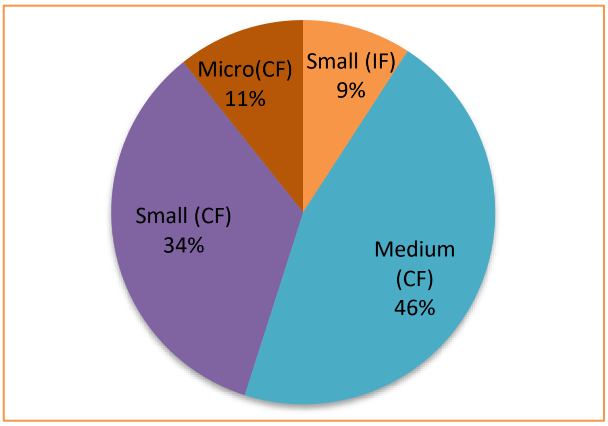


Figure 4.2.13.1b: Share of the annual production of different categories

4.2.13.2 Process technology

The details of melting technologies and primary auxiliary equipment used in the cluster are provided in table 4.2.13.2.

Table 4.2.13.2: Primary technology of Saharanpur foundry cluster

Technology	Purpose
Cupola furnace	All CFs in the cluster are coke fired. The average percentage of coke consumption on metal across the different categories of industries is around 18.2-22.2%.
Induction furnace	IFs are mostly used for producing higher grade casting, and most of them operate daily. The furnace melting capacity is in the range of 50 to 150 tonne per month with the average electricity consumption of 850 kWh per tonne of melt.

4.2.13.3 Energy consumption analysis

Foundries in these clusters use either coke or electricity in melting, depending upon the melting technology employed. Coke is primarily used in cupola furnaces for producing liquid metal.

The energy consumption pattern of the foundry units depends on the melting technology deployed and production capacities. Coke contributes the majority energy share (86%). The share of energy consumption from a different source is provided in figure 4.2.13.3a.

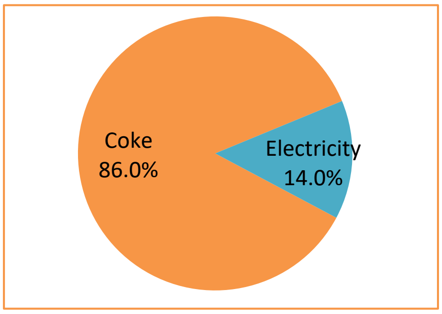


Figure 4.2.13.3a: Share of energy consumption source

The unit level annual energy consumption depends on the annual production range of different industries in the cluster. Table 4.2.13.3a provides the unit level annual energy consumption of different categories of industries in the cluster.

Table 4.2.13.3a: Details of unit level annual energy consumption

Type	Unit	Energy consumption per plant			
		Small (IF)	Medium (CF)	Small (CF)	Micro (CF)
Coke	tonne/year		176	87.5	20
Electricity	kWh/year	1,040,000	96,000	55,000	8,000

The cluster level annual energy consumption by individual category of industries is provided in table 4.2.13.3b.

Table 4.2.13.3b: Details cluster level annual energy consumption

Fuel type	Unit	Small (IF)	Medium (CF)	Small (CF)	Micro (CF)
Coke	tonne/year	-	1,760	1,312	500
Electricity	mil kWh /year	2.1	1.0	0.8	0.2
Thermal	toe/year	-	1,056	787	300
Electrical	toe/year	179	83	71	17
Total	toe/year	179	1,139	858	317

The coke fired cupola furnace based industries consume the maximum share of cluster level energy consumption, which is more than 92%. The distribution of cluster level energy consumption by different categories of industries is provided in figure 4.2.13.3b.

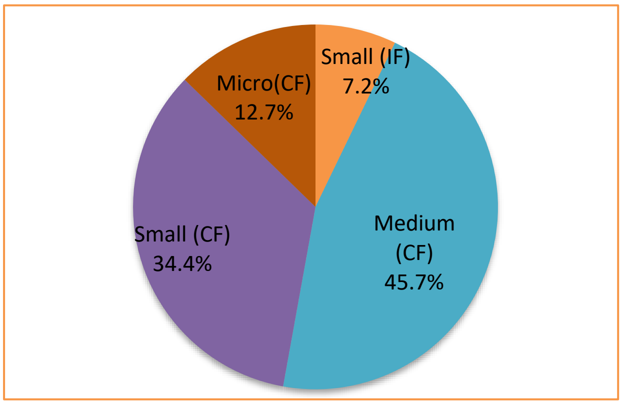


Figure 4.2.13.3b: Distribution of cluster level energy consumption

The total energy consumption in the cluster is estimated to be 2,493 toe per year. The equivalent GHG emissions are estimated to be 13,736 tonnes CO_2 per year (Table 4.2.13.3c).

Table 4.2.13.3c: Energy consumption of Saharanpur foundry cluster

Type	Unit	Energy consumption		GHG emissions
		Quantity	Equivalent (toe/year)	(tonne CO_2/year)
Coke	tonne/year	3,572	2,144	10,403
Electricity	Mil kWh /year	4	350	3,333
Total			2,493	13,736

4.2.13.4 Performance analysis of foundry industries

The average specific energy consumption among different categories of foundry industries in the cluster varies in the range of 3.9 – 5.9 GJ per tonne of casting production. This variation is largely due to the type of energy use, the energy efficiency of technology employed, quality of product and its chemistries, etc. The details of performance in terms of specific energy consumption incurred by different categories of industries are shown in table 4.2.13.4.

Table 4.2.13.4: Performance of foundry industries in Saharanpur cluster

Type	SEC- Thermal (GJ/tonne)	SEC- Electrical (kWh/tonne)	SEC- Cluster (GJ/tonne)
Small (IF)	-	1,083	3.90
Medium (CF)	4.6	100	4.97
Small (CF)	4.6	116	4.99
Micro (CF)	5.6	89	5.90
Minimum	-	89	3.90
Maximum	5.6	1,083	5.90

Note: SEC variations depend on process parameters

The micro category cupola furnace consumes maximum energy for producing per tonne of casting, which is estimated to be 5.9 GJ per tonne (Figure 4.2.13.4).

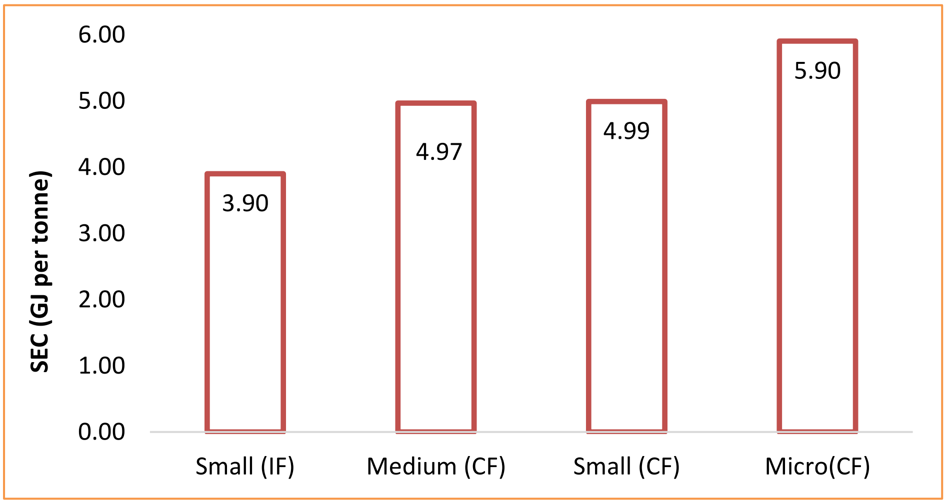


Figure 4.2.13.4: Variation of SEC among different category of industries

The cluster level specific energy consumption considering total annual production in the cluster and the total energy consumption is estimated to be around 5.0 GJ per tonne of casting production.

4.2.13.5 Relevant institutions for Saharanpur foundry industries

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to foundry industries in this cluster are given in table 4.2.13.5.

Table 4.2.13.5: Institutions involved in Saharanpur foundry cluster

Institution/ organization	Contact details	Objectives and roles
Indian Industries Association (IIA)	IIA Bhawan, Trade Center, Pratap Market, Saharanpur-247001 Tel: 91-522-2720090, 4069548 email: iia@iiaonline.in http://www.iiaonline.in	• It is an apex representative body of Micro, Small, and Medium Enterprises (MSME). IIAs headquarter is in Lucknow. The Saharanpur Chapter has around 22 foundries as members.
Saharanpur Industries Association (SIA)	IIA Bhawan, Trade Center, Pratap Market, Saharanpur-247001 email: iia@iiaonline.in http://www.iiaonline.in	• Most of the foundries in the Saharanpur area are members of SIA. It deals with local issues faced by industries.
Uttar Pradesh New and Renewable Energy Development Agency (UPNEDA)	Vibhuti Khand, Gomti Nagar, Lucknow – 226010 Tel: 0522 272 0652 http://upneda.org.in/	• State Designated Agency (SDA) to coordinate, regulate and enforce efficient use of energy and its conservation

4.2.13.6 Other information

There is no project under implementation in the cluster.

4.2.13.7 Summary of findings

The summary of findings related to this foundry cluster is provided in table 4.2.13.7.

Table 4.2.13.7: Summary of findings of Saharanpur foundry cluster

Parameter	Unit	Value
Number of units		102
Annual production	tonne per year	20,970
Total energy consumption	toe per year	2,493
SEC – Overall	GJ per tonne	5.0
GHG emissions	tonne CO_2 per year	13,736
Specific GHG emissions	tonne CO_2 per tonne of casting	0.6
Other relevant information	There is no project under implementation in the cluster	

4.2.14 Indore Foundry Cluster

4.2.14.1 Cluster background

Indore is one of the industrial clusters in the state of Madhya Pradesh, with a mix of small and medium industries making products for the automobile, engineering, railway, and textile machinery for cotton mills. The casting products of the Indore foundry cluster primarily cater to the textile machinery manufacturing industries, automobile industry (mainly commercial vehicles and construction equipment). Apart from Indore city, there are four more industrial areas such as Pithampur, Devas, Ujjain, and Sanwar, where foundry industries are located.

Primary raw material

The base raw materials include pig iron, steel, boring, bought out scrap, in-house foundry return, and rejected castings. Limited alloying elements such as ferro-silicon, ferro-manganese, iron sulphide, silicon carbide, etc., are also used depending on the target chemistries of the castings.

Major products

The products include both grey iron castings and ductile castings to meet the requirement of OEMs from automobile and textile. It also produces ornamental castings, sanitary & pipe fittings, agricultural implements, etc.

Classification of industries

About 46 foundry industries in the cluster manufacture annually about 43,320 tonnes of ferrous casting. Both cupola furnace (CF) and induction furnace (IF) are in use for the melting process. Most of the small foundry units in Indore, Ujjain, and Devas use cupola furnaces, while the larger automotive and steel foundry units use induction furnaces. Considering the melting technology employed and scale of operation, the categorization of industries are provided in table 4.2.14.1.

Table 4.2.14.1: Details of industries

Industry category	Number of units	Production range (tpm)	Average production (tonne/year)
Large (IF)	2	500-1000	18,000
Medium (IF)	3	100-150	4,500
Small (IF)	10	50-100	9,000
Small (NGF)	1	50-150	1,020
Small (CF)	10	30-70	6,000
Micro (CF)	20	10-30	4,800
TOTAL	46		43,320

Source: (1) Cluster profile report, SAMEEKSHA, (2) Analysis of cluster level secondary data by TERI

The majority of the industries operate cupola furnace (67%). The share of different categories of industries is provided in figure 4.2.14.1a. Cumulatively induction furnaces contribute maximum annual casting production, which is about 73 % (figure 4.2.14.1b).

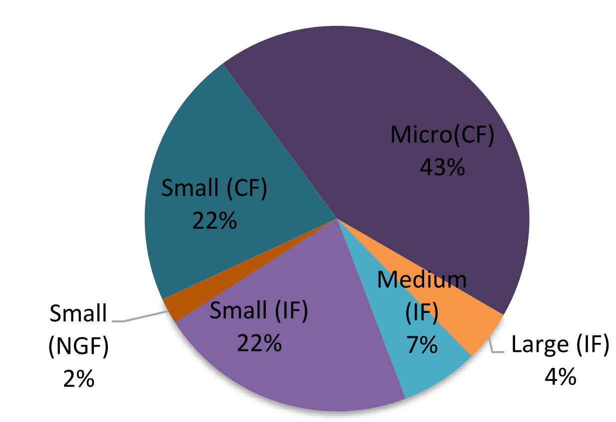


Figure 4.2.14.1a: Share of industries of different categories

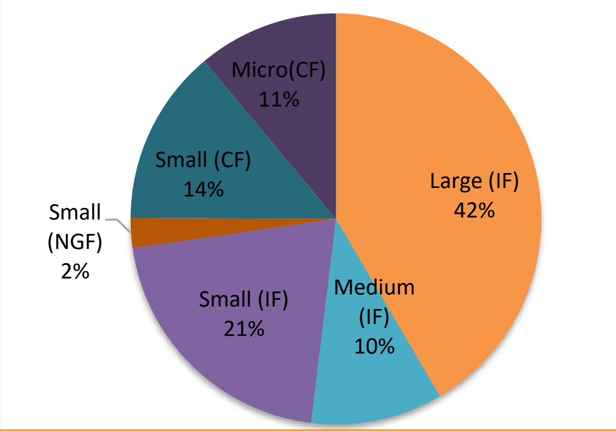


Figure 4.2.14.1b: Share of the annual production of different categories

4.2.14.2 Process technology

The details of melting technologies and primary auxiliary equipment used in the cluster are provided in table 4.2.14.2.

Table 4.2.14.2: Primary technology of Indore foundry cluster

Technology	Purpose
Cupola furnace	CFs in the cluster are mostly coke fired except a few units use natural gas. The average coke consumption on metal across different categories is around 16.7-18.2%.
Induction furnace	IFs are mostly used for producing higher grade casting and most of them operate on daily basis. The melting capacity of IFs is 50 to 1000 tonne per month; the electricity consumption is 622- 844 kWh per tonne melt.

4.2.14.3 Energy consumption analysis

Foundries in these clusters use either coke or electricity in melting, depending upon the melting technology employed. Coke is primarily used in cupola furnaces for producing liquid metal. The energy consumption pattern of the foundry units depends on the melting technology deployed and production capacities. The electricity contributes the majority energy share (>71%). The share of energy consumption from a different source is provided in figure 4.2.14.3a.

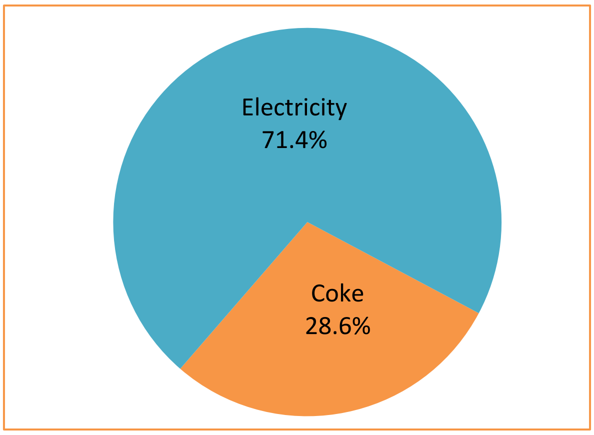


Figure 4.2.14.3a: Share of energy consumption source

The unit level annual energy consumption depends on the annual production range of different industries in the cluster. Table 4.2.14.3a provides the unit level annual energy consumption of different categories of industries in the cluster.

Table 4.2.14.3a: Details of unit level annual energy consumption

Fuel type	Unit	Energy consumption per plant					
		Large (IF)	Medium (IF)	Small (IF)	Small (NGF)	Small (CF)	Micro(CF)
Coke	tonne/year	-	-	-	-	100	45
Natural gas	Sm^3/year	-	-	-	72,000	-	-
Electricity	kWh/year	8,000,000	1,500,000	950,000	102,000	140,000	35,000

Cluster level energy consumption

The cluster level annual energy consumption by individual category of industries is provided in table 4.2.14.3b.

Table 4.2.14.3b: Details cluster level annual energy consumption

Fuel type	Unit	Large (IF)	Medium (IF)	Small (IF)	Small (NGF)	Small (CF)	Micro (CF)
Coke	tonne/year	-	-	-	-	1,000	900
Natural gas	mil Sm^3/year	-	-	-	0.7	-	-
Electricity	mil kWh/year	16	4.5	9.5	1.0	1.4	0.7
Thermal	toe/year	-	-	-	630	600	540
Electrical	toe/year	1,376	387	817	88	120	60
Total	toe/year	1,376	387	817	718	720	600

The induction furnace based industries consume the maximum share of cluster level energy consumption, which is more than 55%. The distribution of cluster level energy consumption by different categories of industries is provided in figure 4.2.14.3b.

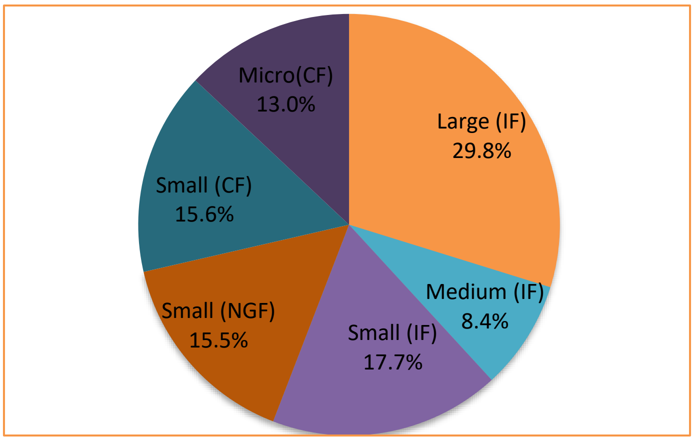


Figure 4.2.14.3b: Distribution of cluster level energy consumption

The total energy consumption in the cluster is estimated to be 4,618 toe per year. The equivalent GHG emissions are estimated to be 33,932 tonne CO_2 per year (Table 4.2.14.3c).

Table 4.2.14.3c: Energy consumption of Indore foundry cluster

Type	Unit	Energy consumption Quantity	Energy consumption Equivalent (toe/year)	GHG emissions (tonne CO2/year)
Coke	tonne/year	1,900	1,140	5,533
Natural gas	mil Sm^3/yr	0.7	630	1,241
Electricity	mil kWh/yr	33	2,848	27,158
Total			4,618	33,932

4.2.14.4 Performance analysis of foundry industries

The average specific energy consumption among different categories of foundry industries in the cluster varies in the range of 3.2 – 5.4 GJ per tonne of casting production, ignoring only one NG fired furnace in the cluster. This variation is largely due to the type of energy use, the energy efficiency of technology employed, quality of product and its chemistries, etc. The details of performance in terms of specific energy consumption incurred by different categories of industries are shown in table 4.2.14.4.

Table 4.2.14.4: Performance of foundry industries in Indore cluster

Type	SEC- Thermal (GJ/tonne)	SEC- Electrical (kWh/tonne)	SEC- Cluster (GJ/tonne)
Large (IF)	-	889	3.2
Medium (IF)	-	1,000	3.6
Small (IF)	-	1,056	3.8
Small (CF)	4.2	233	5.0
Micro(CF)	4.7	146	5.2
Minimum	-	100	3.6
Maximum	4.7	1,056	5.2

Note: SEC variations depend on process parameters

The micro category cupola furnace consumes maximum energy for producing per tonne of casting, which is estimated to be 5.24 GJ per tonne (Figure 4.2.14.4).

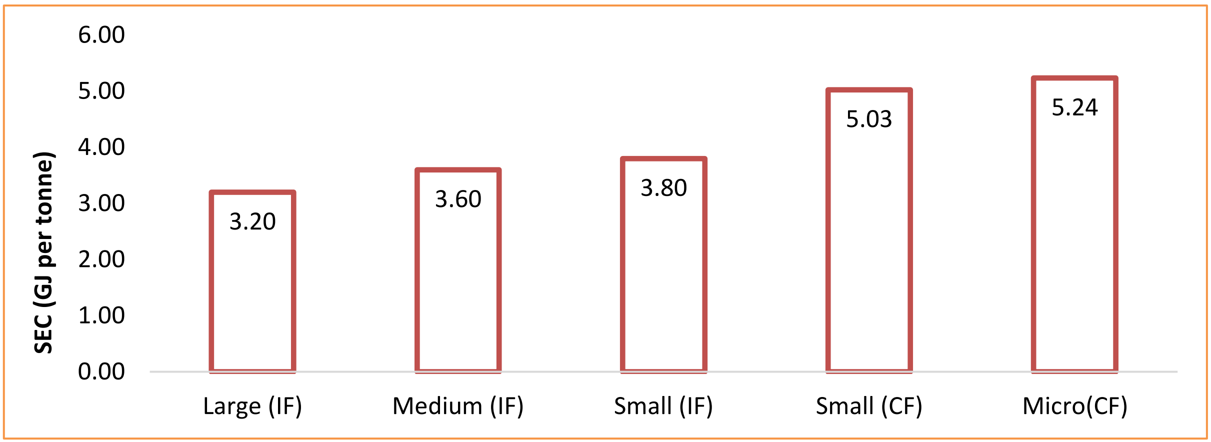


Figure 4.2.14.4: Variation of SEC among the different categories of industries

The cluster level specific energy consumption considering total annual production in the cluster and the total energy consumption is estimated to be around 4.46 GJ per tonne of casting production.

4.2.14.5 Relevant institutions for Indore foundry industries

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to foundry industries in this cluster are given in table 4.2.14.5.

Table 4.2.14.5: Institutions involved in Indore foundry cluster

Institution/ organization	Contact details	Objectives and roles
The Institute of Indian Foundrymen (IIF), Indore Chapter	Bagree Alloys Ltd 72A, Industrial Area : 1 A B Road, Dewas, Madhya Pradesh Tel: 07272 406506 email: agreealloys@dataone.in	• The Indore cluster has no industry association except IIF chapter, which promotes research, training, and development and serves as a nodal point between the customers and suppliers of the Indian foundry industry on a global scale
M.P. Urja Vikas Nigam Limited (MPUVNL)	Urja Bhawan, Link Road No. 2, Shivaji Nagar, Bhopal – 462 016, Madhya Pradesh Tel: 0752 255 6566 http://www.mprenewable.nic.in/contact.html	• State Designated Agency (SDA) to coordinate, regulate and enforce efficient use of energy and its conservation

4.2.14.6 Other information

UNIDO, in association with BEE, has initiated a project to promote energy conservation measures and capacity building of local service providers. This project is under implementation.

4.2.14.7 Summary of findings

The summary of findings related to this foundry cluster is provided in table 4.2.14.7.

Table 4.2.14.7: Summary of findings of Indore foundry cluster

Parameter	Unit	Value
Number of units		46
Annual production	tonne per year	43,320
Total energy consumption	toe per year	4,618
SEC – Overall	GJ per tonne	4.5
GHG emissions	tonne CO_2 per year	33,932
Specific GHG emissions	tonne CO_2 per tonne casting	0.8
Other relevant information	Cluster level initiative by UNIDO is under implementation.	

4.2.15 Faridabad Foundry Cluster

4.2.15.1 Cluster background

Faridabad is one of the prominent industrial clusters in the state of Haryana. The growth of the MSME units in Faridabad is primarily evolved around the large OEM industries like Escorts, Eicher, Mahindra, Yamaha, Honda, Maruti, and JCB, which are operating in and around Faridabad district. Faridabad has majorly 15 industrial areas; the majority of them (10) produce different parts and spare for the automobile market. Foundry industries in the Faridabad cluster are scattered and installed in different industrial segments.

Primary raw material

The base raw materials include pig iron, steel, boring, bought-out scrap, in-house foundry return, and rejected castings. Limited alloying elements such as ferro-silicon, ferro-manganese, iron sulphide, silicon carbide, etc., are also used depending on the target chemistries of the castings.

Major products

The products cluster includes both grey iron castings and ductile castings to meet the requirement of OEMs from automobile and other heavy machinery manufacturing industries. The other casting products from the Faridabad cluster include motor casing, flywheels, brake bodies, pump casing, springs, etc.

Classification of industries

About 340 foundry industries in the cluster manufacture annually about 249,750 tonnes of ferrous casting. Both cupola furnace (CF) and induction furnace (IF) are in use for the melting process. Considering the melting technology employed and scale of operation, the categorization of industries are provided in table 4.2.15.1.

Table 4.2.15.1Details of industries

Industry category	Number of units	Production range (tpm)	Average production (tonne/year)
Medium (IF)	15	200-600	72,000
Small (IF)	70	20-60	33,600
Medium (CF)	20	200-500	84,000
Small (CF)	100	20-60	48,000
Micro(CF)	135	5-10	12,150
TOTAL	340		249,750

Source: (1) Cluster profile report, SAMEEKSHA, (2) Analysis of cluster level secondary data by TERI

The majority of the industries operate cupola furnaces (75%). The share of different categories of industries is provided in figure 4.2.15.1a. Cumulatively cupola furnaces contribute maximum annual casting production, about 58 % (figure 4.2.15.1b).

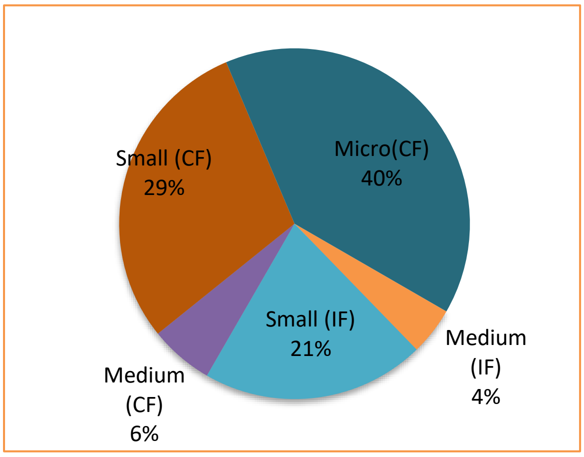


Figure 4.2.15.1a: Share of industries of different categories

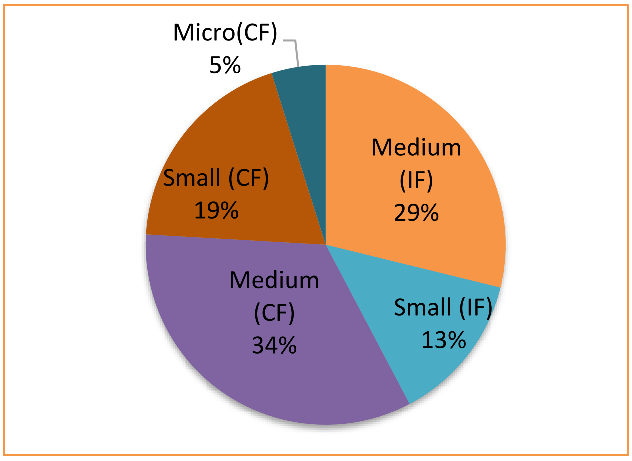


Figure 4.2.15.1b: Share of the annual production of different categories

4.2.15.2 Process technology

The details of melting technologies and primary auxiliary equipment used in the cluster are provided in Table 4.2.15.2.

Table 4.2.15.2: Primary technology of Faridabad foundry cluster

Technology	Purpose
Cupola furnace	All the CFs in the cluster are coke fired. The average percentage of coke consumption on metal across the different categories of industries is about 12.6-22.2%.
Induction furnace	IFs are mostly used for producing higher grade casting, and most of them operate on a daily basis. The furnace capacity is in the range of 50 to 600 tonnes per month With electricity consumption varying between 700-797 kWh per tonne melt.

4.2.15.3 Energy consumption analysis

Foundries in these clusters use either coke or electricity in melting, depending upon the melting technology employed. Coke is primarily used in cupola furnaces for producing liquid metal. The energy consumption pattern of the foundry units depends on the melting technology deployed and production capacities. The coke contributes the majority energy share (>55%). The share of energy consumption from a different source is provided in figure 4.2.15.3a.

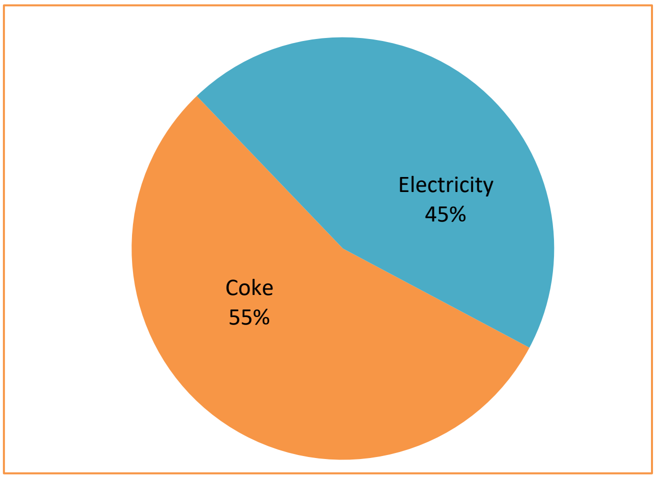


Figure 4.2.15.3a: Share of energy consumption source

The unit level annual energy consumption depends on the annual production range of different industries in the cluster. Table 4.2.15.3a provides the unit level annual energy consumption of different categories of industries in the cluster.

Table 4.2.15.3a: Details of unit level annual energy consumption

Type	Unit	Energy consumption per plant				
		Medium (IF)	Small (IF)	Medium (CF)	Small (CF)	Micro(CF)
Coke	tonne/year	-	-	530	75	20
Electricity	kWh/year	4,800,000	510,000	480,000	10,000	1,000

The cluster level annual energy consumption by individual category of industries is provided in table 4.2.15.3b.

Table 4.2.15.3b: Details cluster level annual energy consumption

Fuel type	Unit	Medium (IF)	Small (IF)	Medium (CF)	Small (CF)	Micro(CF)
Coke	tonne/year	-	-	10,600	7,500	2,700
Electricity	mil kWh /year	72	35.7	9.6	1	0.1
Thermal	toe/year	-	-	6,360	4,500	1,620
Electrical	toe/year	6,192	3,070	826	86	12
Total	toe/year	6,192	3,070	7,185	4,586	1,632

The cupola furnace based industries consumes maximum share of cluster level energy consumption, which is more than 59%. The distribution of cluster level energy consumption by different category of industries is provided with figure 4.2.15.3b.

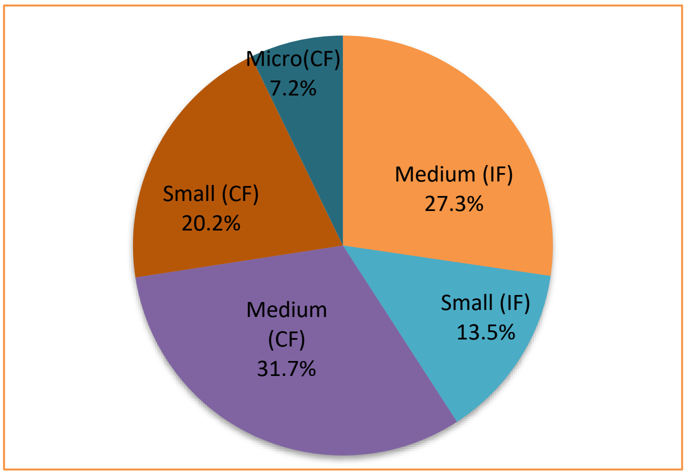


Figure 4.2.15.3b: Distribution of cluster level energy consumption

The total energy consumption in the cluster is estimated to be 22,665 toe per year. The equivalent GHG emissions are estimated to be 157,686 tonne CO_2 per year (Table 4.2.15.3c).

Table 4.2.15.3c: Energy consumption of Faridabad foundry cluster

Energy source	Unit	Energy consumption		GHG emissions
		Quantity	Equivalent (toe/year)	(tonne CO_2/year)
Coke	tonne/year	20,800	12,480	60,569
Electricity	mil kWh/year	118	10,185	97,117
Total			22,665	157,686

4.2.15.4 Performance analysis of foundry industries

The average specific energy consumption of foundry industries in the cluster is in the range of 3.6-5.6 GJ per tonne of casting excluding the one NG fired furnace operating in the cluster. This variation in SEC are largely contributed due to type of energy use, energy efficiency of technology employed, quality of product and its chemistries, etc. The details of performance in terms of specific energy consumption incurred by different category of industries are shown in table 4.2.15.4.

Table 4.2.15.4: Performance of foundry industries in Faridabad cluster

Type	SEC- Thermal (GJ/tonne)	SEC- Electrical (kWh/tonne)	SEC- Cluster (GJ/tonne)
Medium (IF)	-	1,000	3.6
Small (IF)	-	1,062	3.8
Medium (CF)	3.2	114	3.6
Small (CF)	3.9	20	4.0
Micro(CF)	5.6	11	5.6
Minimum	-	11	3.6
Maximum	5.6	1,062	5.6

Note: SEC variations depend on process parameters

The micro category cupola furnace consumes maximum energy for producing per tonne of casting, which is estimated to be 5.6 GJ per tonne (Figure 4.2.15.4).

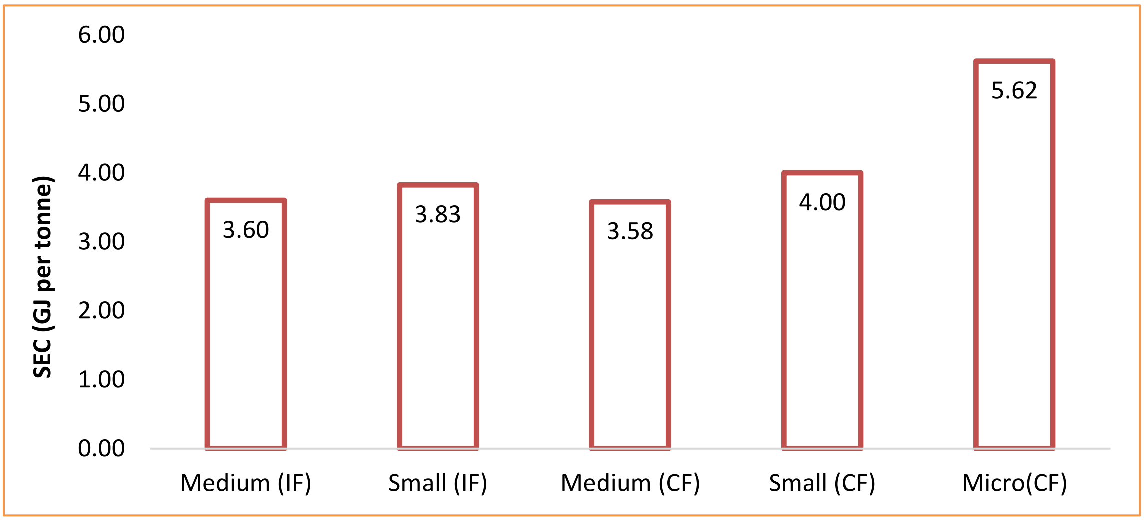


Figure 4.2.15.4: Variation of SEC among different category of industries

The cluster level specific energy consumption considering total annual production in the cluster and the total energy consumption is estimated to be around 3.8 GJ per tonne of casting production.

4.2.15.5 Relevant institutions for Faridabad foundry industries

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to foundry industries in this cluster are given in table 4.2.15.5.

Table 4.2.15.5: Institutions involved in Faridabad foundry cluster

Institution/ organization	Contact details	Objectives and roles
Faridabad Foundry Association	FIA House, Bata Chowk, Faridabad-121001 Tel: 0129-2232136, 2235176 email : fiafbd@dataone.in https://fiafaridabad.com	• Addresses policy and regulatory issues pertaining to foundry industries
Integrated Association of Micro, Small and Medium Enterprises of India (Iam SME of India)	Mathura Rd, Block B, Sector 11, Faridabad, Haryana 121006 Tel: +91-9711123111, 9711101666 info@iamsmeofindia.com https://www.iamsmeofindia.com	• The members of this association consist of diverse industries, including foundry industries. It provides a whole range of services, including raw material and process equipment procurement.
The Institute of Indian Foundrymen (IIF), Faridabad Chapter	Indian Core Oils Pvt. Ltd Plot No 53, Sector- 6 Faridabad : 121 006	• The IIF chapter promotes education, research, training, and

Institution/ organization	Contact details	Objectives and roles
	Tel: 0129 2242381/4711	development to Indian foundrymen • Serves as a nodal point of reference between the customers and suppliers of the Indian foundry industry on a global scale
Department of New & Renewable Energy, Haryana (HAREDA), Panchkula	Akshay Urja Bhawan, Plot No-1, Sector 17, Opp Agarwal Bhavan, Panchkula, Haryana-134109 Tel: 0172 258 7233 email: hareda@chd.nic.in https://hareda.gov.in/	State Designated Agency (SDA) to coordinate, regulate and enforce efficient use of energy and its conservation

4.2.15.6 Other information

No significant cluster level initiative is implemented in the recent past to promote energy conservation and technology upgradation for the foundry industries.

4.2.15.7 Summary of findings

The summary of findings related to this foundry cluster is provided in table 4.2.15.7.

Table 4.2.2.7: Summary of findings of Faridabad foundry cluster

Parameter	Unit	Value
Number of units		340
Annual production	tonne per year	249,750
Total energy consumption	toe per year	22,665
SEC – Overall	GJ per tonne	3.8
GHG emissions	tonne CO_2 per year	157,686
Specific GHG emissions	tonne CO_2 per tonne casting	0.6
Other relevant information	No cluster level initiative is under implementation	

4.2.16 Summary of energy analysis of Foundry sub-sector

A study of the foundry sector shows that there are around 45 foundry clusters in India of which 14 primary clusters constitutes major share of foundry industries The number of industries in these clusters reported to be around 3,681 (74%) out of total 5,000 plants in India.

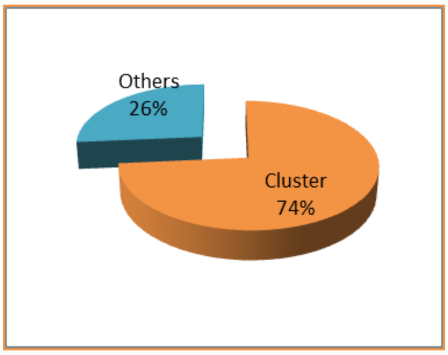


Figure 4.2.16: Distribution of foundry

Most of the industries are observed to be small scale categories comprising 76% of total population of the primary clusters in India. Foundry industries uses both coke fired cupola furnace (69%) and induction heating furnace (31%) for producing liquid metal. Induction furnace produces majority share of the production, which is around 54%. The summary of observations from the reported data related to primary foundry clusters are provided in table 4.2.16.

Table 4.2.16: Summary of energy analysis of Foundry clusters

S No	Cluster	Number of units (Operating)	Production (tpy)	Energy consumption (toe/year)	GHG emissions (t-CO_2/ year)
1	Agra	80	106,320	10,474	84,707
2	Ahmedabad	450	543,600	46,098	346,435
3	Batala-JLN-LDH	450	250,200	20,119	139,136
4	Belgaum	160	211,500	19,010	175,355
5	Coimbatore	535	582,000	44,772	391,081
6	Kolhapur	300	613,500	47,947	429,075
7	Howrah	330	811,200	74,705	400,289
8	Jaipur	120	211,800	20,051	162,102
9	Rajkot	700	537,000	51,219	364,703
10	Samalkha	30	36,480	3,061	16,378
11	Shimoga	38	56,760	6,036	54,847
12	Saharanpur	102	20,970	2,493	13,736
13	Indore	46	43,320	4,618	33,932
14	Faridabad	340	249,750	22,665	157,686
	Total	3,681	4,286,400	374,184	2,773,933

The total production of ferrous castings in India is reported to be 10.1 million tonne during the year 2019-20, second position in the world casting production share, next to China. Based on the findings from analysis, the total energy consumption and GHG emissions of Indian foundry sub-sector is estimated to be about 0.9 million toe per year and 6.6 million tonne CO_2 per tonne respectively. The average specific energy consumption of Indian foundry sector is 3.8 GJ per tonne. Standard energy values and emission factors were used for estimating energy consumption and GHG emissions respectively. The global SEC level of foundry sector is reported to be 1.8-2.9 GJ per tonne equivalent to 0.04-0.1 toe per tonne (source: Global Industrial Energy Efficiency Benchmarking: An Energy Policy Tool).

4.2.17 Cluster selection in foundry sub-sector

4.2.17.1 Selection matrix

The study considered a number of attributes with relevant criteria and score for ranking of the clusters. These attributes are provided in table 4.2.17.1. More details of selection matrix at cluster level are provided in annexure 2.

Table 4.2.17.1: Selection criteria for Foundry sub-sector

S No	Attribute	Criteria	Score
1	Number of units	• <= 200 • 201-200 • 301-400 • >400	2.5 5.0 7.5 10.0
2	Specific energy consumption, GJ per tonne	• >3.50 • 3.51-4.00 • 4.00-4.50 • > 4.50	2.5 5.0 7.5 10.0
3	Variability (technology, fuel, etc.)	• One variable • Two variables • Three variables • More than three variables	2.5 5.0 7.5 10.0
4	GHG emission share	• Less than 1.59% • 1.60-3.59% • 3.60-5.59% • > 5.59%	2.5 5.0 7.5 10.0
5	Prior/on-going activities on energy efficiency at cluster level	• Replication of EE measures • Demonstration undertaken • Cluster level studies conducted • No activities on energy efficiency	2.5 5.0 7.5 10.0
6	Availability of industry association in the cluster	• No industry association • One industry association • More than one association • Industry association, SPVs, etc.	2.5 5.0 7.5 10.0

4.2.17.2 Summary of findings

Based on the attributes and criteria, the project has short-listed Ahmedabad (Gujarat) and Rajkot (Gujarat) for further planning and deep-diving on energy efficiency activities in foundry sub-sector (table 4.2.17.2).

Table 4.2.17.2: Shortlisted clusters for deep-diving

Cluster	State	Score	Rank
Ahmedabad	Gujarat	45.0	1
Rajkot	Gujarat	42.5	2
Coimbatore	Tamil Nadu	37.5	3
Howrah	West Bengal	35.0	4
Batala-Jalandhar-Ludhiana	Punjab	32.5	5
Faridabad	Haryana	30.0	6
Kolhapur	Maharashtra	30.0	6
Jaipur	Rajasthan	30.0	6
Agra	Uttar Pradesh	27.5	9
Belgaum	Karnataka	27.5	9
Shimoga	Karnataka	27.5	9
Saharanpur	Uttar Pradesh	27.5	9
Samalkha	Haryana	25.0	13
Indore	Madhya Pradesh	25.0	14

4.3 Forging industries

4.3.1 Background

The Indian forging industry is one of the major contributors to the manufacturing sector of the Indian economy. The forging industries produce auto components and non-auto components. Automotive components account for about 58% of total production in the country (source: AIFI). Almost 83% of forging industries are micro industries based on their production capacities. Hot closed die type forging industries account for about 63% of total installed capacity (figure 4.3.1).

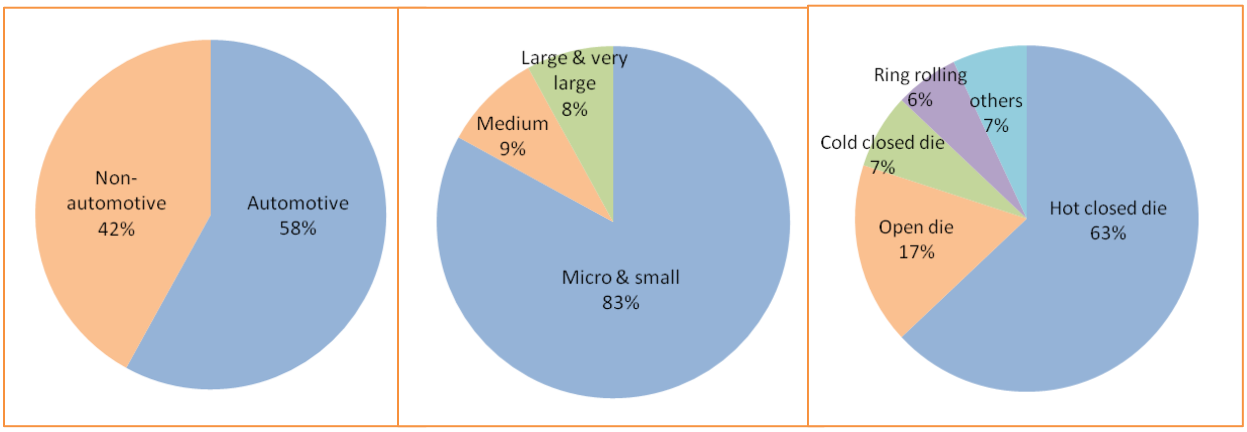


Figure 4.3.1 Break-up of forging industries

4.3.1.1 Spread of industries, products and production

The forging industries are spread over eastern, western, northern and southern regions of the country. The primary forging clusters in India include Pune, Rajkot, Ludhiana, Chennai, etc.

4.3.1.2 Process description and technology use

The major process steps involved in forging include (1) cutting of steel rods as billets, (2) heating of billets in the furnace, (3) forging in presses, (4) trimming and (5) heat treatment (figure 4.3.1.2).

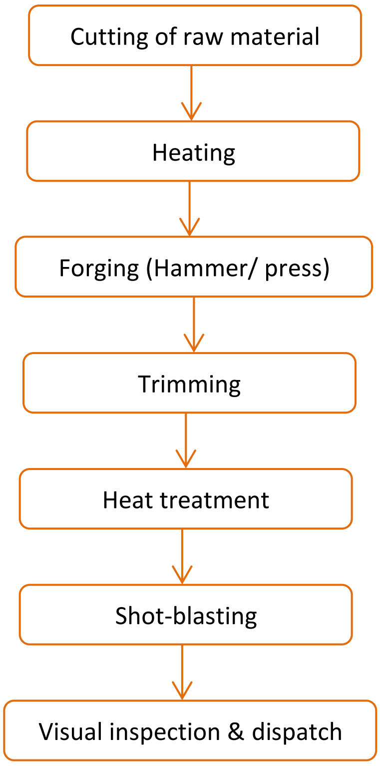


Figure 4.3.1.2: Forging process

Raw material cutting

After quality check, the raw material is cut on bandsaw machine and/or shearing machine in the form of billets as per weight required for forged job in desired length.

Raw material heating and forging

The billets are heated in a furnace (oil/gas fired) or induction billet heater to about 1,200–1,270 °C as per requirements of different grades of steel. The heated billets are removed one by one from the furnace and forged in the hammer to `desired shape in one or number of strokes. A few units use presses for forging of certain products.

Trimming and coining

Trimming and coining presses are used for removing extra material from the forged job. Trimming is done in one stroke in the trimming press.

Heat treatment

After the trimming/coining, depending on the job requirement, heat treatment is done on the forged job in hardening or tempering furnace.

Inspection and dispatch

The inspection of dimensions and quality of jobs are done and sent to the machining shop or dispatch.

4.3.1.3 Raw materials, products and production

The raw materials used by forging industries in the cluster include ingots and bars of different sizes made of mild steel, carbon steel, alloy steel, stainless steel, super alloy, and special steels. The auto components and non-auto components produced from forging industries are used in a wide range of vehicle manufacturing units, engineering industries, electrical equipment manufacturing industries, etc., catering to original equipment manufacturer (OEM) and replacement market and general engineering. Some of the major products produced in the cluster include crank shaft, connecting rods, brake drum, spanners, special tools, etc. The total production from forging industries is 2.8 million tonne, with an average capacity utilization of 62.1%.

4.3.1.4 Other countries having forging industries

North America, Europe, Asia Pacific (China, India and Japan) are the major regions having forging industries.

4.3.1.5 Institutions at national level

The details of industry associations at national level are given in table 4.3.1.5.

Table 4.3.1.5: Relevant institutions at national level

Institution/ organization	Contact details	Objectives and roles
Association of Indian Forging Industry (AIFI)	101/112 Nyati Millennium, Off. Nagar Road Viman Nagar (Near Datta Mandir) Pune – 411014	• Promoting technology upgradation through workshops, seminars, training programmes and conferences • Dissemination of relevant information for overall improvements

4.3.1.6 Coverage of clusters/states

The following forging industry clusters were covered for analysis of energy consumption.

1. Chennai
2. Ludhiana
3. Pune
4. Rajkot
5. Other clusters

4.3.2 Chennai cluster

4.3.2.1 Background

Chennai forging cluster is located in Tamil Nadu state. There are about 50 forging units, located in various industrial estates such as SIDCO Industrial Estates in Thirumudivakkam, Ambatur, Thirumazhisai, Ponneri, etc., which are located around Chennai. The forging units in Chennai cluster produce precision auto components and non-auto components which are supplied to a wide range of vehicle production industries and machinery and engineering, electrical equipment production industries, and others. Based on the capacities, the forging industries are categorized into four types within the cluster. The total production from Chennai forging cluster is estimated to be 65,280 tonne per year during 2016-17 (table 4.3.2.1).

Table 4.3.2.1: Production from Chennai forging cluster

Type	Number of industries		Capacity (tpm/industry)		Production
	Total	Operating	Minimum	Maximum	(tonne/year)
Micro	10	10	80	90	10,200
Small	30	30	90	110	36,000
Medium	6	6	110	350	8,280
Large	4	4	350	550	10,800
Total	50	50			65,280

Source: Cluster profile – Chennai forging industry, SAMEEEKSHA

The production share of forging industries shows that smaller units account for more than half of the production at the cluster level (Figure 4.3.2.1).

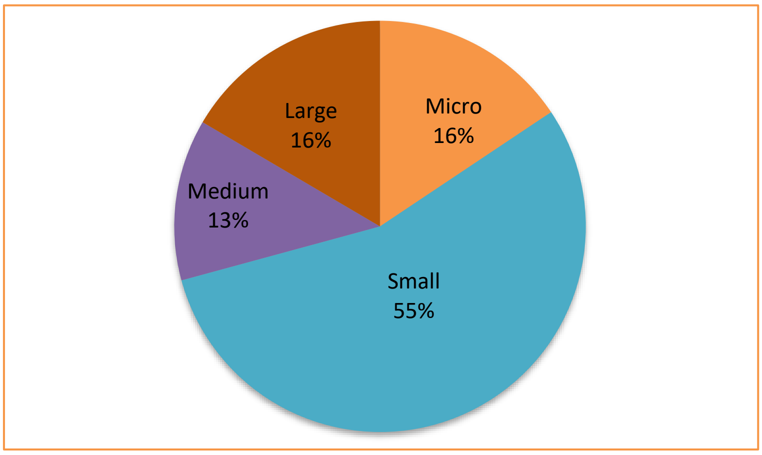


Figure 4.3.2.1: Share of production in Chennai forging cluster

4.3.2.2 Process technology

The raw materials used by forging industries in the cluster include ingots and bars of different sizes made of mild steel, carbon steel, alloy steel, stainless steel, super alloy, and special steels. The products from the cluster are mainly used in sectors like automobile, light and heavy machine components, and electrical equipment, catering both to OEM and replacement market and general engineering.

The major process steps involved in forging include (1) cutting of steel rods as billets, (2) heating of billets in the furnace, (3) forging in presses, (4) trimming and (5) heat treatment. The technologies used in forging in the cluster are provided in table 4.3.2.2.

Table 4.3.2.2: Process technology used in Chennai forging cluster

Technology	Purpose
Furnace (FO, electrical)	Heating of raw materials (billets of different grades of steel)
Hammer, screw press	Forging of hot billets into various shapes

4.3.2.3 Energy consumption analysis

The forging industries in Chennai cluster commonly use furnace oil in the furnaces for heating of raw materials. Electricity is used for heating of raw materials, heat treatment and meeting other electrical loads. DG sets are used to meet electricity needs during power-cuts.

Furnace oil contributes the majority energy share (>75%). The share of energy consumption from different sources is provided in figure 4.3.2.3a.

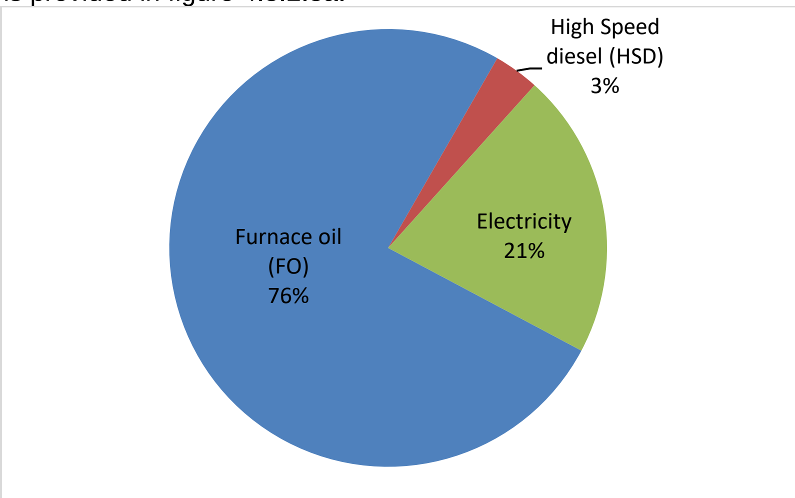


Figure 4.3.2.3a: Share of energy consumption source

Thermal energy in furnaces accounts for about 75% of total energy consumption. The total energy consumption of forging industries in the cluster is estimated to be 9,221 toe per year. The equivalent GHG emissions are estimated to be 40,274 tonne CO_2 per year (Table 4.3.2.3).

Table 4.3.2.3: Energy consumption of Chennai forging industry cluster

Type	Unit	Micro	Small	Medium	Large	Total	Energy consumption (toe/yr)	GHG(t-CO_2/yr)
Furnace oil	Tpy	1,095	4,202	928	706	6,930	6,965	21,492
HSD	kL/yr	25.3	216	58	54	353	309	896
Electricity	mil kWh/yr	4.9	7.9	3.6	6.6	22.6	1,947	17,886
Total							9,221	40,274

The small size category forging industries consumes maximum share of cluster level energy consumption (55%). The distribution of cluster level energy consumption by different category of industries is provided with figure 4.3.2.3b.

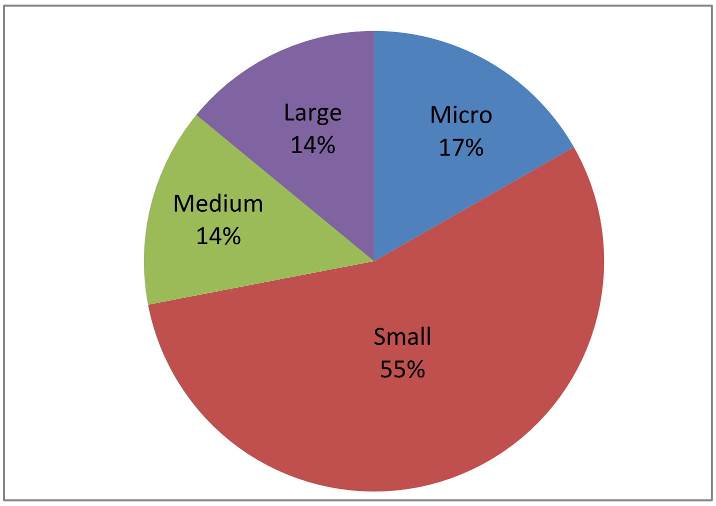


Figure 4.3.2.3b: Distribution of cluster level energy consumption

4.3.2.4 Performance of forging industries

The overall SEC of Chennai forging cluster works out to be 5.9 GJ per tonne. This includes SEC (thermal) of 4.7 GJ per tonne and SEC (electrical) of 347 kWh per tonne (table 4.3.2.4).

Table 4.3.2.4: Performance of forging industries (Chennai cluster)

Type	SEC-Thermal (GJ/tonne)	SEC-Electrical (kWh/tonne)	SEC-Cluster (GJ/tonne)
Micro	4.6	480	6.3
Small	5.1	220	5.9
Medium	5.0	430	6.5
Large	2.9	580	5.0
Overall	4.7	347	5.9

The medium category furnace consumes maximum energy for producing per tonne of products, which is estimated to be 6.5 GJ per tonne (Figure 4.3.2.4).

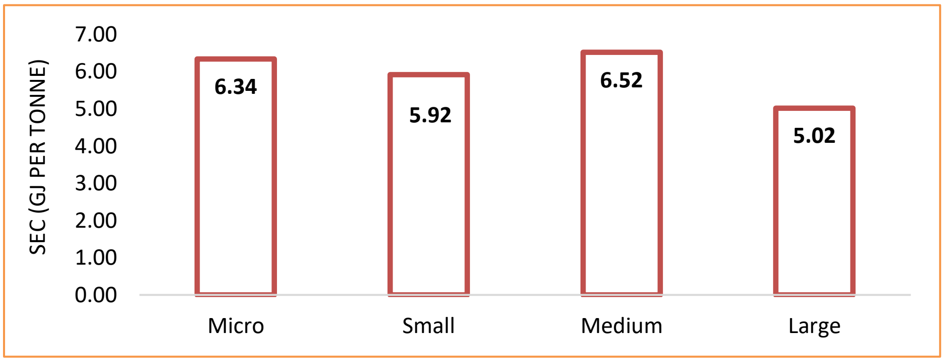


Figure 4.3.2.4: Variation of SEC among different category of industries

The cluster level specific energy consumption considering total annual production in the cluster and the total energy consumption is estimated to be around 5.9 GJ per tonne of production.

4.3.2.5 Relevant institutions for forging industries

The details of industry associations and state designated agencies (SDAs) in Tamil Nadu are given in table 4.3.2.5.

Table 4.3.2.5: Relevant institutions involved in Tamil Nadu

Institution/ organization	Contact details	Objectives and roles
Association of Indian Forging Industry (AIFI) – Chennai chapter	Thirumudivakkam Industrial Estate Manufacturer Association, No. PP3, Communication Centre SIDCO Industrial Estate, Thirumudivakkam, Chennai-600 044, Tel: 044 4383 7173 email: admin@tiema.co.in http://tiema.co.in	• Welfare and grievance redressal of member industries
Electrical Inspectorate Department	Government of Tamil Nadu Thiru Vi.Ka. Industrial Estate, Guindy, Chennai-600 032 Tel: 044 2250 0184/ Email: ceig@tn.gov.in https://www.tnei.tn.gov.in/pages/contactus	• Promotion of energy efficiency and energy conservation

4.3.2.6 Other information

The Bureau of Energy Efficiency has initiated an energy mapping study of the cluster which is on-going.

4.3.2.7 Summary of findings

The summary of findings of forging industries in Chennai cluster is provided in table 4.3.2.7.

Table 4.3.2.7: Summary of findings of Chennai forging cluster

Parameter	Remarks
Total number of forging industries	50
Number of operating industries	50
Total energy consumption	9,221 toe per year
Specific energy consumption	• Thermal – 4.7 GJ per tonne • Electrical – 347 kWh per tonne • Overall - 5.9 GJ per tonne
GHG emissions	40,953 tonne CO_2 per year
Specific GHG emissions	0.6 tonne CO_2 per tonne
Other relevant information	The Bureau of Energy Efficiency has initiated an energy mapping study of the cluster which is on-going.

4.3.3 Ludhiana cluster

4.3.3.1 Background

Ludhiana forging cluster is located in Punjab state. There are about 500 forging units operating in the cluster. The forging industries are mainly located in Daba road, Saniwal Delo road, Focal point (Phase I-VIII) and Industrial area A,B and C. Based on the capacities, the forging industries are categorized into four types within the cluster. About 60% of the forging industries in the cluster comes under small category. The total production from Ludhiana forging cluster is estimated to be 0.4 million tonne per year during 2016-17 (table 4.3.3.1).

Table 4.3.3.1: Production from Ludhiana forging cluster

Type	Number of industries		Capacity (tpm/industry)		Production
	Total	Operating	Minimum	Maximum	(tonne/year)
Micro	150	150	10	30	30,000
Small	300	300	30	100	195,000
Medium	50	50	100	200	75,000
Large	10	10	500	1000	75,000
Total	510	510			375,000

Source: Cluster profile – Ludhiana forging industry, SAMEEEKSHA

The production share of forging industries shows that smaller units account for more than half of the production at the cluster level (figure 4.3.3.1).

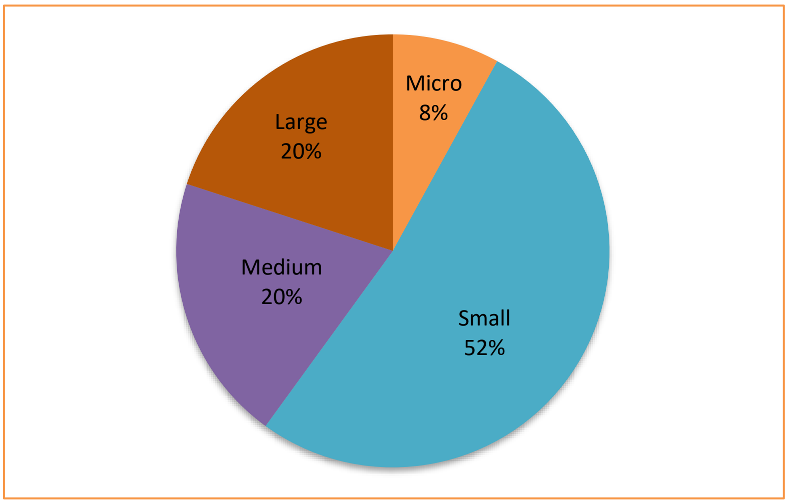


Figure 4.3.3.1 Share of production in Ludhiana forging cluster

4.3.3.2 Process technology

The raw materials used by forging industries in the cluster include ingots and bars of different sizes made of mild steel, carbon steel, alloy steel, stainless steel, super alloy, and special steels. The major products produced in the cluster include crank shaft, connecting rods, brake drum, spanners, special tools, etc.

The major process steps involved in forging include (1) cutting of steel rods as billets, (2) heating of billets in the furnace, (3) forging in presses, (4) trimming and (5) heat treatment. The technologies used in forging in the cluster are provided in table 4.3.3.2.

Table 4.3.3.2: Process technology used in Ludhiana forging cluster

Technology	Purpose
Furnace (FO based)	Heating of raw materials (billets of different grades of steel)
Hammer, screw press	Forging of hot billets into various shapes

4.3.3.3 Energy consumption analysis

The forging industries in Ludhiana cluster use mainly furnace oil for heating of raw materials. Grid electricity is used to cater to the electrical load requirements. DG sets are used to meet electricity needs during power-cuts.

Furnace oil contributes the majority energy share (>70%). The share of energy consumption from different sources is provided in figure 4.3.3.3a.

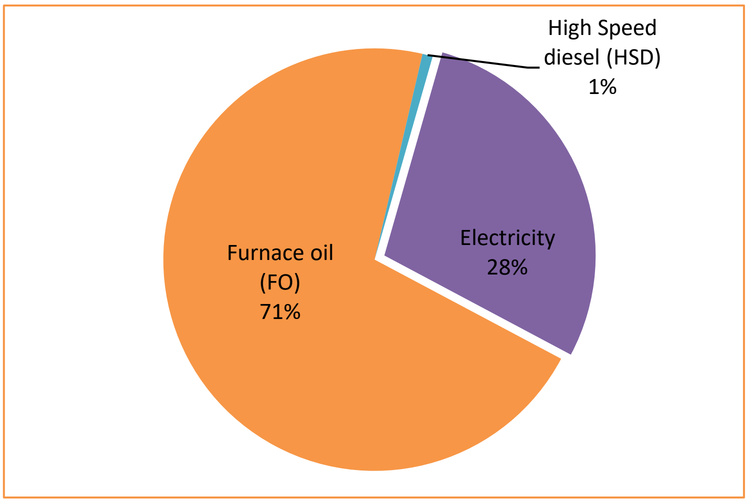


Figure 4.3.3.3a: Share of energy consumption source

Thermal energy in furnaces accounts for about 72% of total energy consumption. The total energy consumption of forging industries in the cluster is estimated to be 58,496 toe per year. The equivalent GHG emissions are estimated to be 281,565 tonne CO_2 per year (Table 4.3.3.3).

Table 4.3.3.3: Energy consumption of Ludhiana forging industry cluster

Type	Unit	Micro	Small	Medium	Large	Total	Energy consumption (toe/yr)	GHG ($t\text{-}CO_2/yr$)
Furnace oil	tpy	4,482	22,759	77,03	6,302	41,246	41,452	127,904
HSD	kL/yr	60	293	94	83	529	462	1,341
Electricity	mil kWh/yr	21	114	24	34	193	16,582	152,320
Total							58,496	281,565

The small size category forging industries consumes maximum share of cluster level energy consumption (56%). The distribution of cluster level energy consumption by different category of industries is provided with figure 4.3.3.3b.

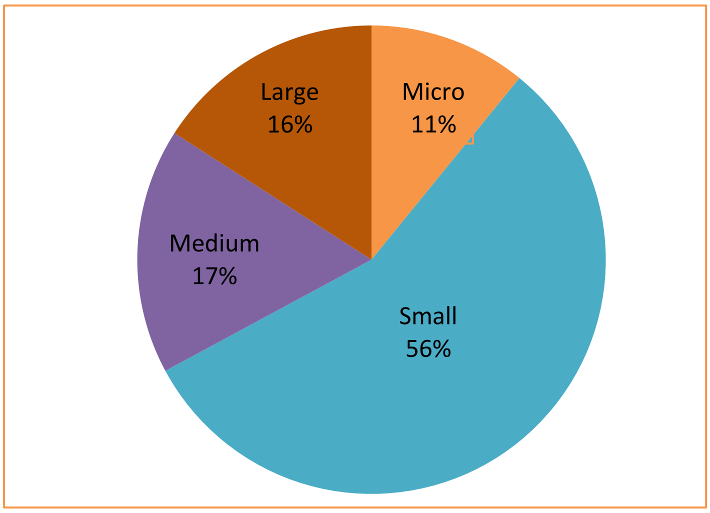


Figure 4.3.3.3b: Distribution of cluster level energy consumption

4.3.3.4 Performance of forging industries

The overall SEC of Ludhiana forging cluster works out to be 6.5 GJ per tonne. This includes SEC (thermal) of 4.7 GJ per tonne and SEC (electrical) of 514 kWh per tonne (table 4.3.3.4).

Table 4.3.3.4: Performance of forging industries (Ludhiana cluster)

Type	SEC-Thermal (GJ/tonne)	SEC-Electrical (kWh/tonne)	SEC-Cluster (GJ/tonne)
Micro	6.4	700	8.9
Small	5.0	583	7.1
Medium	4.4	325	5.5
Large	3.6	450	5.2
Overall	4.7	514	6.5

The micro category furnace consumes maximum energy for producing per tonne of products, which is estimated to be 8.9 GJ per tonne (Figure 4.3.3.4).

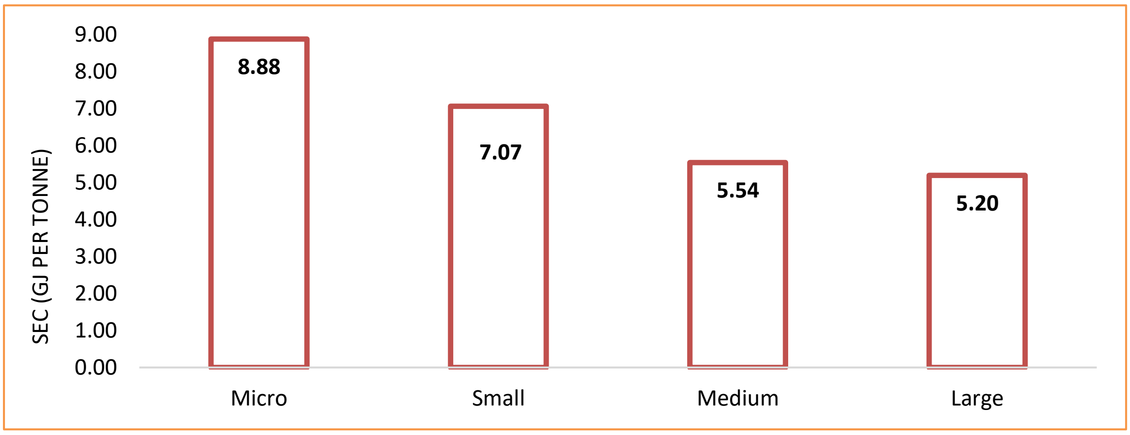


Figure 4.3.3.4: Variation of SEC among different category of industries

The cluster level specific energy consumption considering total annual production in the cluster and the total energy consumption is estimated to be around 6.5 GJ per tonne of production.

4.3.3.5 Relevant institutions for forging industries

The details of industry associations and state designated agencies (SDAs) in Punjab are given in table 4.3.3.5.

Table 4.3.3.5: Relevant institutions involved in Punjab

Institution/ organization	Contact details	Objectives and roles
Punjab Forging Industries Association	Chamber of Industries and Commercial Undertaking, Focal point Phase-V Tel: 0161 267 2888 email: chamber@cicuindia.org https://www.cicuindia.org/	• Welfare activities and grievance redressal of member industries
Punjab Energy Development Agency (PEDA)	Solar Passive Complex, Plot No. 1-2, Sector 33-D,Chandigarh – 160 034 Tel: 0172 266 3382 Email: ceo@peda,gov.in https://www.peda.gov.in/	• Implementation of Energy Conservation Act • Creating awareness to adopt non-conventional energy sources and energy saving / Conservation

4.3.3.6 Other information

The Bureau of Energy Efficiency has initiated an energy mapping study of the cluster which is on-going.

4.3.3.7 Summary of findings

The summary of findings of forging industries in Ludhiana cluster is provided in table 4.3.3.7.

Table 4.3.3.7: Summary of findings of Ludhiana forging cluster

Parameter	Remarks
Total number of forging industries	510
Number of operating industries	510
Total energy consumption	58,496 toe per year
Specific energy consumption	Thermal – 4.7 GJ per tonne Electrical – 514 kWh per tonne Overall – 6.5 GJ per tonne
GHG emissions	281,565 tonne CO_2 per year
Specific GHG emissions	0.7 tonne CO_2 per tonne
Other relevant information	The Bureau of Energy Efficiency has initiated an energy mapping study of the cluster which is on-going.

4.3.4 Pune cluster

4.3.4.1 Background

Pune forging cluster is located in Maharashtra state. There are about 65 forging units, located in various industrial estates such as Pimpri-Chinchwad MIDC, Chakan MIDC, Bhosari MIDC, and other areas like Kharadi, Alandi, Haveli, Shikrapur, and Sanaswadi. The products from the cluster are custom made and used mainly in the automotive sector. Based on the capacities, the forging industries are categorized into four types within the cluster. The total production from Pune forging cluster is estimated to be 0.2 million tonne per year during 2016-17 (table 4.3.4.1).

Table 4.3.4.1: Production from Pune forging cluster

Type	Number of industries		Capacity (tpm/industry)		Production
	Total	Operating	Minimum	Maximum	(tonne/year)
Micro	13	10	10	20	1,800
Small	23	20	20	100	14,400
Medium	17	15	100	400	45,000
Large	12	10	400	1,500	102,600
Total	65	55			163,800

Source: Based on 'Financing Energy Efficiency at MSMEs, WB-GEF-SIDBI project' and inputs from industry stakeholders

The production share of forging industries shows that larger units account for about 63% of total production at the cluster level and medium size units account for 27% (Figure 4.3.4.1).

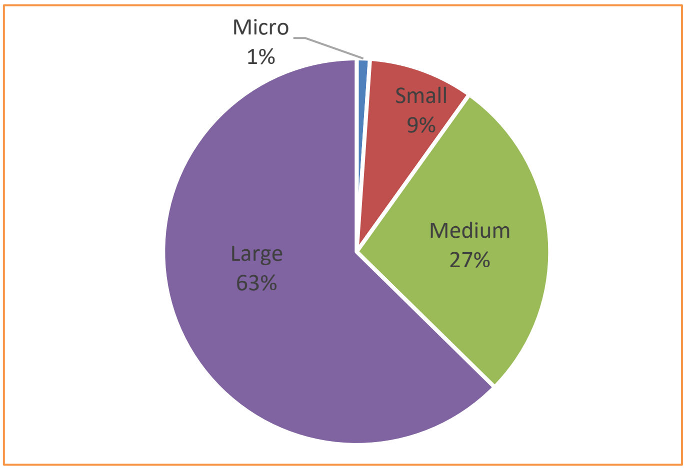


Figure 4.3.4.1 Share of production in Pune forging cluster

4.3.4.2 Process technology

The raw materials used by forging industries in the cluster include ingots and bars of different sizes made of mild steel, carbon steel, alloy steel, stainless steel, super alloy, and special steels. The major products manufactured in the cluster include propeller shaft, front axle, upper pin, crown wheels, gears, shafts, connecting rods, forks, camshafts, and wheel hubs.

The major process steps involved in forging include (1) cutting of steel rods as billets, (2) heating of billets in the furnace, (3) forging in presses, (4) trimming and (5) heat treatment. The technologies used in forging in the cluster are provided in table 4.3.4.2.

Table 4.3.4.2: Process technology used in Pune forging cluster

Technology	Purpose
Furnace (FO, NG & electricity)	Heating of raw materials (billets of different grades of steel)
Hammer, screw press	Forging of hot billets into various shapes

4.3.4.3 Energy consumption analysis

Furnace oil, natural gas and electricity are used for heating raw materials in the furnaces for forging as well as processes like hardening, tempering, and stress relieving. DG sets are used to meet electricity needs during power-cuts.

Electricity contributes the majority energy share (49%) followed by natural gas (22%) and furnace oil (22%). The share of energy consumption from different sources is provided in figure 4.3.4.3a.

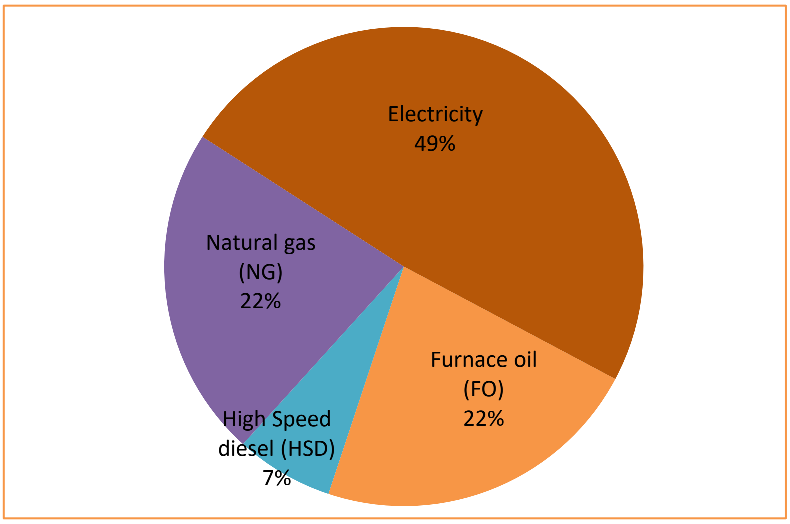


Figure 4.3.4.3a: Share of energy consumption source

The total energy consumption of forging industries in the cluster is estimated to be 26,233 toe per year. The equivalent GHG emissions are estimated to be 151,946 tonne CO_2 per year (Table 4.3.4.3).

Table 4.3.4.3: Energy consumption of Pune forging industry cluster

Type	Unit	Micro	Small	Medium	Large	Total	Energy consumption (toe/yr)	GHG (t-CO_2/yr)
Furnace oil	tpy	280	493	1,546	3,507	5,826	5,855	18,067
Natural gas	mil Sm^3/yr	-	0.6	1.9	4.2	6.7	5,876	11,575
HSD	kL/yr	-	180	558	1,248	1,986	1,736	5,036
Electricity	mil kWh/yr	0.7	8.5	31	108	148	12,766	117,268
Total							26,233	151,946

The large size category forging industries consumes maximum share of cluster level energy consumption (67%). The distribution of cluster level energy consumption by different category of industries is provided with figure 4.3.4.3b.

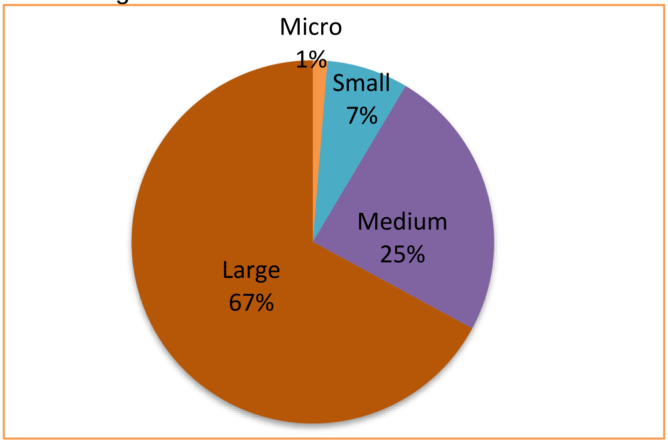


Figure 4.3.4.3b: Distribution of cluster level energy consumption

4.3.4.4 Performance of forging industries

The overall SEC of Pune forging cluster works out to be 6.7 GJ per tonne. This includes SEC (thermal) of 3.4 GJ per tonne and SEC (electrical) of 906 kWh per tonne (table 4.3.4.4).

Table 4.3.4.4: Performance of forging industries (Pune cluster)

Type	SEC-Thermal (GJ/tonne)	SEC-Electrical (kWh/tonne)	SEC-Cluster (GJ/tonne)
Micro	6.5	380	7.9
Small	3.4	590	5.5
Medium	3.4	700	5.9
Large	3.4	1050	7.2
Overall	3.4	906	6.7

The micro category furnace consumes maximum energy for producing per tonne of products, which is estimated to be 7.9 GJ per tonne (Figure 4.3.4.4).

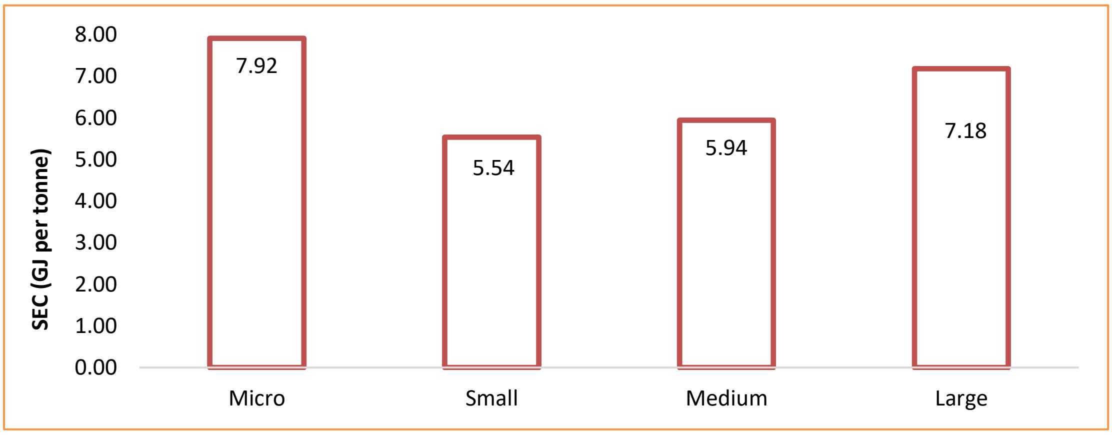


Figure 4.3.4.4: Variation of SEC among different category of industries

The cluster level specific energy consumption considering total annual production in the cluster and the total energy consumption is estimated to be around 6.7 GJ per tonne of production.

4.3.4.5 Relevant institutions for forging industries

The details of industry associations and state designated agencies in Maharashtra are given in table 4.3.4.5.

Table 4.3.4.5: Relevant institutions involved in Maharashtra

Institution/ organization	Contact details	Objectives and roles
Association of Indian Forging Industry (AIFI)	101/112 Nyati Millennium, Off. Nagar Road Viman Nagar (Near Datta Mandir), Pune-411014 Tel: 0202663 4099, 2663 4451 https://www.indianforging.org/contact-us	• Promoting technology upgradation through workshops, seminars, training programmes and conferences • Dissemination of relevant information for overall improvements
Maharashtra Energy Development Agency (MEDA)	MHADA Commercial Complex, 2nd Floor, Opp. Tridal Nagar, Yerwada, Pune – 411 006 Tel: 02035000450 email: meda@mahaurja.com https://www.mahaurja.com/meda	• Regulating energy conservation and promoting the development of renewable energy • Taking concrete steps for conventional energy conservation measures including industries

4.3.4.6 Other information

Some of the initiatives in the cluster include the following:

(1) A project on “Financing energy efficiency at MSMEs” was implemented under WB-GEF-SIDBI programme, wherein a number of energy conservation measures were implemented in a number of forging industries in Pune cluster.

(2) The Bureau of Energy Efficiency has initiated an energy mapping study of the cluster which is on-going.

4.3.4.7 Summary of findings

The summary of findings of forging industries in Pune cluster is provided in table 4.3.4.7.

Table 4.3.4.7: Summary of findings of Pune forging cluster

Parameter	Remarks
Total number of forging industries	65
Number of operating industries	55
Total energy consumption	26,233 toe per year
Specific energy consumption	Thermal – 3.4 GJ per tonne Electrical – 906 kWh per tonne Overall – 6.7 GJ per tonne
GHG emissions	151,946 tonne CO_2 per year
Specific GHG emissions	0.9 tonne CO_2 per tonne
Other relevant information	• WB-GEF-SIDBI project implemented energy conservation measures in different forging industries in Pune cluster

	• BEE has initiated an energy mapping study of the cluster which is on-going.

4.3.5 Rajkot cluster

4.3.5.1 Background

Rajkot forging cluster is located in Gujarat state. There are about 90 forging units, located in various industrial estates such as Vavdi, Aji, Bajarang, Samrat, etc. The Rajkot forging cluster mainly caters to Original Equipment Manufacturers (OEMs) like Tata Motors, Mahindra & Mahindra, L&T, Force Motors, Bajaj Auto, General Motors, Godrej, Ashok Leyland etc. Based on the capacities, the forging industries are categorized into four types within the cluster. The total production from Rajkot forging cluster is estimated to be 0.3 million tonne per year during 2016-17 (table 4.3.5.1).

Table 4.3.5.1: Production from Rajkot forging cluster

Type	Number of industries		Capacity (tpm/industry)		Production (tonne/year)
	Total	Operating	Minimum	Maximum	
Micro	20	20	15	35	6,000
Small	40	40	40	220	62,400
Medium	28	28	220	550	129,360
Large	2	2	2,000	4,500	78,000
Total	90	90			275,760

Source: Cluster profile – Rajkot forging industry, SAMEEEKSHA and interactions with industries

The production share of forging industries shows that medium sized units account for about 47% of total production at the cluster level and larger units account for 28% (figure 4.3.5.1).

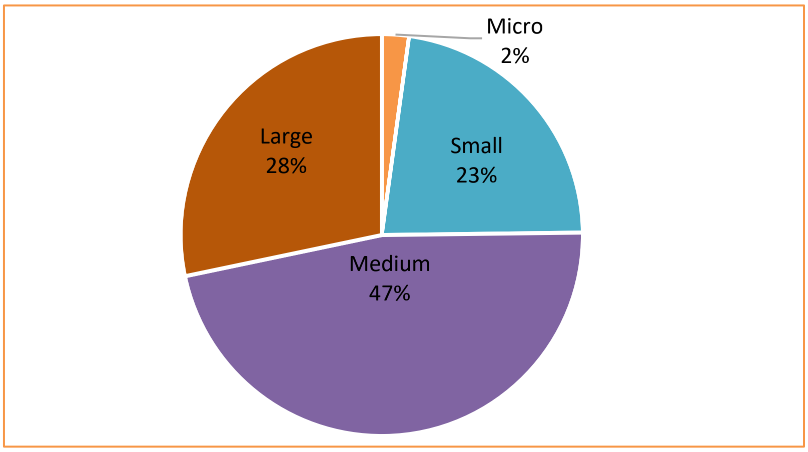


Figure 4.3.5.1 Share of production in Rajkot forging cluster

4.3.5.2 Process technology

The raw materials used by forging industries in the cluster include ingots and bars of different sizes made of mild steel, carbon steel, alloy steel, stainless steel, super alloy, and special steels. The products from the Rajkot forging cluster are used mainly in different sectors automobiles, light and heavy machine tools, compressors, stationary diesel engines, earth moving equipment, material handling equipment, catering to both OEM and replacement market, general engineering.

The major process steps involved in forging include (1) cutting of steel rods as billets, (2) heating of billets in the furnace, (3) forging in presses, (4) trimming and (5) heat treatment. The technologies used in forging in the cluster are provided in table 4.3.5.2.

Table 4.3.5.2: Process technology used in Rajkot forging cluster

Technology	Purpose
Furnace (FO, gas & electrical)	Heating of raw materials (billets of different grades of steel)
Hammer, press and ring rolling machine	Forging of hot billets into various shapes

4.3.5.3 Energy consumption analysis

The forging industries in Rajkot cluster commonly use furnace oil in the furnaces for heating of raw materials. Electricity is used for heating of raw materials, heat treatment and meeting other electrical loads. DG sets are used to meet electricity needs during power-cuts.

Furnace oil contributes the majority energy share (48%) followed by natural gas (29%) and electricity (21%). The share of energy consumption from different sources is provided in figure 4.3.5.3a.

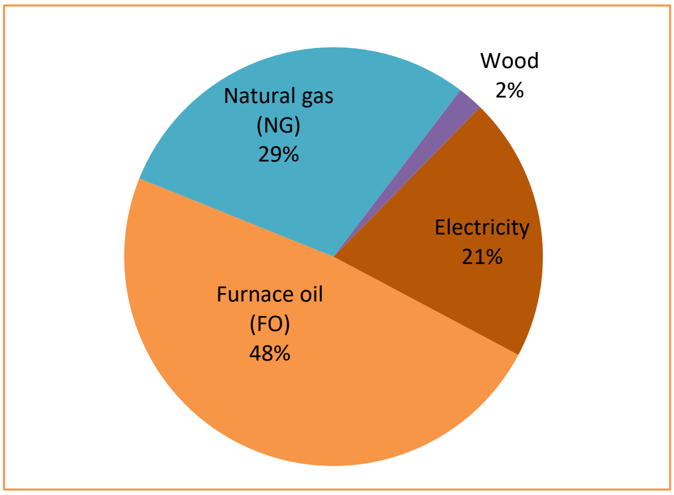


Figure 4.3.5.3a: Share of energy consumption source

Thermal energy in furnaces accounts for about 75% of total energy consumption. The total energy consumption of forging industries in the cluster is estimated to be 46,559 toe per year. The equivalent GHG emissions are about 183,642 tonne CO_2 per year (Table 4.3.5.3).

Table 4.3.5.3: Energy consumption of Rajkot forging industry cluster

Type	Unit	Micro	Small	Medium	Large	Total	Energy consumption (toe/yr)	GHG (t-CO_2/yr)
Furnace oil	tpy	1,120	7,843	12,863	560	22,386	22,498	69,420
Natural gas	mil Sm³/yr	-	-	-	15.6	15.6	13,626	26,840
Wood	tpy	-	-	-	2,476	2,476	923	-
Electricity	mil kWh/yr	0.4	26	19	65	111	9,512	87,382
Total							46,559	183,642

4.3.5.4 Performance of forging industries

The overall SEC of Rajkot forging cluster works out to be 7.1 GJ per tonne. This includes SEC (thermal) of 5.6 GJ per tonne and SEC (electrical) of 401 kWh per tonne (table 4.3.5.4).

Table 4.3.5.4: Performance of forging industries (Rajkot cluster)

Type	SEC-Thermal (GJ/tonne)	SEC-Electrical (kWh/tonne)	SEC-Cluster (GJ/tonne)
Micro	7.9	61	8.1
Small	5.3	423	6.8
Medium	4.2	146	4.7
Large	8.1	833	11.1
Overall	5.6	401	7.1

The large size category forging industries consumes maximum share of cluster level energy consumption (44%). The distribution of cluster level energy consumption by different category of industries is provided with figure 4.3.5.3b.

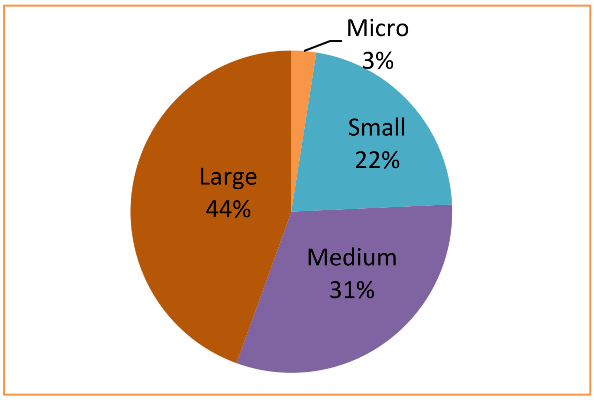


Figure 4.3.5.3b: Distribution of cluster level energy consumption

The large category furnace consumes maximum energy for producing per tonne of products, which is estimated to be 11.1 GJ per tonne (Figure 4.3.5.4).

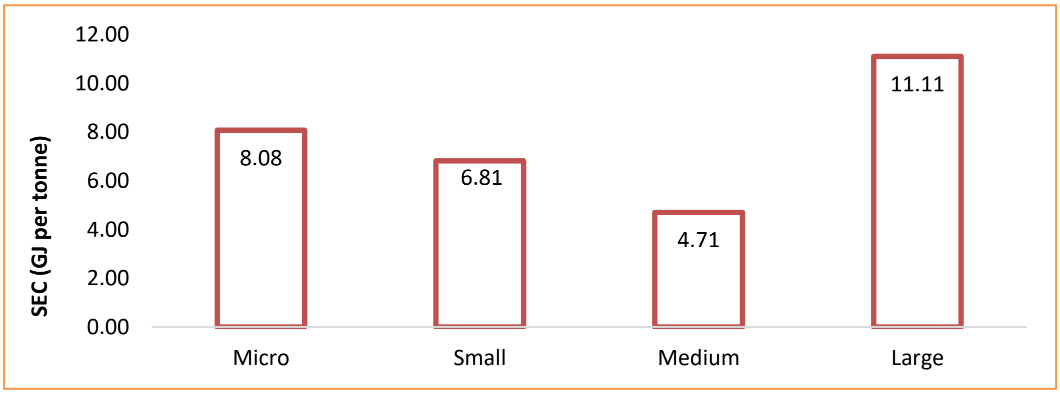


Figure 4.3.5.4: Variation of SEC among different category of industries

The cluster level specific energy consumption considering total annual production in the cluster and the total energy consumption is estimated to be around 7.1 GJ per tonne of production.

4.3.5.5 Relevant institutions for forging industries

The details of industry associations and state designated agencies (SDAs) in Gujarat are given in table 4.3.5.5.

Table 4.3.5.5: Relevant institutions involved in Gujarat

Institution/ organization	Contact details	Objectives and roles
Rajkot Engineering Association (REA)	Bhaktinagar Railway Station Bhaktinagar Industrial Area, Rajkot-360002 Tel: 0281 236 2235 email: info@reaindia.com https://www.reaindia.com/	• Awareness generation on energy efficiency • Welfare and grievance redressal for member industries
Gujarat Energy Development Agency (GEDA)	4th floor, Block No. 11 & 12,Udyog Bhavan, Sector-11, Gandhinagar – 382017 Tel: 079-23257251,54 Email : info@geda.org.in http://www.geda.org.in	• Works closely on energy conservation and renewable energy development • Organizes awareness workshops on energy conservation

4.3.5.6 Other information

There are no specific studies focusing on adoption of energy efficiency in forging industries in Rajkot cluster.

4.3.5.7 Summary of findings

The summary of findings of forging industries in Rajkot cluster is provided in table 4.3.5.7.

Table 4.3.5.7: Summary of findings of Rajkot forging cluster

Parameter	Remarks
Total number of forging industries	90
Number of operating industries	90
Total energy consumption	46,559 toe per year
Specific energy consumption	Thermal – 5.6 GJ per tonne Electrical – 401 kWh per tonne Overall – 7.1 GJ per tonne
GHG emissions	183,642 tonne CO_2 per year
Specific GHG emissions	0.7 tonne CO_2 per tonne
Other relevant information	No specific study conducted or on-going pertaining to implementation of energy efficient technologies in the cluster

4.3.6 Other clusters

4.3.6.1 Background

The other foundry clusters include Bengaluru, Coimbatore, Faridabad, Ghaziabad, Gurgaon, Hyderabad, Jamshedpur, Mumbai, Kolkata and Vadodara. The details of number of units, production and energy consumption details for these clusters are not readily available. Hence the total production available at national level was used to assess the overall energy consumption of these clusters. The total production from other forging clusters is estimated to be 1.5 million tonne per year (around 54%) during 2016-17.

4.3.6.2 Process technology

The raw materials used by forging industries generally include mild steel, carbon steel, alloy steel, stainless steel, super alloy, and special steels. The products from the forging clusters are used for both automotive and non-automotive components. The major process steps involved in forging include (1) cutting of steel rods as billets, (2) heating of billets in the furnace, (3) forging in presses, (4) trimming and (5) heat treatment.

4.3.6.3 Energy consumption analysis

Based on data from other clusters, it is assumed that furnace oil is commonly used for heating of raw materials in forging industries. The total energy consumption of forging industries in other cluster is estimated to be 199,125 toe per year, which includes 139,707 toe of thermal energy and 691 million kWh of electricity. The equivalent GHG emissions are estimated to be 1.0 million tonne CO_2 per year.

4.3.6.4 Performance of forging industries

The overall SEC of other forging clusters works out to be 5.5 GJ per tonne. This includes SEC (thermal) of 3.8 GJ per tonne and SEC (electrical) of 454 kWh per tonne.

4.3.6.5 Relevant institutions for forging industries

With scattered nature of industries, the details of industry associations and state designated agencies (SDAs) are not provided in this report.

4.3.6.6 Other information

The Bureau of Energy Efficiency has initiated an energy mapping study of the cluster which is on-going in Bengaluru and Delhi.

4.3.6.7 Summary of findings

The summary of findings of forging industries in other clusters is provided in table 4.3.6.7.

Table 4.3.6.7: Summary of findings of other forging clusters

Parameter	Remarks
Total energy consumption	199,125 toe per year
Specific energy consumption	Thermal – 3.8 GJ per tonne Electrical – 454 kWh per tonne Overall – 5.5 GJ per tonne
GHG emissions	1.0 million tonne CO_2 per year
Specific GHG emissions	0.6 tonne CO_2 per tonne
Other relevant information	The Bureau of Energy Efficiency has initiated an energy mapping study of the cluster which is on-going in Bengaluru and Delhi.

4.3.7 Summary of energy analysis of forging industries

The total production in forging sector is estimated to be 2.8 million tonne (2016-17). The total energy consumption of forging industries is estimated to be 339,635 toe per year with an equivalent GHG emissions of 1.6 million tonne CO_2 (table 4.3.7). The following considerations and assumptions were made while undertaking analysis of the sub-sector.

- The average capacity utilization of forging sector is 62.1% (source: AIFI)
- Standard energy values and emission factors were used for estimating energy consumption and GHG emissions respectively.

Table 4.3.7: Summary of energy analysis of forging industries

S No	State	Total industries	Production (million tpy)	Energy consumption (toe/year)	GHG emissions ($t\text{-}CO_2$/year)
1	Chennai	50	65,280	9,221	40,274
2	Ludhiana	510	372,000	58,496	281,565
3	Pune	55	161,000	26,233	151,946
4	Rajkot	90	268,548	46,559	183,642
5	Others*	-	1,523,172	199,125	976,895
	Total	705	2,390,000	339,635	1,634,322

** Number of industries in other clusters - Not available*

The global SEC level of forging industries is reported to be 12.7 GJ per tonne (source: Energy Efficiency by determining the production process with the lowest energy consumption in a steel forging facility - Umit Unver, Ozlem Kara).

4.3.8 Cluster selection in Forging sub-sector

4.3.8.1 Selection matrix

The study considered a number of attributes with relevant criteria and score for ranking of the states. These attributes are provided in table 4.3.8.1. More details of selection matrix at cluster level are provided in annexure 2.

Table 4.3.8.1: Selection criteria for forging industry clusters

S No	Attribute	Criteria	Score
1	Number of units	• <= 50 • 51-75 • 75-100 • > 100	2.5 5.0 7.5 10.0
2	Specific energy consumption, GJ per tonne	• <5.50 • 5.51-6.00 • 6.01-7.00 • >7.00	2.5 5.0 7.5 10.0
3	Variability (raw material, technology, fuel, product, etc.)	• One variable • Two variables • Three variables • More than three variables	2.5 5.0 7.5 10.0
4	GHG emission share	• <5% • 5-10% • 11-15% • > 15%	2.5 5.0 7.5 10.0
5	Prior/on-going activities on energy efficiency at cluster level	• Replication of EE measures • Demonstration undertaken • Cluster level studies conducted • No activities on energy efficiency	2.5 5.0 7.5 10.0
6	Availability of industry association in the cluster	• No industry association • One industry association • More than one association • Industry association, SPVs, etc.	2.5 5.0 7.5 10.0

4.3.8.2 Summary of findings

Based on the attributes and criteria, the project has short-listed Rajkot (Gujarat) and Ludhiana (Punjab) forging clusters for further planning and deep-diving on energy efficiency activities in forging sub-sector (table 4.3.8.2).

Table 4.3.8.2: Shortlisted clusters forging clusters for deep-diving

Cluster	State	Score	Ranking
Rajkot	Gujarat	45.0	1
Ludhiana	Punjab	40.0	2
Chennai	Tamil Nadu	32.5	3
Pune	Maharashtra	30.0	4

4.4 Steel re-rolling mills

4.4.1 Background

Steel-rolling contributes to major share of finished steel production in India of which most of them belong to MSME category. Steel re-rolling mills (SRRM) usually are family-run small and medium enterprises (SMEs) whose value proposition lies in flexibility in production for meeting low-tonnage requirements in various grades, shapes and sizes to serve niche markets. The key customer industries being served by the steel re-rolling sector are construction, infrastructure, automobiles, pipes and tubes, telecommunications etc. The steel re-rolling industry caters to 68% of the domestic demand and has a share of 80% in the exports of rounds and bars and thus constitutes a vital part of the steel industry in India.

At present, there are 1,313 numbers of steel rolling mills (Ref: JPC Iron and Steel Database 2019-20) installed in India. The summary of steel re-rolling mill classification based on their operating status and PAT is given in table 4.4.1a.

Table 4.4.1a: Classification of SRRM units based on PAT status

Category	Total	Working	Temporarily Closed
No. of Units	1,313	1,017	296
Under PAT	56	45	11
NON-DC	1,257	972	285

Source: The Iron and Steel Database 2019-20 Joint Plant Committee

The installed capacities of smaller units range between 24 TPD to 240 TPD, medium sized units range between 241 to 1,200 TPD and large units range above 1,200 TPD. Based on the daily production capacity, the units can be classified as shown below.

Table 4.4.1b: Classification of SRRM units based on installed capacity

Category	Small (<=240 TPD)	Medium (>240 & <=1,200 TPD)	Large (>1200 TPD)
Existing DC	9	23	24
Potential DC	5	24	8
NON-DC	1,035	185	0
Total	1,049	232	32

About 56 SRRM plants are presently covered under the 'Perform, Achieve and Trade' (PAT) scheme of the Bureau of Energy Efficiency (BEE). The annual energy consumption of these units exceeds the revised threshold limit for iron & steel industry (presently 20,000 tonnes of oil equivalent per year) due to presence of upstream processes such as pellet plants, Blast furnace (BF), sponge iron plant (DRI), Basic Oxygen Furnace (BOF), Electric Arc Furnace (EAF) and Electric Induction Furnace (EIF) to manufacture various crude steel products. Hence, these units are not considered for analysis. Therefore, this mapping report shall be focusing only on production of Non-DC steel re-rolling units for such composite / integrated steel plants.

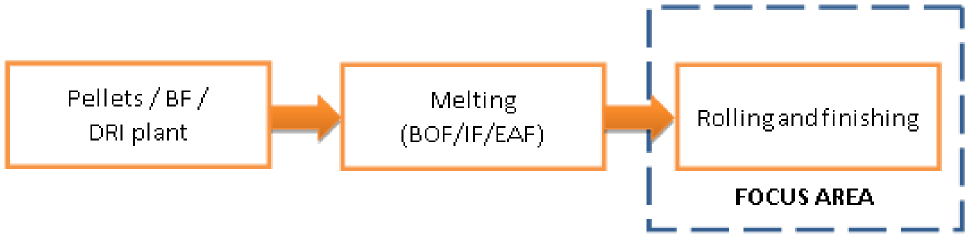


Figure 4.4.1: Focus area in integrated/ composite steel plants

4.4.1.1 Spread of SRRM plants, products and production

Of the 1,257 Non-DC units, only 897 units are standalone units and other 360 number of units are installed with other crude steel making process plants (upstream). Steel re-rolling mills combined with induction furnace and sponge iron plant forms the major share of composite units (329 out of 360 nos). A brief summary is pictorially represented in figure 4.4.1.1.

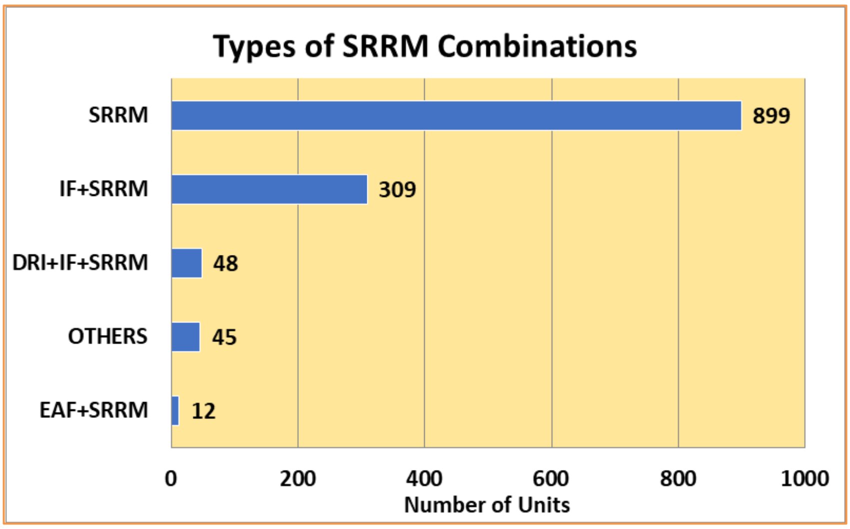


Figure 4.4.1.1: Categorization of SRRM plants

The details of stand-alone and composite units along with their operating status are provided in below table 4.4.1.1a and annexure 4.4.1.1.

Table 4.4.1.1a: Categorization of SRRM plants

Category	Total	PAT	Non-DC		
			Total	Working	Temporarily Closed
SRRM (Standalone)	899	2	897	671	226
Composite Units					
IF + SRRM	309	2	307	259	48
DRI + IF + SRRM	48	26	22	17	5
EAF + SRRM	12	2	10	8	2
BF + BOF + SRRM	9	7	2	2	-
PELLETS + DRI + IF + SRRM	8	6	2	2	-

Category	Total	PAT	Non-DC		
			Total	Working	Temporarily Closed
EAF + IF + SRRM	5	0-	5	5	-
BF + DRI + IF + SRRM	4	1	3	2	1
BF + DRI + EAF + SRRM	3	3	-	-	-
PELLETS + BF + DRI + EAF + SRRM	3	2	1	1	-
PELLETS + BF + DRI + IF + SRRM	2	1	1	1	-
DRI + SRRM	2	-	2	1	1
BF + DRI + SRRM	1	-	1	0	1
BF + DRI + EAF + IF + SRRM	1	-	1	1	-
DRI + EAF + SRRM	1	1	-	-	-
DRI + EAF + IF + SRRM	1	-	1	1	-
BF + SRRM	1	-	1	-	1
PELLETS + BF + BOF + SRRM	1	1	-	-	-
PELLETS + BF + IF + SRRM	1	-	1	1	-
PELLETS + BF + DRI + EAF + IF + SRRM	1	1	-	-	-
PELLETS + BF + DRI + BOF + EAF + SRRM	1	1	-	-	-
Total	1,313	56	1,257	972	285

The Non-DC SRRM units in India are spread across 28 different states and their summary is tabulated below (table 4.4.1.1b).

Table 4.4.1.1b: State-wise spread of Non-DC SRRM units in India

S.No	State	No. of Clusters	Total Units	Working	Temporarily Closed
1	Andhra Pradesh	8	36	28	8
2	Arunachal Pradesh	1	3	2	1
3	Assam	4	7	3	4
4	Bihar	5	27	16	11
5	Chhattisgarh	5	115	93	22
6	Dadra And Nagar Haveli	1	7	5	2
7	Delhi	2	2	2	-
8	Goa	2	14	11	3
9	Gujarat	12	114	77	37
10	Haryana	4	9	8	1
11	Himachal Pradesh	3	25	22	3
12	Jammu And Kashmir	3	17	17	-
13	Jharkhand	8	40	22	18
14	Karnataka	9	18	12	6
15	Kerala	7	38	29	9
16	Madhya Pradesh	4	32	29	3
17	Maharashtra	13	84	65	19

S.No	State	No. of Clusters	Total Units	Working	Temporarily Closed
18	Meghalaya	1	6	5	1
19	Odisha	5	23	14	9
20	Puducherry	2	13	11	2
21	Punjab	7	231	211	20
22	Rajasthan	11	58	47	11
23	Tamil Nadu	17	105	79	26
24	Telangana	6	63	42	21
25	Tripura	1	1	1	-
26	Uttar Pradesh	21	95	68	27
27	Uttarakhand	3	14	12	2
28	West Bengal	8	60	41	19
	Total	173	1,257	972	285

On further state-wise analysis, it was found that the plants are scattered across 173 different districts / clusters and their summary is tabulated below (table 4.4.1.1c).

Table 4.4.1.1c: Cluster-wise spread of Non-DC SRRM units in India

S. No	State	District / clusters	Total	Working	Temporarily Closed
1	Andhra Pradesh	Ananthapur	11	10	1
2		Chittoor	3	3	-
3		East Godavari	4	2	2
4		Krishna	5	5	-
5		Nellore	1	-	1
6		Prakasam	1	-	1
7		Visakhapatnam	10	8	2
8		Vizianagaram	1	-	1
9	Arunachal Pradesh	Papum Pare	3	2	1
10	Assam	Hailakandi	1	-	1
11		Kamrup	4	2	2
12		Karbi Angling	1	1	-
13		Tinsukia	1	-	1
14	Bihar	Begusarai	1	-	1
15		Lakhisarai	1	-	1
16		Muzaffarpur	1	1	-
17		Patna	22	15	7
18		West Champaran	2	-	2
19	Chhattisgarh	Bilaspur	1	-	1
20		Durg	7	7	-
21		Raigarh	3	3	-
22		Raipur	102	81	21
23		Rajnandgaon	2	2	-

S. No	State	District / clusters	Total	Working	Temporarily Closed
24	Dadra and Nagar Haveli	Dadra and Nagar Haveli	7	5	2
25	Delhi	East Delhi	1	1	-
26		North-west Delhi	1	1	-
27	Goa	North Goa	4	3	1
28		South Goa	10	8	2
29	Gujarat	Ahmedabad	13	9	4
30		Bharuch	1	1	-
31		Bhavnagar	46	22	24
32		Gandhinagar	3	3	-
33		Kutch	4	4	-
34		Mehsana	32	28	4
35		Panchmahals	4	3	1
36		Patan	1	1	-
37		Rajkot	2	-	2
38		Surendranagar	1	-	1
39		Vadodara	2	1	1
40		Valsad	5	5	-
41	Haryana	Faridabad	5	5	-
42		Hisar	2	2	-
43		Panipat	1	-	1
44		Yamunanagar	1	1	-
45	Himachal Pradesh	Sirmaur	14	11	3
46		Solan	9	9	-
47		Una	2	2	-
48	Jammu and Kashmir	Jammu	6	6	-
49		Kathua	1	1	-
50		Samba	10	10	-
51	Jharkhand	Bokaro	2	1	1
52		East Singhbhum	7	3	4
53		Giridih	12	10	2
54		Koderma	2	1	1
55		Ramgarh	5	2	3
56		Ranchi	3	-	3
57		Seraikela	7	5	2
58		West Singhbhum	2	-	2
59	Karnataka	Bangalore	5	3	2
60		Bangalore rural	1	1	-
61		Bellary	3	2	1
62		Chickballapur	1	1	-
63		Chitradurga	1	1	-
64		Dakshina Kannada	1	-	1
65		Dharwad	2	2	-

S. No	State	District / clusters	Total	Working	Temporarily Closed
66		Koppal	2	1	1
67		Mysore	2	1	1
68	Kerala	Ernakulam	8	5	3
69		Kannur	2	1	1
70		Kasargod	1	1	-
71		Kollam	1	-	1
72		Kozhikode	4	4	-
73		Palakkad	19	17	2
74		Thrissur	3	1	2
75	Madhya Pradesh	Bhopal	1	1	-
76		Dhar	8	6	2
77		Indore	22	22	-
78		Jabalpur	1	-	1
79	Maharashtra	Aurangabad	1	1	-
80		Chandrapur	1	-	1
81		Jalna	25	21	4
82		Kolhapur	4	4	-
83		Nagpur	12	8	4
84		Nashik	3	2	1
85		Palghar	16	14	2
86		Pune	6	6	-
87		Raigad	6	4	2
88		Sangli	1	1	-
89		Satara	1	1	-
90		Solapur	1	1	-
91		Thane	7	2	5
92	Meghalaya	Ri Bhoi (Byrnihat)	6	5	1
93	Odisha	Cuttack	2	1	1
94		Jharsuguda	2	1	1
95		Kendujhar	2	2	-
96		Khordha	2	-	2
97		Sunderghar	15	10	5
98	Puducherry	Karaikal	4	3	1
99		Puducherry	9	8	1
100	Punjab	Fatehgarh sahib	142	132	10
101		Hoshiarpur	1	1	-
102		Jalandhar	2	2	-
103		Ludhiana	81	73	8
104		Patiala	1	1	-
105		Sangrur	1	1	-
106		Sas nagar	3	2	1
107	Rajasthan	Ajmer	7	4	3
108		Alwar	1	1	-

S. No	State	District / clusters	Total	Working	Temporarily Closed
109		Alwar (Bhiwadi)	10	9	1
110		Jaipur (bagru)	7	5	2
111		Jaipur (jaitpura)	2	-	2
112		Jaipur (Jhotwara)	6	6	-
113		Jaipur (Kaladera)	1	1	-
114		Jaipur (vki)	18	15	3
115		Jalore	1	1	-
116		Kota	4	4	-
117		Sikar	1	1	-
118	Tamil Nadu	Chennai	23	18	5
119		Coimbatore	14	8	6
120		Dharmapuri	2	1	1
121		Dindigul	1	1	-
122		Erode	4	3	1
123		Kanchipuram	4	3	1
124		Karur	2	1	1
125		Krishnagiri	5	5	-
126		Madurai	1	-	1
127		Namakkal	4	3	1
128		Perambalur	1	-	1
129		Pudukkottai	2	2	-
130		Salem	6	6	-
131		Thoothukudi	1	1	-
132		Tiruchirappalli	7	6	1
133		Tiruvallur	27	20	7
134		Tiruvannamalai	1	1	-
135	Telangana	Hyderabad	11	5	6
136		Medak	26	19	7
137		Mehbub nagar	14	13	1
138		Nalgonda	1	-	1
139		Rangareddy	10	4	6
140		Sangareddy	1	1	-
141	Tripura	West Tripura	1	1	-
142	Uttar Pradesh	Agra	1	-	1
143		Aligarh	9	6	3
144		Allahabad	1	1	-
145		Bijnor	2	1	1
146		Bulandshahr	1	1	-
147		Fatehpur	3	3	-
148		Firozabad	1	-	1
149		Gautam Buddha Nagar	4	3	1
150		Ghaziabad	14	10	4

S. No	State	District / clusters	Total	Working	Temporarily Closed
151		Gorakhpur	2	2	-
152		Hamirpur	2	2	-
153		Jalaun	1	1	-
154		Jaunpur	4	2	2
155		Jhansi	2	1	1
156		Kanpur Dehat	1	-	1
157		Kanpur Nagar	8	5	3
158		Lucknow	15	12	3
159		Mirzapur	1	1	-
160		Muzaffarnagar	19	14	5
161		Rae Bareli	1	1	-
162		Unnao	3	2	1
163	Uttarakhand	Haridwar	5	5	-
164		Pauri Garhwal	2	2	-
165		Udham Singh Nagar	7	6	1
166	West Bengal	Bankura	7	4	3
167		Bardhaman	25	20	5
168		Birbhum	1	1	-
169		Hooghly	5	2	3
170		Howrah	17	10	7
171		Kolkata	1	1	-
172		Purulia	3	2	1
173		West Medinipur	1	1	-

Source: Analysis of JPC data 2019-20

A majority of the SRRM units (767 out of 1,257 plants accounting for 61% of total Non-DC units) are concentrated in 25 clusters with majority in Fatehgarh Sahib (Mandi Gobindgarh), Raipur, Ludhiana, Bhavnagar, Mehsana, Tiruvallur, Jalna, Indore, etc.

4.4.1.2 Process description and technology use

Steel re-rolling process

Steel re-rolling mills are used to roll different kinds of metal objects to give them desired shape, thickness, density and curves. The reheating process in a typical re-rolling mill includes charging of raw billets, ingots or blooms in a reheating furnace using generally coal as fuel. Once desired temperature of raw material is achieved, it is manually or automatically racked to push into the rolling floor, where iron rollers (also called drums) are used to squeeze and stretch the hot raw material into finished steel products. The process flow in a steel rerolling mill is shown in the figure 4.4.1.2a.

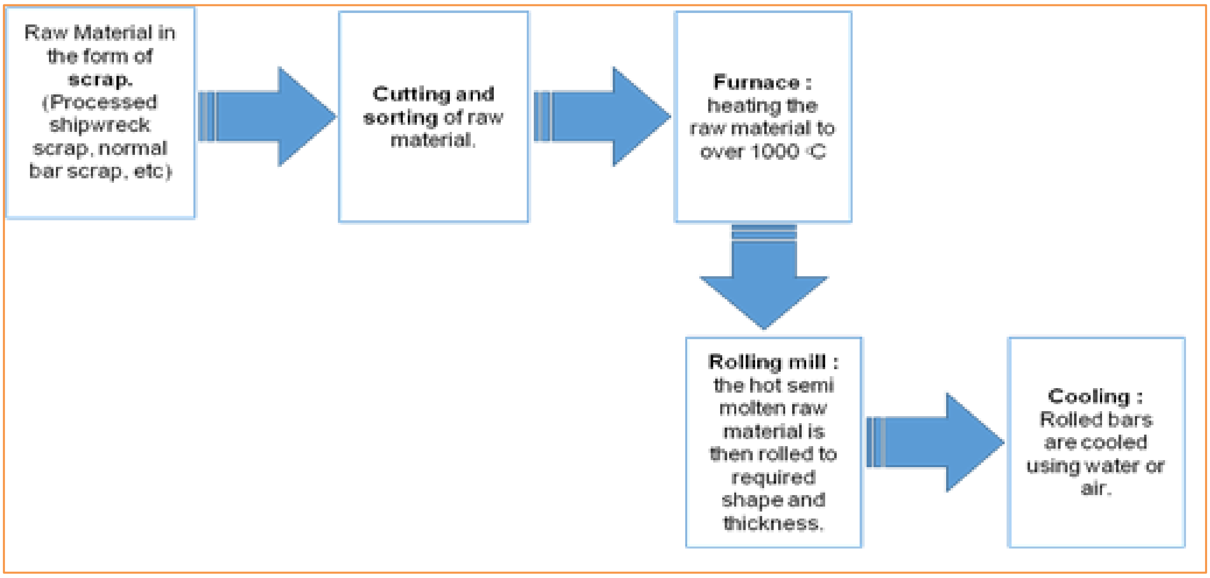


Figure 4.4.1.2a: Process flow in a steel rerolling mil

Technologies employed

Reheating and rolling are two important sections of a steel rerolling unit, which are described below.

i) Reheating furnace


Reheating furnace

Reheating furnaces are used in hot rolling mills to heat the steel feedstock to temperatures of around 1,200-1,250 ^{0}C, which is suitable for plastic deformation of steel and hence for rolling in the mill. Most of rerolling mills have installed pusher hearth type of furnaces. The furnaces employed in SRRM clusters are essentially pulverised coal fired systems with very low level of automation. Some of the units use furnace oil and recently few plants have started using natural gas. Since the units in the cluster are quite small, raw materials are procured from the market and hot charging is not possible in these kinds of systems.


Recuperator

Retrofitting the existing systems with ‘waste heat recovery’ (WHR) systems in reheating furnaces is one of the widely adopted energy conversation measure. These locally designed and fabricated ‘recuperators’ have been installed in reheating furnaces for preheating of combustion air fed into the furnace.

ii) Rolling mill

The primary function of the hot rolling mill is to reheat slabs/ingots/ billets/blooms close to soaking temperature, followed by rolling into thinner and longer products through successive rolling mill stands. The heated slab is rolled in a roughing stand, in which the thickness is reduced in various passes, back and forth. The length of the slab would have increased from 3 to 6 meters to an intermediate slab which is up to 40 meters long. The material is then rolled down to between 32 mm to 1.8 mm in only one pass through stands.

Rerolling section

Recently, plants have adopted for use of continuous casting machines whereby molten metal is solidified into a "semi-finished" billet, bloom, or slab for subsequent rolling in the finishing mills to achieve improved yield, quality, productivity and cost efficiency. It allows lower-cost production of metal sections with better quality, due to the inherently lower costs of continuous, standardised production of a product, as well as providing increased control over the process through automation.

Raw materials, products and production

Different raw materials used in steel re-rolling mills include waste of large steel process industries in form of bars and section, raw billets, ingots and blooms. Apart from this, energy used in re-heating furnace such as coal, furnace oil, natural gas, biomass and electricity are the other resources used in SRRM units. The major products manufactured in SRRM clusters include rounds, squares, TMT bars, flats, special window sections, thinner size HR strips, hexagons, wire rods, angles, channels, H-beams, I-beams, etc. The bars and rods constitute about 40% of the total production.

In 2019-20, the average capacity utilization of SRRM plants in India was 69.8% (JPC, 2020). There are about 1,257 SRRM plants which are not covered under PAT scheme. Of these, the number of operating industries was 972. The total estimated production of SRRM plants of Non-PAT category (working units) is 34.3 million tonnes (2019-20) as shown in Table 4.4.1.2a.

Table 4.4.1.2a: Details of SRRM plants under Non-PAT category

Category	Total	Working	Temporarily Closed
Number of plants	1,257	972	285
Production (million tonnes)	41.5	34.3	7.2

Source: JPC data analysis, 2020

Other countries producing rolled products

China, Japan, Indonesia, Thailand and Bangladesh are the largest producers of rolled products.

Institutions at national level

Steel Re-rolling Mills Association of India (SRMA), Kolkata and All India Steel Re-rollers Association (AISRA), New Delhi are the apex body at national level dealing with SRRM plants. The roles of associations are shown in table 4.4.1.2b.

Table 4.4.1.2b: Roles of institutions

Organization	Contact details	Roles
Steel Re-rolling Mills Association of India (SRMA)	46-C, 10th floor, Everest Building, Chowringhee Road, Middleton Row, Kolkata - 700071 Tel: 033-2288 5697, 2288 558, 6600 6600 http://www.srma.co.in	• Policy related issues and technological updates in various forums. • Providing opportunities and exposure to its members in domestic and international technological developments / innovations in manufacturing, raw materials, energy, environment, etc. related issues.
All India Steel Re-rollers Association (AISRA)	Sagar Apartments, 6, Tilak Marg, New Delhi -110001 Tel: 011-2338 9957, 5536 3874	• Providing opportunities to the members in domestic and international technological developments in manufacturing, energy and related issues.

Coverage of Clusters

The district/cluster wise classification of number of units (total, working and temp closed) along with their installed capacities is provided in table 4.4.1.2c.

Table 4.4.1.2c: District/cluster wise classification of number units

District / Cluster	Total Nos	Capacity, '000 Tonnes	Working Nos	Capacity, '000 Tonnes	Temporarily Closed Nos	Capacity, '000 Tonnes
Fatehgarh Sahib	142	4,045	132	3,866	10	179
Raipur	102	4,621	81	3,933	21	688
Ludhiana	81	2,566	73	2,489	8	76
Bhavnagar	46	629	22	439	24	189
Mehsana	32	653	28	616	4	37
Tiruvallur	27	1,944	20	1,712	7	232
Medak	26	947	19	683	7	264
Jalna	25	1,767	21	1,712	4	55
Bardhaman	25	3,791	20	3,188	5	603
Chennai	23	259	18	92	5	167
Indore	22	176	22	176	0	0
Patna	22	1,340	15	1,184	7	156
Others clusters	755	39,245	554	31,050	201	8,196
Total	1,257	59,435	972	49,180	285	10,255

Clusters having more than 20 number of operating units were selected for further data collation and detailed analysis. The analysis shows that nine (9) clusters cover 419 working units out of top 25 clusters having 627 units (Figure 4.4.2.1).These 9 clusters are covered in the following sections.

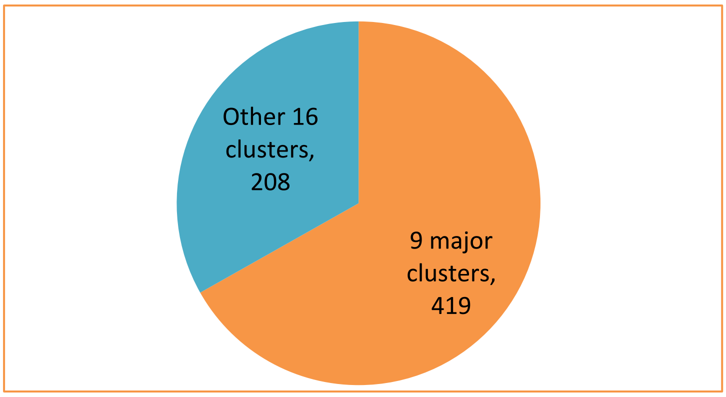


Figure 4.4.2.1 Distribution of clusters in rerolling sub-sector

4.4.2 Bardhaman (Burdwan)

4.4.2.1 Background

Bardhaman steel re-rolling mills cluster is situated in West Bengal state in eastern part of India. The end products from steel re-rolling mills include mild steel (MS) angles, flats, squares, and round bars. There are about 25 numbers of SRRM plants in the cluster. Only 21 units fall under Non-DC category and 4 units fall under existing DC / potential DC category due to presence of upstream process plants. Hence, these units will not be considered for cluster level analysis. The total production of SRRM from 16 operating plants is estimated to be 1.19 million tonnes considering 69.8% of capacity utilization (source: JPC, 2020) as shown in table 4.4.2.1.

Table 4.4.2.1: Production of Non-DC SRRM plants (Bardhaman)

Unit Category	Installed Units	Operating units	Temp. closed units
Small (<240 TPD)	10	7	3
Medium (>240 & <=1,200 TPD)	11	9	2
Larger units (>1,200 TPD)	4	4	0
Total*	21	16	5
Estimated production (million tonne)*	1.6	1.2	0.4

** Excluding details of larger units*
Source: Analysis of JPC data, 2020

About 10 units have been installed with EIF and one unit with EAF for scrap melting. Out of 4 larger units, three units have upstream process plants such as BF, DRI, etc. and one unit is already included under PAT scheme.

4.4.2.2 Process technology

The SRRM units use re-heating furnaces along with pulverized coal and furnace oil as fuel. The brief details of technology used in production are provided in Table 4.4.2.2.

Table 4.4.2.2: Process technology used in SRRM plants – Bardhaman

Technology	Purpose
Reheating furnace (coal / FO firing)	Heating feedstock to 1,200-1,250 °C for using in rolling process.
Rolling mill	Rolling slabs, ingots, billets, blooms to thinner and longer sizes through successive rolling mill stands driven by electric motors

4.4.2.3 Energy consumption analysis

Pulverized coal and furnace oil are the major fuels used in re-heating furnaces which accounts for about 80-85% of total energy consumption in SRRM manufacturing and the remaining energy consumption is in form of electricity mainly to meet electrical loads of these plants. The total energy consumption of SRRM plants under Non-DC category is 54,580 toe per year. This does not include energy consumption of induction furnaces which are exclusively used for production of raw materials used in steel rerolling mills. The equivalent GHG emissions are estimated to be 251,097 tonne CO_2 per year (Table 4.4.2.3).

Table 4.4.2.3: Energy consumption of Non-DC SRRM plants – Bardhaman Cluster

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent (toe/year)	(tonne CO_2/year)
Coal	75,024 tonne	39,012	146,297
Furnace oil	6,923 kL	6,496	21,468
Electricity	105 mil kWh/year	9,072	83,333
Total		54,580	251,097

Note (1) Based on interaction with plant personnel; (2) 300 days of operation

Coal contributes the majority energy share (71%). The share of energy consumption from different sources is provided in figure 4.4.2.3a.

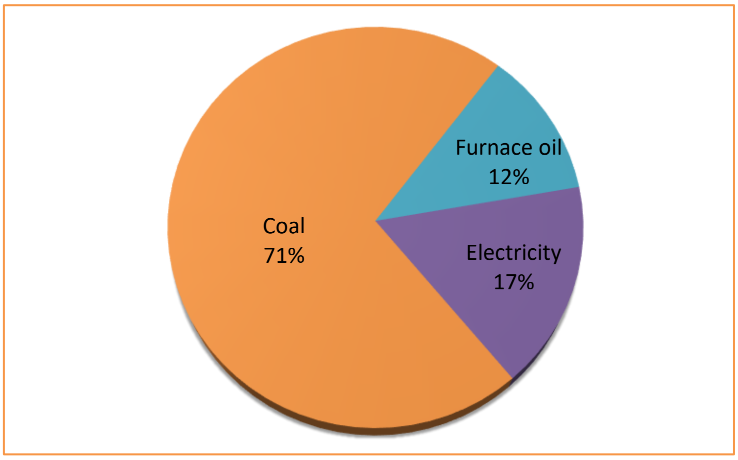


Figure 4.4.2.3a: Share of energy consumption source

The coal based medium size category industries consumes maximum share of cluster level energy consumption (72%). The distribution of cluster level energy consumption by different category of industries is provided with figure 4.4.2.3b.

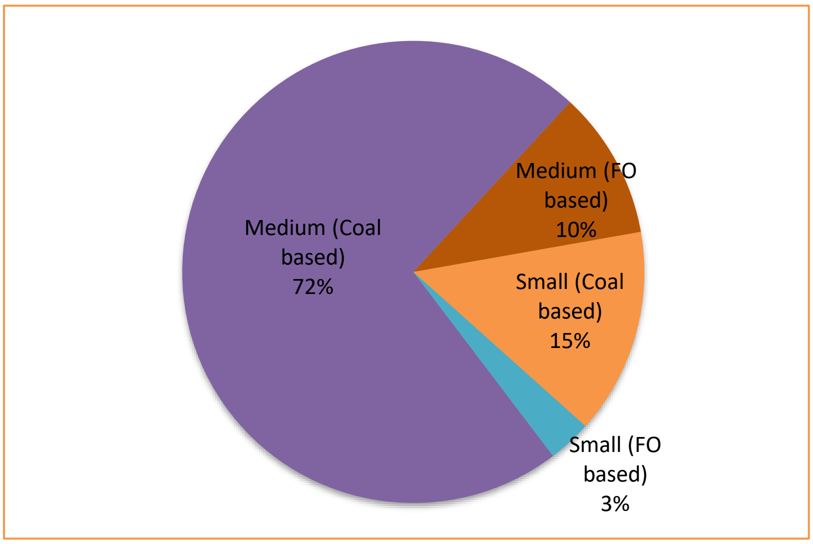


Figure 4.4.2.3b: Distribution of cluster level energy consumption

4.4.2.4 Performance of SRRM plants

The specific fuel consumption for coal based units is in the range of 70-80 kg per tonne of metal, furnace oil based units is in the range of 48-60 litre per tonne of metal and the specific electricity consumption is in the range of 65-100 kWh per tonne based on capacity of the unit. The overall SEC of SRRM plants is estimated to be 1.9 GJ per tonne as shown in table 4.4.2.4.

Table 4.4.2.4: Performance of Re-rolling Units (Bardhaman cluster)

Type	SEC-Thermal (GJ/tonne)	SEC-Electrical (kWh/tonne)	SEC-Cluster (GJ/tonne)
Small (Coal based)	1.7	100	2.1
Small (FO based)	2.7	85	2.7
Medium (Coal based)	1.5	90	1.8
Medium (FO based)	1.9	65	2.1
Overall	1.6	89	1.9

The small (FO based) category units consumes maximum energy for producing per tonne of products, which is estimated to be 2.66 GJ per tonne (Figure 4.4.2.4).

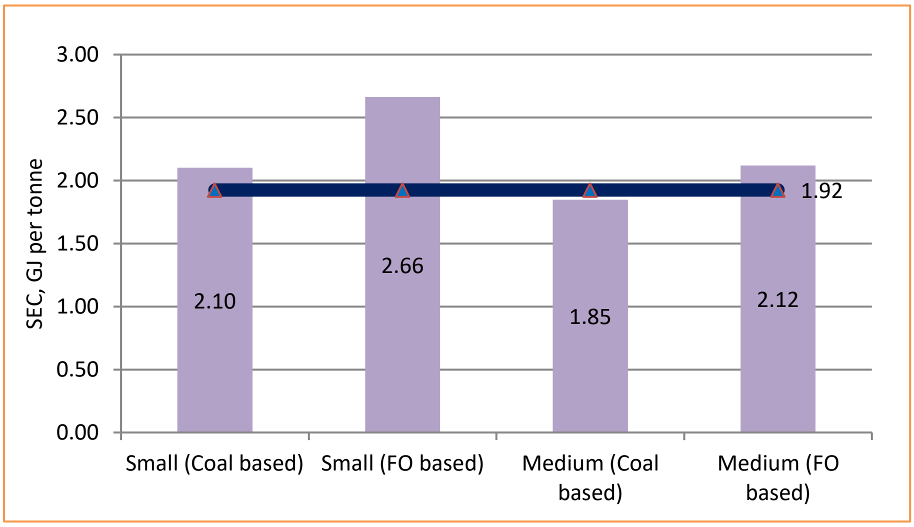


Figure 4.4.2.4: Performance of SRRM plants-- Bardhaman

4.4.2.5 Relevant institutions for SRRM sub-sector

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to SRRM industries in Bardhaman district are given in table 4.4.2.5.

Table 4.4.2.5: Institutions involved in Bardhaman Cluster

Institution/ organization	Contact details	Objectives and roles
Steel Rerolling Mills Association of India	46-C, 10th floor, Everest Building, Chowringhee Road, Middleton Row, Kolkata - 700071 Tel: 033-2288 5697, 2288 558, 6600 6600 http://www.srma.co.in	• Policy related issues and technological updates in various forums. • Providing opportunities and exposure to its members in domestic and international technological developments / innovations in manufacturing, raw materials, energy and environment related issues.
West Bengal State Electricity Distribution Company Limited– (WBSDA)	Chief Engineer & Nodal officer, Planning, Investigation & Design Department, Vidyut Bhavan, 5th floor, B-Block, Idhan nagar, Sector - II, Kolkata – 700091 https://www.wbsedcl.in/irj/go/km/docs/internet/new_website/WBSDA_New.html	• Establishing and promoting the energy conservation ethic within the government and all consumer classes in the state of West Bengal

4.4.2.6 Other information

There is no information about on-going activities available about this cluster.

4.4.2.7 Summary of findings

The summary of findings in Bardhaman is provided in table 4.4.2.7.

Table 4.4.2.7: Summary of findings in Bardhaman

Parameter	Remarks
Number of Non-DC category plants	25
Operating plants of Non-DC category	16 (excluding four larger units)
Total energy consumption	54,580 toe
SEC– Overall	1.9 GJ per tonne
GHG emissions	251,097 million tonne CO_2 per year
Specific GHG emissions	0.2 tonne CO_2 per tonne
Other relevant information	Not available

4.4.3 Bhavnagar

4.4.3.1 Background

Bhavnagar steel re-rolling mills cluster is situated in Bhavnagar district of Gujarat in western India. The raw material for steel re-rolling industries located in 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 further input material for steel rolling mills. The end products from steel re-rolling mills include mild steel (MS) angles, flats, squares, and round bars. The re-rolling mills processing billets/ingot (i.e., final product of steel melting units) produce round bars/thermo mechanically treated (TMT) bars; mills processing sheets as raw material produce mainly angles, flats, and squares.

Bhavnagar cluster used to have 120 number of SRRM plants some years back. At present, only 46 numbers of SRRM plants are available (JPC 2020) and all units fall under Non-DC category type. The total production of SRRM from 22 operating plants is estimated to be 0.30 million tonne considering 69.8% of capacity utilization (source: JPC, 2020) as shown in table 4.4.3.1. Of the 46 numbers of total units, only two units are installed along with induction furnace for scrap melting.

Table 4.4.3.1: Production of Non-DC SRRM plants (Bhavnagar)

Unit Category	Installed units	Operating units	Temporarily closed units
Small (<240 TPD)	45	21	24
Medium (>240 & <=1,200 TPD)	1	1	0
Larger units (>1,200 TPD)	0	0	0
Total	46	22	24
Production (million tonne)	0.4	0.3	0.1

Source: Analysis of JPC data, 2020

4.4.3.2 Process technology

The SRRM units use re-heating furnaces along with pulverized coal as fuel. The brief details of technology used in SRRM production in Bhavnagar cluster are provided in Table 4.4.3.2.

Table 4.4.3.2: Process technology used in SRRM plants – Bhavnagar

Technology	Purpose
Reheating furnace S(coal / oil firing)	Heating feedstock to 1,200-1,250 °C for using in rolling process.
Rolling mill	Rolling slabs, ingots, billets, blooms to thinner and longer sizes through successive rolling mill stands driven by electric motors

4.4.3.3 Energy consumption analysis

Pulverized coal, the major fuel used in re-heating furnaces, accounts for about 80-85% of total energy consumption in rerolling units. The balance 15-20% of energy consumption is accounted by electricity to meet motive loads. The total energy consumption of SRRM plants under Non-DC category is 19,587 toe per year. This does not include energy consumption of induction furnaces which are exclusively used for production of raw materials used in steel rerolling mills. The equivalent GHG emissions are estimated to be 92,370 tonne CO_2 per year (table 4.4.3.3).

Table 4.4.3.3: Energy consumption of Non-DC SRRM plants – Bhavnagar cluster

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent (toe/year)	(tonne CO_2/year)
Coal	30,975 tonne	16,107	60,401
Electricity	40.5 mil kWh/year	3,480	31,969
Total	-	19,587	92,370

Note (1) Based on secondary resources; (2) 300 days of operation

Coal contributes the majority energy share (82%). The share of energy consumption from different sources is provided in figure 4.4.3.3a.

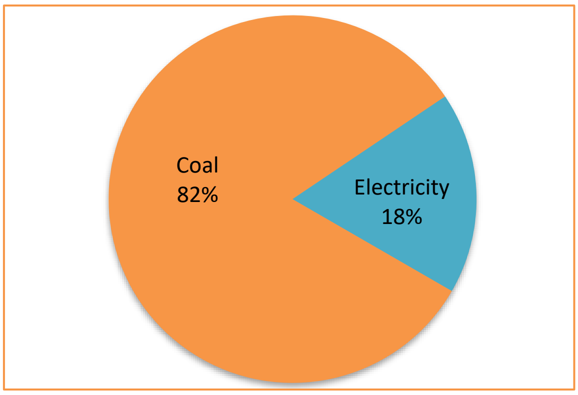


Figure 4.4.3.3a: Share of energy consumption source

The coal based small size category industries consumes maximum share of cluster level energy consumption (85%). The distribution of cluster level energy consumption by different category of industries is provided with figure 4.4.3.3b.

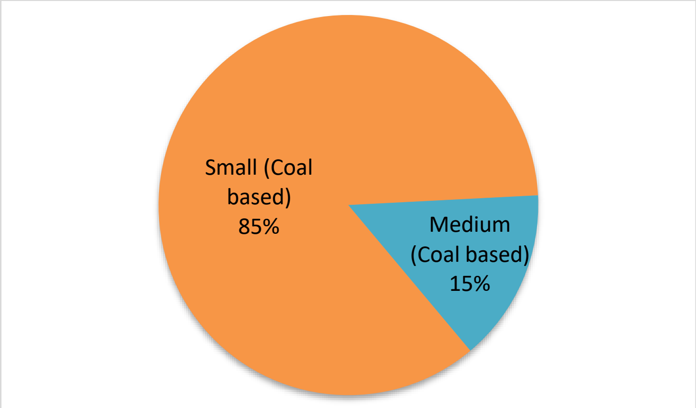


Figure 4.4.3.3b: Distribution of cluster level energy consumption

4.4.3.4 Performance of SRRM plants

The specific coal consumption is in the range of 86-105 kg per tonne of metal and the specific electricity consumption is in the range of 118-136 kWh per tonne based on capacity of the unit. The overall specific energy consumption of SRRM plants is estimated to be 2.7 GJ per tonne as shown in table 4.4.3.4.

Table 4.4.3.4: Performance of Non-DC SRRM plants – Bhavnagar

Type	SEC-Thermal (GJ/tonne)	SEC-Electrical (kWh/tonne)	SEC-Cluster (GJ/tonne)
Small (Coal based)	2.3	136	2.8
Medium (Coal based)	1.9	118	2.3
Overall	2.2	133	2.7

The small (coal based) category units consumes maximum energy for producing per tonne of products, which is estimated to be 2.8 GJ per tonne (Figure 4.4.3.4).

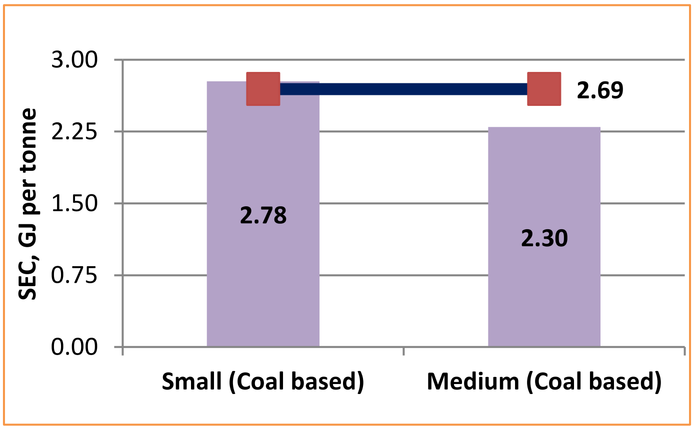


Figure 4.4.3.4: Performance of SRRM plants - Bhavnagar

4.4.3.5 Relevant institutions for SRRM sub-sector

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to SRRM industries in Bhavnagar district are given in table 4.4.3.5.

Table 4.4.3.5: Institutions involved in Bhavnagar Clusters

Institution/ organization	Contact details	Objectives and roles
Sihor Steel Re-Rolling Mills Association	Plot No. 101, GIDC, Phase-2, Sihor, Bhavnagar – 364240 Tel: 98252 05053	• Plays an active role to sustainability of steel re-rolling units towards raw material availability, product development, technology upgradation and exposure on energy efficiency and cost-effective practices.
Gujarat Energy Development Agency (GEDA)	4th floor, Block No. 11 & 12, Udyog Bhavan, Sector-11, Gandhinagar – 382017, Tel: 079-23257251,54 Email : info@geda.org.in http://www.geda.org.in	• Coordinate, regulate and enforce efficient use of energy and its conservation

4.4.3.6 Other information

The other information at the cluster level includes the following:

(1) The United Nations Development Program (UNDP) has implemented a project on "Removal of Barriers to Energy Efficiency Improvement in the Steel Re-Rolling Mill Sector in India" promoting energy efficiency in the cluster.

(2) An on-going study undertaken by Bureau of Energy Efficiency (BEE) is focusing on energy efficiency and sectoral mapping for SRRM clusters in India.

4.4.3.7 Summary of findings

The summary of findings in Bhavnagar is provided in table 4.4.3.7.

Table 4.4.3.7: Summary of findings in Bhavnagar

Parameter	Remarks
Number of Non-DC category plants	46
Operating plants of Non-DC category	22
Total energy consumption	19,587 toe
SEC– Overall	2.6 GJ per tonne
GHG emissions	92,370 tonne CO_2 per year
Specific GHG emissions	0.3 tonne CO_2 per tonne
Other relevant information	• At present, about 60% of units have temporarily closed and units are operating at 50 -70% installed capacity.

Parameter	Remarks
	• Study on-going pertaining to energy efficiency improvements by BEE • UNDP conducted energy efficiency improvement study from 2004 to 2013

4.4.4 Fatehgarh Sahib - Mandi Gobindgarh

4.4.4.1 Background

Fatehgarh Sahib (Mandi Gobindgarh) is the largest steel rerolling cluster in India located in the state of Punjab. The major products manufactured are rounds, squares, TMT bars, press patti, etc. There are about 142 numbers of SRRM plants and all fall under Non-DC category type. The total production of SRRM from 132 operating plants is estimated to be 2.70 million tonnes considering 69.8% of capacity utilization (source: JPC, 2020) as shown in table 4.4.4.1.

Table 4.4.4.1: Production of Non-DC SRRM plants (Fatehgarh Sahib)

Unit Category	Installed Units	Operating units	Temporarily closed units
Small (<240 TPD)	132	122	10
Medium (>240 & <=1,200 TPD)	10	10	-
Total	142	132	10
Production (million tonne)	2.8	2.7	0.1

Source: Analysis of JPC data, 2020

Of the 142 numbers of total units, 10 units have been installed along with induction furnace for scrap melting and only one unit has both EAF and induction furnace in its upstream process.

4.4.4.2 Process technology

The SRRM units use re-heating furnaces along with pulverized coal or furnace oil used as fuel. At present, about 31 units have switched over to natural gas. The brief details of technology used in SRRM production in Fatehgarh Sahib Cluster are provided in Table 4.4.4.2.

Table 4.4.4.2: Process technology used in SRRM plants – Fatehgarh Sahib

Technology	Purpose
Reheating furnace(coal / FO / NG)	Heating steel feedstock to 1,200-1,250 °C for using in rolling process.
Rolling mill	Rolling slabs, ingots, billets, blooms to thinner and longer sizes through successive rolling mill stands driven by electric motors

4.4.4.3 Energy consumption analysis

Pulverized coal, natural gas and furnace oil are the fuels used in re-heating furnaces which accounts for about 70-80% of total energy consumption in SRRM manufacturing and the remaining energy consumption is in form of electricity mainly to meet electrical loads of these plants. The total energy consumption of SRRM plants under Non-DC category is 129,510 toe per year. This does not include energy consumption of induction furnaces which are exclusively used for production of raw materials used in steel rerolling mills. The equivalent GHG emissions are estimated to be 572,245 tonne CO_2 per year (Table 4.4.4.3).

Table 4.4.4.3: Energy consumption of Non-DC SRRM plants – Fatehgarh Sahib Cluster

Fuel	Energy consumption Quantity	Equivalent (toe/year)	GHG emissions (tonne CO_2/year)
Coal	145,344 tonne	75,579	283,421
Furnace oil	9256 kL	8,685	28,702
Natural gas	24.6 mil SCM	21,549	42,446
Electricity	275.5 mil kWh/year	23,696	217,676
Total		129,510	572,245

Note: (1) Based on interaction with industry association, (2) 300 days of operation

Coal contributes the majority energy share (58%). The share of energy consumption from different sources is provided in figure 4.4.4.3a.

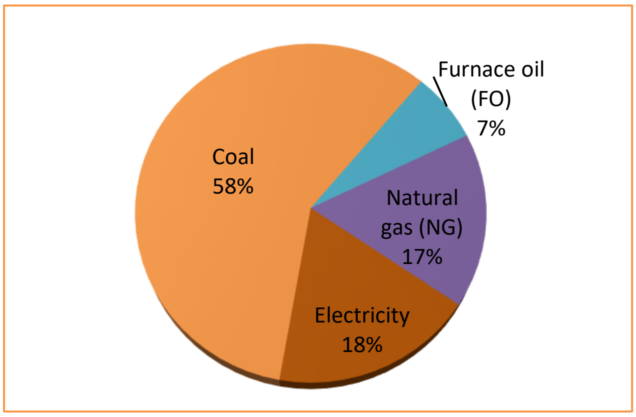


Figure 4.4.4.3a: Share of energy consumption source

The coal based small size category industries consumes maximum share of cluster level energy consumption (53%). The distribution of cluster level energy consumption by different category of industries is provided with figure 4.4.4.3b.

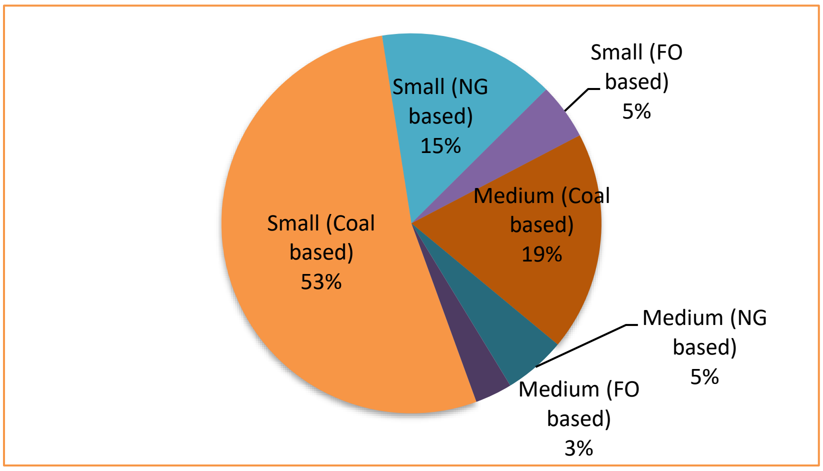


Figure 4.4.4.3b: Distribution of cluster level energy consumption

4.4.4.4 Performance of SRRM plants

The specific energy consumption of coal-based units are in the range of 70-80 kg per tonne of metal, furnace oil based units are 48-52 litre per tonne metal, natural gas based units are 42-44 SCM per tonne metal and the specific electricity consumption is in the range of 90-110 kWh per tonne based on capacity of the unit. The overall SEC of SRRM plants is estimated to be 2.1 GJ per tonne as shown in table 4.4.4.4.

Table 4.4.4.4: Performance of Non-DC SRRM plants – Fatehgarh Sahib (Mandi Gobindgarh)

Type	SEC-Thermal (GJ/tonne)	SEC-Electrical (kWh/tonne)	SEC-Cluster (GJ/tonne)
Small (Coal based)	1.7	110	2.1
Small (NG based)	1.6	100	2.0
Small (FO based)	2.0	105	2.4
Medium (Coal based)	1.5	100	1.9
Medium (NG based)	1.5	90	1.9
Medium (FO based)	1.9	95	2.2
Overall	1.7	105	2.1

The small (FO based) category units consumes maximum energy for producing per tonne of products, which is estimated to be 2.4 GJ per tonne (Figure 4.4.4.4).

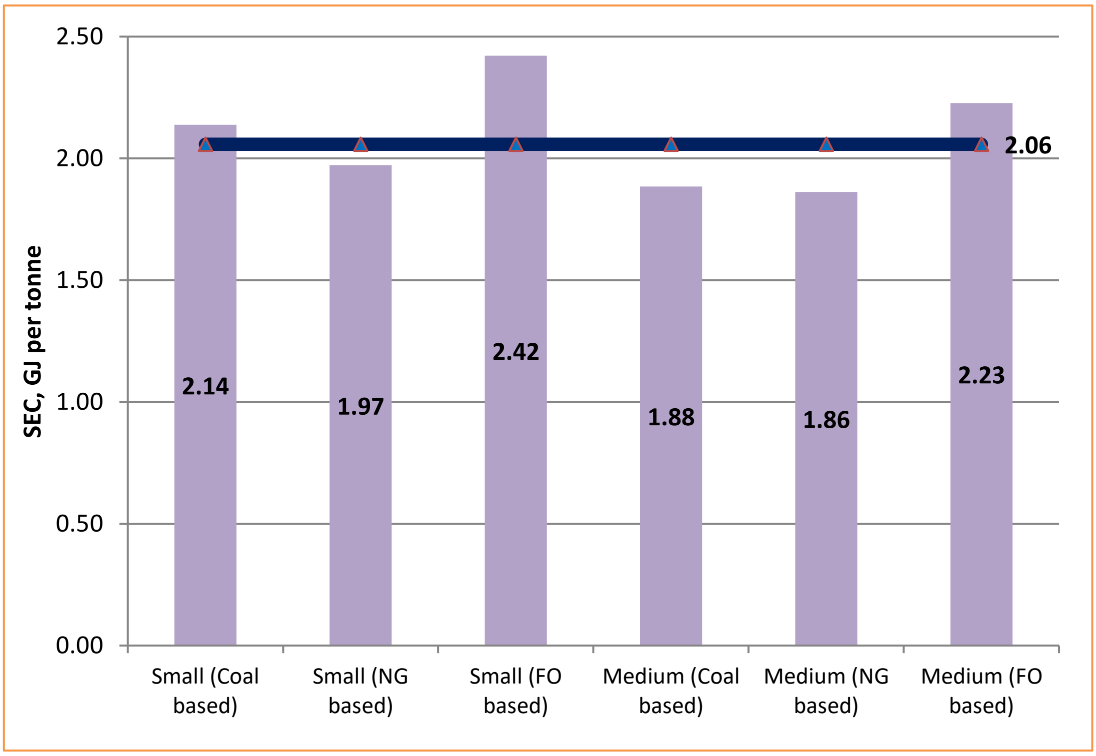


Figure 4.4.4.4: Performance of SRRM plants – Fatehgarh Sahib

4.4.4.5 Relevant institutions for SRRM sub-sector

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to SRRM industries in Fatehgarh district are given in table 4.4.4.5.

Table 4.4.4.5: Institutions involved in Mandi Gobindgarh

Institution/ organization	Contact details	Objectives and roles
Punjab State Industrial Development Corporation (PSIDC)	18, Himalaya Marg, Sector 34A, Sector 17, Chandigarh-160017 Tel:9815455532 email: arunjit.sidhu@investpunjab.gov.in https://pbindustries.gov.in/static/about_punjab;Key=PSIDC	• Roles of institutional entrepreneur, financial institution and facilitator for promotion of industries
National Institute of Secondary Steel Technology	PB92, GT. Road, Near RIMT Mandi Gobindgarh, Punjab-147301 Tel: 01765 292 393 email: info@nisst.org https://www.nisst.org/	• Provides trained technical manpower through short and long-term courses • Brings awareness about state of the art technologies by organising events. • Conducts research, development & design work in frontier areas
Punjab Energy Development Agency (PEDA)	Solar Passive Complex, Plot No. 1-2, Sector 33-D, Chandigarh – 160034 Tel: 0172 266 3382 Email: ceo@peda.gov.in https://www.peda.gov.in/	• Implementation of Energy Conservation Act • Creating awareness on energy conservation

4.4.4.6 Other information

The other information at the cluster level includes the following:

(1) The United Nations Development Program (UNDP) has implemented a project on "Removal of Barriers to Energy Efficiency Improvement in the Steel Re-Rolling Mill Sector in India" promoting energy efficiency in the cluster.

(2) An on-going study undertaken by the BEE is focusing on energy efficiency and sectoral mapping for SRRM clusters in India.

4.4.4.7 Summary of findings

The summary of findings in Fatehgarh Sahib (Mandi Gobindgarh) is provided in table 4.4.4.7.

Table 4.4.4.7: Summary of findings in Fatehgarh Sahib (Mandi Gobindgarh)

Parameter	Remarks
Number of Non-DC category SRRM plants	142
Operating plants of Non-DC category	132
Total energy consumption	129,510 toe
SEC– Overall	2.1 GJ per tonne

Parameter	Remarks
GHG emissions	572,245 tonne CO_2 per year
Specific GHG emissions	0.2 tonne CO_2 per tonne
Other relevant information	• About 31 units have switched over to NG based production and another 100 units have agreed in principle for switch over to NG due to strict emission norms of state PCB. • Study on-going pertaining to energy efficiency improvements by BEE • UNDP conducted energy efficiency improvement study during the period 2004 to 2013

4.4.5 Indore

4.4.5.1 Background

Indore (Sanwer Road Industrial Area) steel re-rolling mills cluster is situated in Madhya Pradesh state in central part of India. The end products from steel re-rolling mills include steel bars, flats, angles, channel from iron scrap/steel ingots. There are 22 numbers of SRRM plants in the cluster and fall under Non-DC category. The total production of SRRM from all 22 operating plants is estimated to be 0.26 million tonnes considering 69.8% of capacity utilization (source: JPC, 2020) as shown in table 4.4.5.1.

Table 4.4.5.1: Production of Non-DC SRRM plants (Indore)

Unit Category	Installed units	Operating units	Temporarily closed units
Small (<240 TPD)	21	21	-
Medium (>240 & <=1,200 TPD)	1	1	-
Total	22	22	-
Production (million tonne)	0.3	0.3	-

Source: Analysis of JPC data, 2020

4.4.5.2 Process technology

The SRRM units use re-heating furnaces along with pulverized coal as fuel. The brief details of technology used in production are provided in Table 4.4.5.2.

Table 4.4.5.2: Process technology used in SRRM plants – Indore

Technology	Purpose
Reheating furnace (coal firing)	Heating steel feedstock to 1,200-1,250 °C for using in rolling process.
Rolling mill	Rolling slabs, ingots, billets, blooms to thinner and longer sizes through successive rolling mill stands driven by electric motors

4.4.5.3 Energy consumption analysis

Pulverized coal is the major fuel used in re-heating furnaces which accounts for about >80 - 85% of total energy consumption in SRRM manufacturing and the remaining energy consumption is in form of electricity mainly to meet electrical loads of these plants. The total energy consumption of SRRM plants under Non-DC category is 16,474 toe per year. The equivalent GHG emissions are 73,967 tonne CO_2 per year (Table 4.4.5.3).

Table 4.4.5.3: Energy consumption of Non-DC SRRM plants – Indore cluster

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent (toe/year)	(tonne CO_2/year)
Coal	27,369 tonne	14,232	53,370
Electricity	26.1 mil kWh/year	2,242	20,598
Total		16,474	73,967

Note: (1) Based on secondary resources / interaction with plant; (2) 300 days of operation

Coal contributes the majority energy share (86%). The share of energy consumption from different sources is provided in figure 4.4.5.3a.

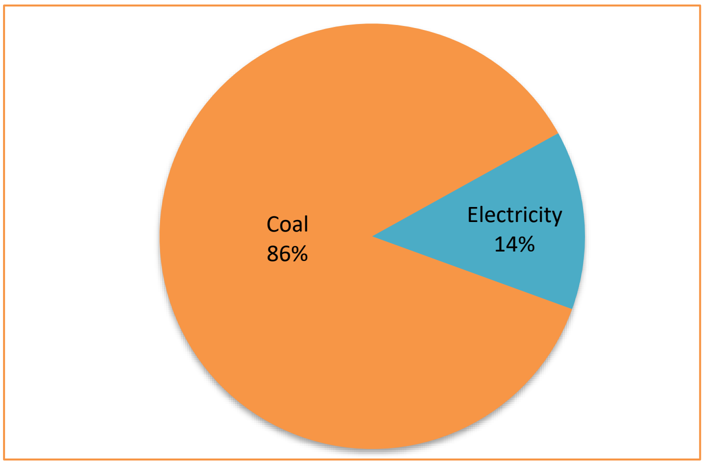


Figure 4.4.5.3a: Share of energy consumption source

The coal based small size category industries consumes maximum share of cluster level energy consumption (58%). The distribution of cluster level energy consumption by different category of industries is provided with figure 4.4.5.3b.

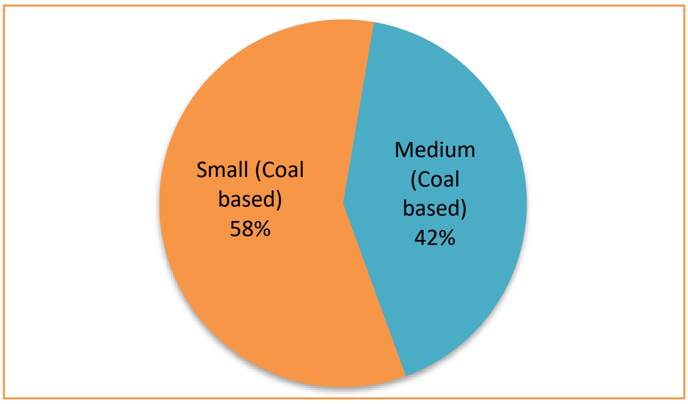


Figure 4.4.5.3b: Distribution of cluster level energy consumption

4.4.5.4 Performance of SRRM plants

The specific fuel consumption for coal based units is in the range of 100 – 110 kg per tonne of metal and the specific electricity consumption is in the range of 95 -105 kWh per tonne based on capacity of the unit. The overall SEC of SRRM plants is estimated to be 2.7 GJ per tonne as shown in table 4.4.5.4.

Table 4.4.5.4: Performance of Non-DC SRRM plants - Indore

Type	SEC-Thermal (GJ/tonne)	SEC-Electrical (kWh/tonne)	SEC-Cluster (GJ/tonne)
Small (Coal based)	2.4	105	2.8
Medium (Coal based)	2.2	95	2.5
Overall	2.3	101	2.7

The small (coal based) category units consumes maximum energy for producing per tonne of products, which is estimated to be 2.8 GJ per tonne (Figure 4.4.5.4).

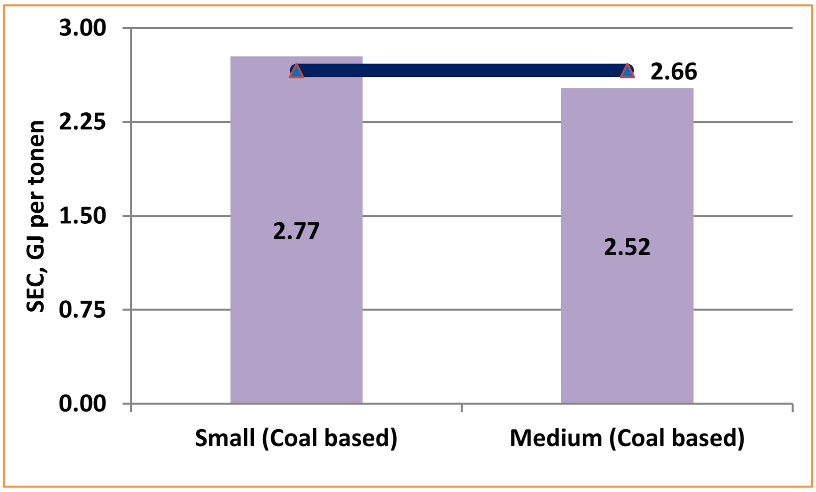


Figure 4.4.5.4: Performance of SRRM plants - Indore

4.4.5.5 Relevant institutions for SRRM sub-sector

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to SRRM industries in Indore district are given in table 4.4.5.5.

Table 4.4.5.5: Institutions involved in Indore Clusters

Institution/ organization	Contact details	Objectives and roles
Association in Indore, Madhya Pradesh	96, Polo Ground, Above State Bank Of Indore, Polo Ground, Indore, Madhya Pradesh 452003; Tel: 0731 2421837	To assist manufacturing industries in identifying energy efficient technologies and improve energy efficiency in SME clusters
M.P. Urja Vikas Nigam Limited (MPUVNL)	Urja Bhawan, Link Road No. 2, Shivaji Nagar, Bhopal – 462 016, Tel: 0752 255 6566 http://www.mprenewable.nic.in/contact.html	State Designated Agency (SDA) to coordinate, regulate and enforce efficient use of energy and its conservation

4.4.5.6 Other information

United Nations Development Program (UNDP) has implemented a project on “Removal of Barriers to Energy Efficiency Improvement in the Steel Re-Rolling Mill Sector in India” promoting energy efficiency in the cluster.

4.4.5.7 Summary of findings

The summary of findings in Indore is provided in table 4.4.5.7.

Table 4.4.5.7: Summary of findings in Indore

Parameter	Remarks
Number of Non-DC category SRRM plants	22
Operating plants of Non-DC category	22
Total energy consumption	16,474 toe
SEC– Overall	2.7 GJ per tonne
GHG emissions	73,967 tonne CO_2 per year
Specific GHG emissions	0.3 tonne CO_2 per tonne
Other relevant information	UNDP conducted energy efficiency improvement study from 2004 to 2013

4.4.6 Jalna

4.4.6.1 Background

Jalna steel re-rolling mills cluster is situated in Maharashtra state in western part of India. The end products from steel re-rolling mills include TMT bars, mild steel (MS) angles, flats and squares. There are 25 numbers of SRRM plants in the cluster. Of these, 23 units fall under Non-DC category and 2 units fall under potential DC category due to their higher installed capacity along with EIF. Hence, these units will not be considered for cluster level analysis. The total production of SRRM from 19 operating plants is estimated to be 0.8 million tonnes considering 69.8% of capacity utilization as shown in table 4.4.6.1 (source: JPC, 2020).

Table 4.4.6.1: Production of Non-DC SRRM plants (Jalna)

Unit Category	Installed Units	Operating units	Temporarily closed units
Small (<240 TPD)	17	13	4
Medium (>240 & <=1,200 TPD)	6	6	0
Larger units (>1,200 TPD)	2	2	0
Total*	23	19	4
Estimated production (million tonne)*	0.8	0.8	0.04

** Excluding details of larger units*

Source: Analysis of JPC data, 2020

Of the 25 numbers of total units, 7 units have been installed with EIF. This cluster has few of the modernized plants installed with complete automation and continuous casting machines.

4.4.6.2 Process technology

The SRRM units use re-heating furnaces along with pulverized coal as fuel. The brief details of technology used in production are provided in Table 4.4.6.2.

Table 4.4.6.2: Process technology used in SRRM plants – Jalna

Technology	Purpose
Reheating furnace (coal firing)	Heating steel feedstock to about 1,200-1,250 °C for using in rolling process.
Rolling mill	Rolling slabs, ingots, billets, blooms to thinner and longer sizes through successive rolling mill stands driven by electric motors
Continuous casting machines	To form billets which can be rolled directly into bars / rods

4.4.6.3 Energy consumption analysis

Pulverized coal is the major fuel used in re-heating furnaces which accounts for about 80 - 85% of total energy consumption in SRRM manufacturing and the remaining energy consumption is in form of electricity mainly to meet electrical loads of these plants. The total energy consumption of SRRM plants under Non-DC category is 29,562 toe per year. This does not include energy consumption of induction furnaces which are exclusively used for production of raw materials used in steel rerolling mills. The equivalent GHG emissions are estimated to be 137,494 tonne CO_2 per year (Table 4.4.6.3).

Table 4.4.6.3: Energy consumption of Non-DC SRRM plants – Jalna Cluster

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent (toe/year)	(tonne CO_2/year)
Coal	47,427 tonne	24,662	92,483
Electricity	57 mil kWh/year	4,900	45,011
Total		29,562	137,494

Note (1) Based on interaction with plant personnel; (2) 300 days of operation

Coal contributes the majority energy share (83%). The share of energy consumption from different sources is provided in figure 4.4.6.3a.

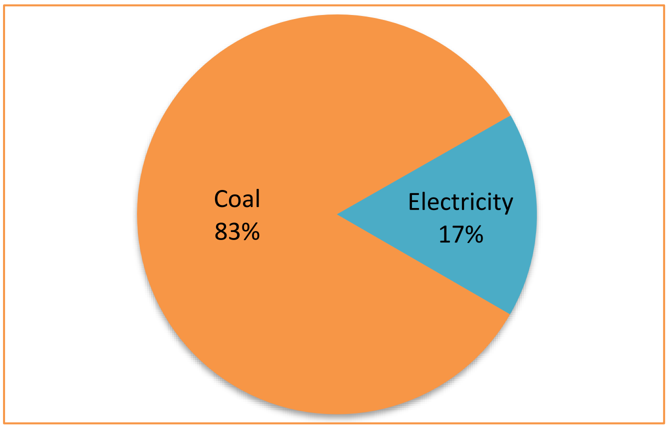


Figure 4.4.6.3a: Share of energy consumption source

The coal based medium size category industries consumes maximum share of cluster level energy consumption (86%). The distribution of cluster level energy consumption by different category of industries is provided with figure 4.4.6.3b.

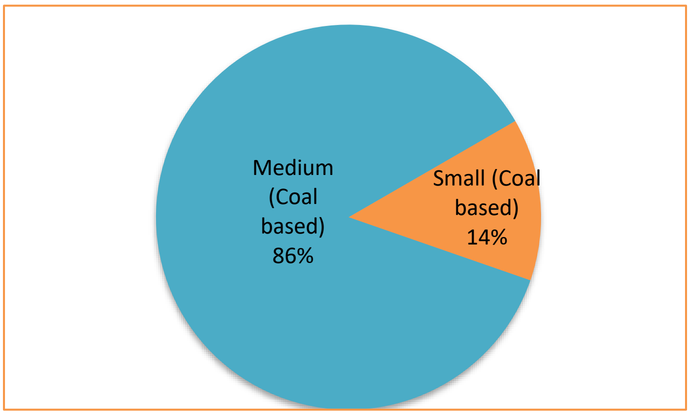


Figure 4.4.6.3b: Distribution of cluster level energy consumption

4.4.6.4 Performance of SRRM plants

The specific energy consumption for coal based units is in the range of 60- 70 kg coal per tonne of metal and electricity in the range of 70 -100 kWh per tonne. The overall SEC of SRRM plants is estimated to be 1.6 GJ per tonne as shown in table 4.4.6.4.

Table 4.4.6.4: Performance of Non-DC SRRM plants – Jalna

Type	SEC-Thermal (GJ/tonne)	SEC-Electrical (kWh/tonne)	SEC-Cluster (GJ/tonne)
Small (Coal based)	1.5	100	2.0
Medium (Coal based)	1.3	70	1.6
Overall	1.3	74	1.6

The small (coal based) category units consumes maximum energy for producing per tonne of products, which is estimated to be 1.9 GJ per tonne (Figure 4.4.6.4).

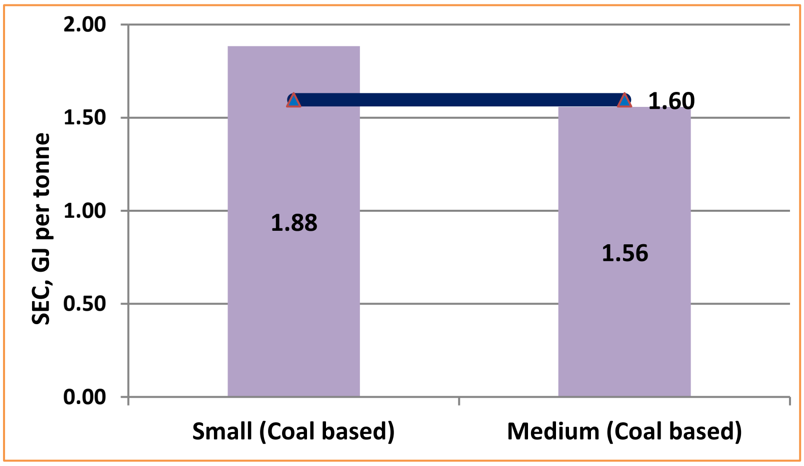


Figure 4.4.6.4: Performance of SRRM plants - Jalna

4.4.6.5 Relevant institutions for SRRM sub-sector

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to SRRM industries in Jalna district are given in table 4.4.6.5.

Table 4.4.6.5: Institutions involved in Jalna Clusters

Institution/ organization	Contact details	Objectives and roles
Steel Manufacturers Association of Maharashtra (SMAM)	5th floor, Potia industrial estate, Darukhana, Mumbai-400010 Tel: 022 2372 6689 email: sram.1113@rediffmail.com, sram10982@gmail.com https://www.sramlive.in/index.php	• Ensuring smooth working of the steel industries and grievances redressal
Maharashtra Energy Development Agency (MEDA)	MHADA commercial complex, 2nd floor,Opp. Tridal Nagar, Yerwada, Pune – 411 006 Tel: 020-35000450 email: meda@mahaurja.com https://www.mahaurja.com/meda/	• Regulating energy conservation and promoting the development of renewable energy • Taking concrete steps for conventional energy conservation measures including industries

4.4.6.6 Other information

The other information includes the following:

(1) United Nations Development Program (UNDP) has implemented a project on “Removal of Barriers to Energy Efficiency Improvement in the Steel Re-Rolling Mill Sector in India” which promotes energy efficiency in the cluster.

(2) An on-going study undertaken by Bureau of Energy Efficiency (BEE) is focusing on energy efficiency and sectoral mapping for SRRM clusters in India.

4.4.6.7 Summary of findings

The summary of findings in Jalna is provided in table 4.4.6.7.

Table 4.4.6.7: Summary of findings in Jalna

Parameter	Remarks
Number of Non-DC category SRRM plants	25
Operating plants of Non-DC category	19 (Excluding 2 larger units)
Total energy consumption	29,562 toe
SEC– Overall	1.6 GJ per tonne
GHG emissions	137,494 tonne CO_2 per year
Specific GHG emissions	0.2 tonne CO_2 per tonne
Other relevant information	• Study on-going pertaining to energy efficiency improvements by BEE • UNDP conducted energy efficiency improvement study from 2004 to 2013

4.4.7 Ludhiana

4.4.7.1 Background

Ludhiana steel re-rolling mills cluster is situated in Punjab state. The end products from steel re-rolling mills include mild steel (MS) angles, flats, squares, and round bars. The re-rolling mills processing billets/ingot (i.e. final product of steel melting units) produce round bars/thermo mechanically treated (TMT) bars; mills processing sheets as raw material produce mainly angles, flats, and squares. There are about 81 numbers of SRRM plants and all units fall under Non-DC category. The total production of 72 operating plants is estimated to be 1.7 million tonne considering 69.8% of capacity utilization (source: JPC, 2020) as shown in table 4.4.7.1.

Table 4.4.7.1a: Production of Non-DC SRRM plants (Ludhiana)

Unit category	Installed Units	Operating units	Temporarily closed units
Small (<240 TPD)	74	65	9
Medium (>240 & <=1,200 TPD)	7	7	0
Larger units (>1,200 TPD)	0	0	0
Total	81	72	9
Production (million tonne)	1.8	1.7	0.05

Source: Analysis of JPC data, 2020

Of 81 total numbers of units, 12 units have induction furnaces, 3 units have electric arc furnaces and one unit has both induction furnace and electric arc furnace (table 4.4.7.1b).

Table 4.4.7.2 Composite units in Ludhiana cluster

S.No	Unit Name	Installed capacity (tpy)		
		EAF	IF	Re-rolling
1	Upper India Steel Mfg Co. Ltd.	50,000		124,300
2	Aarti Steel Ltd.	118,000	50,000	200,000
3	Arora Iron And Steel Rolling Mills	294,000		291,000
4	Vardhman Special Steels	225,000		200,000

4.4.7.2 Process technology

The SRRM units use re-heating furnaces along with pulverized coal and furnace oil as fuel. The brief details of technology used in production are provided in Table 4.4.7.2.

Table 4.4.7.2: Process technology used in SRRM plants – Ludhiana

Technology	Purpose
Reheating furnace (coal / FO)	Heating steel feedstock to 1,200-1,250 °C for using in rolling process.
Rolling mill	Rolling slabs, ingots, billets, blooms to thinner and longer sizes through successive rolling mill stands driven by electric motors

4.4.7.3 Energy consumption analysis

Pulverized coal, sourced from local markets, is the major fuel used in re-heating furnaces which accounts for about >80 - 85% of total energy consumption in SRRM manufacturing and the remaining energy consumption is in form of electricity mainly to meet electrical loads of these plants. The total energy consumption of SRRM plants under Non-DC category is 89,504 toe per year. This does not include energy consumption of EIF and EAF which are exclusively used for production of raw materials used in steel rerolling mills. The equivalent GHG emissions are estimated to be 412,275 tonne CO_2 per year (Table 4.4.7.3).

Table 4.4.7.3: Energy consumption of Non-DC SRRM plants – Ludhiana Cluster

Fuel	Energy consumption		GHG emissions (tonne CO_2/year)
	Quantity	Equivalent (toe/year)	
Coal	124,905 tonne	64,951	243,565
Furnace oil	10,298 kL	9,664	31,935
Electricity	173 mil kWh/year	14,889	136,775
Total		89,504	412,275

Note: (1) Based on interaction with plant personnel (2) 300 days of operation

Coal contributes the majority energy share (72%). The share of energy consumption from different sources is provided in figure 4.4.7.3a.

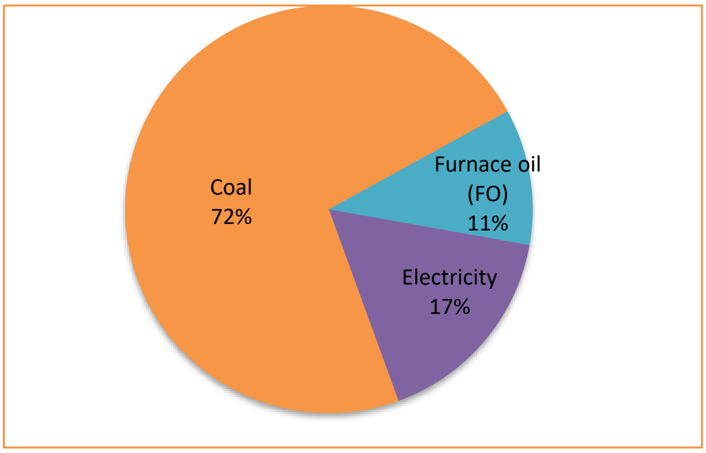


Figure 4.4.7.3a: Share of energy consumption source

The coal based small size category industries consumes maximum share of cluster level energy consumption (53%). The distribution of cluster level energy consumption by different category of industries is provided with figure 4.4.7.3b.

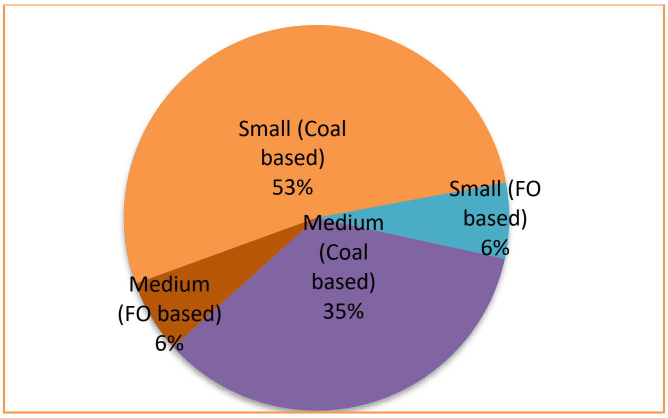


Figure 4.4.7.3b: Distribution of cluster level energy consumption

4.4.7.4 Performance of SRRM plants

The specific fuel consumption for coal based units is in the range of 75-85 kg per tonne of metal, furnace oil based units is in the range of 46-58 litre per tonne of metal and the specific electricity consumption is in the range of 75-105 kWh per tonne based on capacity of the unit. The overall specific energy consumption (SEC) of SRRM plants is estimated to be 2.1 GJ per tonne as shown in table 4.4.7.4.

Table 4.4.7.4: Performance of Non-DC SRRM plants – Ludhiana

Type	SEC-Thermal (GJ/tonne)	SEC-Electrical (kWh/tonne)	SEC-Cluster (GJ/tonne)
Small (Coal based)	1.8	105	2.2
Small (FO based)	2.3	100	2.6
Medium (Coal based)	1.6	95	2.0
Medium (FO based)	1.8	75	2.1
Overall	1.8	99	2.1

The small (FO based) category units consumes maximum energy for producing per tonne of products, which is estimated to be 2.6 GJ per tonne (Figure 4.4.7.4).

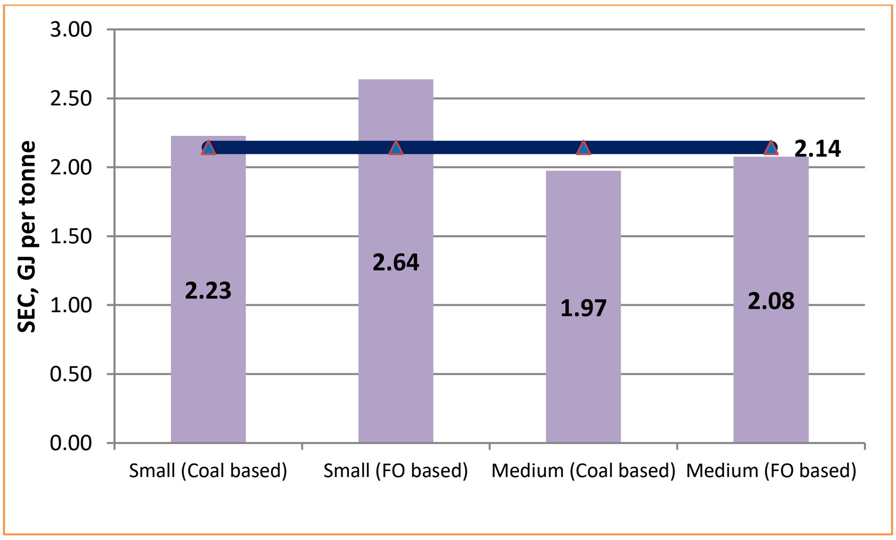


Figure 4.4.7.4: Performance of SRRM plants - Ludhiana

4.4.7.5 Relevant institutions for SRRM sub-sector

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to SRRM industries in Ludhiana district are given in table 4.4.7.5.

Table 4.4.7.5: Institutions involved in Ludhiana cluster

Institution/ organization	Contact details	Objectives and roles
Ludhiana Steel Rolling Mills Association	Details not available	Welfare activities and grievances redressal of member industries

4.4.7.6 Other information

The other information at the cluster level includes the following:

(1) United Nations Development Program (UNDP) has implemented a project on "Removal of Barriers to Energy Efficiency Improvement in the Steel Re-Rolling Mill Sector in India" which promotes energy efficiency in the cluster.

(2) An on-going study by BEE is focusing on energy efficiency and sectoral mapping of SRRM clusters.

4.4.7.7 Summary of findings

The summary of findings in Ludhiana is provided in table 4.4.7.7.

Table 4.4.7.7: Summary of findings in Ludhiana

Parameter	Remarks
Number of Non-DC category SRRM plants	81
Operating plants of Non-DC category	72
Total energy consumption	89,504 toe
SEC– Overall	2.1 GJ per tonne
GHG emissions	412,275 tonne CO_2 per year
Specific GHG emissions	0.2 tonne CO_2 per tonne
Other relevant information	• On-going study pertaining to energy efficiency improvements by BEE • UNDP undertook energy efficiency improvement project during the period 2004-2013

4.4.8 Mehsana

4.4.8.1 Background

Mehsana steel re-rolling mills cluster is situated in Mehsana district in Gujarat. The raw material is sourced from ship breaking industries. The steel melting units also procure scrap raw material to produce billets and ingots, which is further input material for steel rolling mills. The end products from steel re-rolling mills include mild steel (MS) angles, flats, squares, and round bars. The re-rolling mills processing billets/ingot (i.e., final product of steel melting units) produce round bars/thermo mechanically treated (TMT) bars; mills processing sheets as raw material produce mainly angles, flats, and squares.

At present, Mehsana cluster has 32 numbers of SRRM plants (JPC 2020) and all units fall under Non-DC category type. The total production of SRRM from 28 operating plants is estimated to be 0.4 million tonne considering 69.8% of capacity utilization (source: JPC, 2020) as shown in table 4.4.8.1. Of the total units, only 3 units are installed along with induction furnace for scrap melting.

Table 4.4.8.1: Production of Non-DC SRRM plants (Mehsana)

Unit Category	Installed units	Operating units	Temporarily closed units
Small (<240 TPD)	31	27	4
Medium (>240 & <=1,200 TPD)	1	1	-
Total	32	28	4
Production (million tonne)	0.5	0.4	0.03

Source: Analysis of JPC data, 2020

4.4.8.2 Process technology

The SRRM units use re-heating furnaces with pulverized coal as fuel. The brief details of technology used in SRRM production in Mehsana cluster are provided in Table 4.4.8.2.

Table 4.4.8.2: Process technology used in SRRM plants – Mehsana

Technology	Purpose
Reheating furnace (pulverised coal)	Heating steel feedstock to 1,200-1,250 °C for using in rolling process.
Rolling mill	Rolling slabs, ingots, billets, blooms to thinner and longer sizes through successive rolling mill stands driven by electric motors

4.4.8.3 Energy consumption analysis

Pulverized coal, sourced from local markets, is the major fuel used in re-heating furnaces which accounts for about >80 - 85% of total energy consumption in SRRM manufacturing and the remaining energy consumption is in form of electricity mainly to meet electrical loads of these plants. The total energy consumption of SRRM plants under Non-DC category is 21,342 toe per year. This does not include energy consumption of induction furnaces which are exclusively used for production of raw materials used in steel rerolling mills. The equivalent GHG emissions are estimated to be 119,826 tonne CO_2 per year (Table 4.4.8.3).

Table 4.4.8.3: Energy consumption of Non-DC SRRM plants – Mehsana Cluster

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent (toe/year)	(tonne CO_2/year)
Coal	41,043 tonne	21,342	80,034
Electricity	50 mil kWh/year	4,332	39,792
Total		25,674	119,826

Note: (1) Based on secondary resources / interaction with plant; (2) 300 days of operation

Coal contributes the majority energy share (83%). The share of energy consumption from different sources is provided in figure 4.4.8.3a.

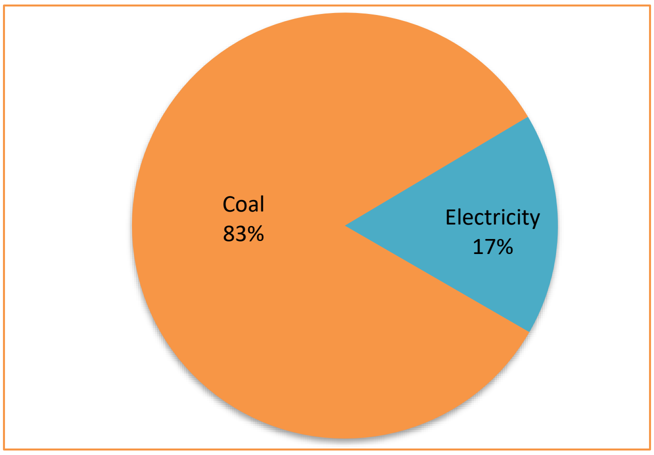


Figure 4.4.8.3a: Share of energy consumption source

The coal based small size category industries consumes maximum share of cluster level energy consumption (71%). The distribution of cluster level energy consumption by different category of industries is provided with figure 4.4.8.3b.

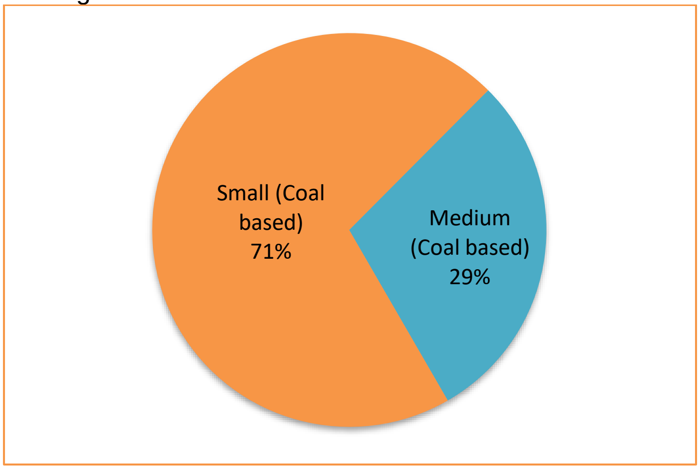


Figure 4.4.8.3b: Distribution of cluster level energy consumption

4.4.8.4 Performance of SRRM plants

The specific coal consumption is in the range of 85-100 kg per tonne of metal and the SEC is in the range of 110-120 kWh per tonne based on capacity of the unit. The overall SEC of SRRM plants is estimated to be 2.5 GJ per tonne (table 4.4.8.4).

Table 4.4.8.4: Performance of Non-DC SRRM plants - Mehsana

Type	SEC-Thermal (GJ/tonne)	SEC-Electrical (kWh/tonne)	SEC-Cluster (GJ/tonne)
Small (Coal based)	2.2	120	2.6
Medium (Coal based)	1.8	110	2.3
Overall	2.1	117	2.5

The small (coal based) category units consumes maximum energy for producing per tonne of products, which is estimated to be 2.6 GJ per tonne (Figure 4.4.8.4).

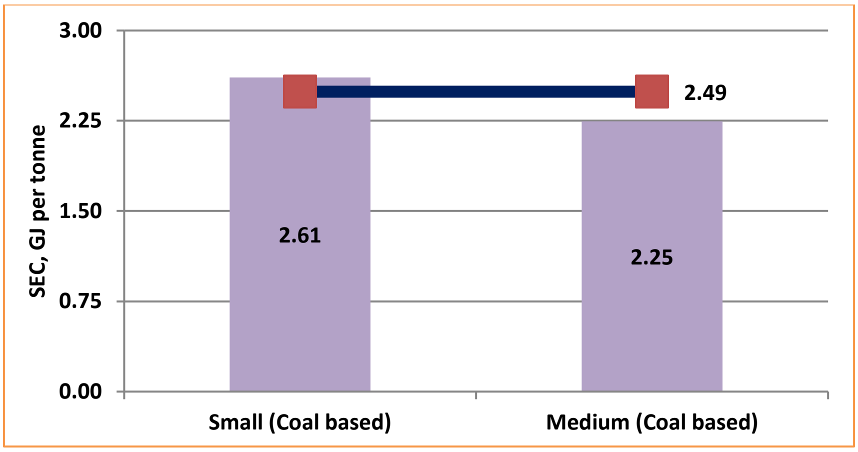


Figure 4.4.8.4: Performance of SRRM plants – Mehsana Cluster

4.4.8.5 Relevant institutions for SRRM sub-sector

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to SRRM industries in Mehsana district are given in table 4.4.8.5.

Table 4.4.8.5: Institutions involved in Mehsana Cluster

Institution/ Organization	Contact details	Objectives and roles
All India Steel Rollers Association (AISRA)	Sagar Apartments, 6, Tilak Marg New Delhi -110001 Tel: 011-2338 9957, 5536 3874	• Providing opportunities to the members in domestic and international technological developments in manufacturing, energy and related issues.
Gujarat Energy Development Agency (GEDA)	4thfloor, Block No. 11 & 12, Udyog Bhavan, Sector-11, Gandhi nagar – 382017, Gujarat Tel: 079-23257251,54 Email : info@geda.org.in	• State Designated Agency (SDA) to coordinate, regulate and enforce efficient use of energy and its conservation

4.4.8.6 Other information

There is no information about on-going activities available about this cluster.

4.4.8.7 Summary of findings

The summary of findings in Mehsana cluster is provided in table 4.4.8.7.

Table 4.4.8.7: Summary of findings in Mehsana Cluster

Parameter	Remarks
Number of Non-DC category SRRM plants	32
Operating plants of Non-DC category	28
Total energy consumption	25,674 toe
SEC– Overall	2.5 GJ per tonne
GHG emissions	119,826 tonne CO_2 per year
Specific GHG emissions	0.3 tonne CO_2 per tonne
Other relevant information	Not Available

4.4.9 Raipur

4.4.9.1 Background

Raipur steel re-rolling mills cluster is situated in Chhattisgarh state is the 2nd largest cluster (based on number of units) after Mandi Gobindgarh cluster. The end products from steel re-rolling mills include mild steel (MS) angles, flats, squares, and round bars. The re-rolling mills processing billets/ingot (i.e., final product of steel melting units) produce round bars/thermo mechanically treated (TMT) bars; mills processing sheets as raw material produce mainly angles, flats, and squares.

There are about 102 numbers of SRRM plants of which 101 numbers of units fall under Non-DC category. The total production of SRRM from 81 operating plants is estimated to be 2.7 million tonnes considering 69.8% of capacity utilization (source: JPC, 2020) as shown in table 4.4.9.1.

Table 4.4.9.1: Production of Non-DC SRRM plants (Raipur)

Unit Category	Installed Units	Operating units	Temp. closed units
Small (<240 TPD)	86	67	19
Medium (>240 & <=1,200 TPD)	16	14	2
Total	102	81	21
Estimated production (million tonne)	3.2	2.7	0.5

Source: Analysis of JPC data, 2020

Of the 102 numbers of total units, 27 units have been installed along with induction furnace for scrap melting. Only two units are installed along with DRI and induction furnace based composite plants.

4.4.9.2 Process technology

The SRRM units use re-heating furnaces along with pulverized coal and furnace oil as fuel. The brief details of technology used in production are provided in Table 4.4.9.2.

Table 4.4.9.2: Process technology used in SRRM plants – Raipur

Technology	Purpose
Reheating furnace (coal, FO)	Heating steel feedstock to 1,200-1,250 °C for using in rolling process.
Rolling mill	Rolling slabs, ingots, billets, blooms to thinner and longer sizes through successive rolling mill stands driven by electric motors

4.4.9.3 Energy consumption analysis

Pulverized coal, sourced from local markets, is the major fuel used in re-heating furnaces which accounts for about >80 - 85% of total energy consumption in SRRM manufacturing and the remaining energy consumption is in form of electricity mainly to meet electrical loads of these plants.

The total energy consumption of SRRM plants under Non-DC category is 143,290 toe per year. This does not include energy consumption of induction furnaces which are exclusively used for production of raw materials used in steel rerolling mills. The equivalent GHG emissions are estimated to be 655,712 tonne CO_2 per year (Table 4.4.9.3).

Table 4.4.9.3: Energy consumption of Non-DC SRRM plants – Raipur Cluster

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent (toe/year)	(tonne CO_2/year)
Coal	201,123 tonne	104,584	392,190
Furnace oil	16675 kL	15,647	51,710
Electricity	280.7 mil kWh/year	23,058	211,813
Total		143,290	655,712

Note: (1) Based on interaction with plant personnel; (2) 300 days of operation

Coal contributes the majority energy share (73%). The share of energy consumption from different sources is provided in figure 4.4.9.3a.

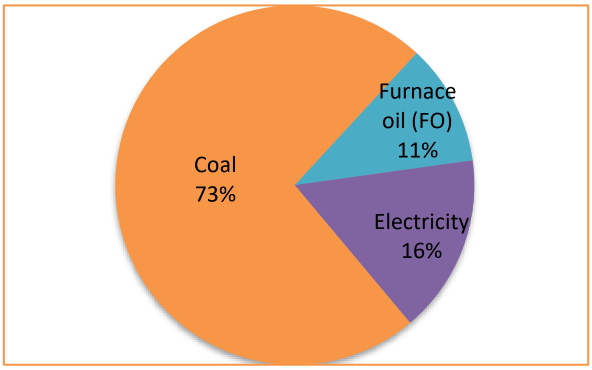


Figure 4.4.9.3a: Share of energy consumption source

The coal based small size category industries consumes maximum share of cluster level energy consumption (49%). The distribution of cluster level energy consumption by different category of industries is provided with figure 4.4.9.3b.

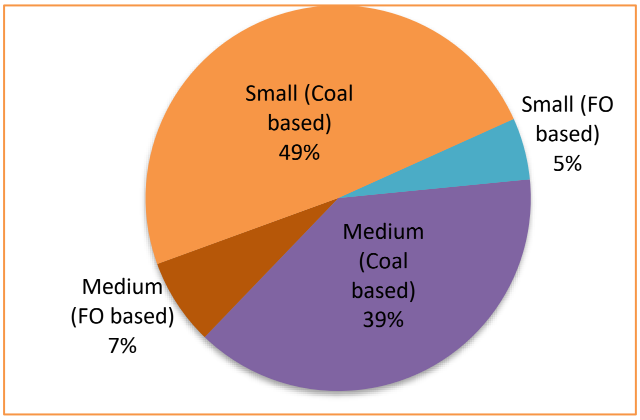


Figure 4.4.9.3b: Distribution of cluster level energy consumption

4.4.9.4 Performance of SRRM plants

The specific fuel consumption for coal based units is in the range of 75-90 kg per tonne of metal, furnace oil based units is in the range of 50-56 litre per tonne of metal and the specific electricity consumption is in the range of 76-100 kWh per tonne based on capacity of the unit. The overall specific energy consumption (SEC) of SRRM plants is estimated to be 2.2 GJ per tonne as shown in table 4.4.9.4.

Table 4.4.9.4: Performance of Non-DC SRRM plants - Raipur

Type	SEC-Thermal (GJ/tonne)	SEC-Electrical (kWh/tonne)	SEC-Cluster (GJ/tonne)
Small (Coal based)	2.0	100	2.3
Small (FO based)	2.2	84	2.5
Medium (Coal based)	1.6	100	2.0
Medium (FO based)	2.0	76	2.2
Overall	1.8	98	2.2

The small (FO based) category units consumes maximum energy for producing per tonne of products, which is estimated to be 2.5 GJ per tonne (Figure 4.4.9.4).

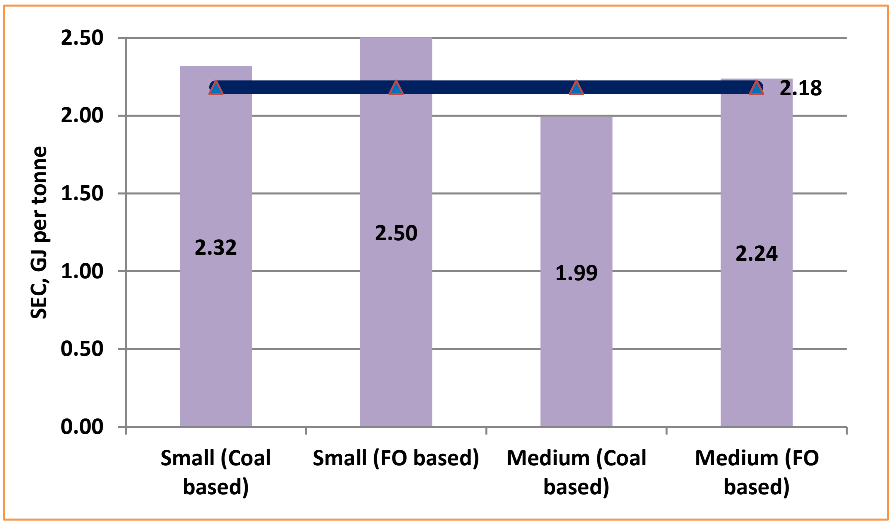


Figure 4.4.9.4: Performance of SRRM plants – Raipur Cluster

4.4.9.5 Relevant institutions for SRRM sub-sector

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to SRRM industries in Raipur district are given in table 4.4.9.5.

Table 4.4.9.5: Institutions involved in Raipur Clusters

Institution/ organization	Contact details	Objectives and roles
Raipur Iron & Steel Trade Association	RISTA C/o.308,3rd floor, Samta Shopping arcade,Samtacolony,Raipur-492001	Welfare activities and grievances redressal of member industries
Urla Industries Association	Urla Industrial Complex, Raipur 493221 Tel: 0771 2323850	Welfare activities and grievances redressal of member industries
Chhattisgarh State Renewable Energy Development Agency(CREDA)	2ndfloor, CSERC Building, Shanti Nagar, Raipur, Tel: 83700 09931 email: contact.creda@gov.in http://www.creda.in	Implementing schemes pertaining to renewable energy and energy conservation activities

4.4.9.6 Other information

The other information pertaining to cluster level initiatives include the following:

(1) United Nations Development Program (UNDP) has implemented a project on "Removal of Barriers to Energy Efficiency Improvement in the Steel Re-Rolling Mill Sector in India" which promotes energy efficiency in the cluster.

(2) On-going study by BEE focuses on energy efficiency and sectoral mapping for SRRM clusters.

4.4.9.7 Summary of findings

The summary of findings in Raipur is provided in table 4.4.9.7.

Table 4.4.9.7: Summary of findings in Raipur

Parameter	Remarks
Number of Non-DC category SRRM plants	102
Operating plants of Non-DC category	81
Total energy consumption	143,290 toe
SEC– Overall	2.2 GJ per tonne
GHG emissions	655,712 tonne CO_2 per year
Specific GHG emissions	0.2 tonne CO_2 per tonne
Other relevant information	• About 20% of units have temporarily closed due to pandemic and present units are operating at 60 - 70% installed capacity. • Study on-going pertaining to energy efficiency improvements by BEE • UNDP study on energy efficiency improvement study during the period 2004-2013

4.4.10 Tiruvallur

4.4.10.1 Background

Tiruvallur steel re-rolling mills cluster is situated in Tamil Nadu state is the largest cluster (based on number of units) in Southern part of India. There are about 27 numbers of SRRM plants of which 26 numbers of units fall under Non-DC category. Only one unit falls under potential DC unit due to presence of DRI and EIF process plant. Hence, this unit will not be considered for cluster level analysis. The total production of SRRM from 19 operating plants is estimated to be 0.8 million tonnes considering 69.8% of capacity utilization (source: JPC, 2020) as shown in table 4.4.10.1.Of the 27 numbers of total units, 11 units have been installed along with induction furnace for scrap melting. Only one unit has been installed with DRI and EIF plants.

Table 4.4.10.1: Production of Non-DC SRRM plants (Tiruvallur)

Unit Category	Installed Units	Operating units	Temporarily closed units
Small (<240 TPD)	20	14	6
Medium (>240 & <=1,200 TPD)	6	5	1
Larger units (>1,200 TPD)	1	1	0
Total*	26	19	7
Production (million tonne)*	1.0	0.8	0.2

** Excluding details of large category unit , Source: Analysis of JPC data, 2020*

4.4.10.2 Process technology

The SRRM units use re-heating furnaces along with pulverized coal and furnace oil as fuel. The brief details of technology used in production are provided in Table 4.4.10.2.

Table 4.4.10.2: Process technology used in SRRM plants – Tiruvallur

Technology	Purpose
Reheating furnace (coal, FO)	Heating steel feedstock to 1,200-1,250 °C for using in rolling process.
Rolling mill	Rolling slabs, ingots, billets, blooms to thinner and longer sizes through successive rolling mill stands driven by electric motors

4.4.10.3 Energy consumption analysis

Pulverized coal and furnace oil are the major fuels used in re-heating furnaces which accounts for about >80 - 85% of total energy consumption in SRRM manufacturing and the remaining energy consumption is in form of electricity mainly to meet electrical loads of these plants. The total energy consumption of SRRM plants under Non-DC category is 43,520 toe per year. This does not include energy consumption of induction furnaces which are exclusively used for production of raw materials used in steel rerolling mills. The equivalent GHG emissions are estimated to be 203,243 tonne CO_2 per year (Table 4.4.10.3).

Table 4.4.10.3: Energy consumption of Non-DC SRRM plants – Tiruvallur Cluster

Fuel	Energy consumption		GHG emissions (tonne CO_2/year)
	Quantity	Equivalent (toe/year)	
Coal	57,600 tonne	29,952	112,320
Furnace oil	6,109 kL	5,733	18,946
Electricity	91 mil kWh/year	7,836	71,978
Total		43,520	203,243

Note 1: Based on interaction with plant personnel 2) 300 days of operation

Coal contributes the majority energy share (69%). The share of energy consumption from different sources is provided in figure 4.4.10.3a.

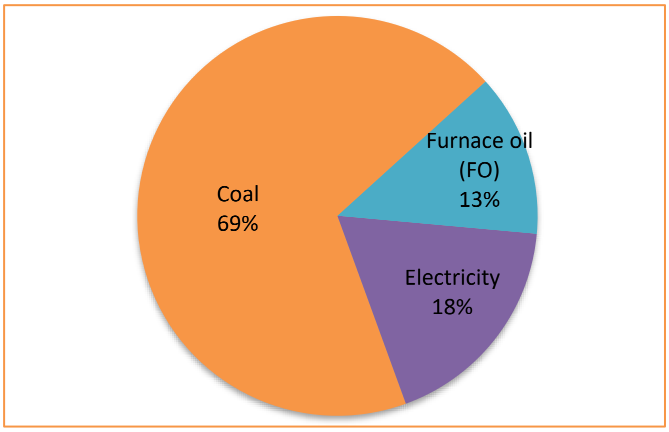


Figure 4.4.10.3a: Share of energy consumption source

The coal based small size category industries consumes maximum share of cluster level energy consumption (48%). The distribution of cluster level energy consumption by different category of industries is provided with figure 4.4.10.3b.

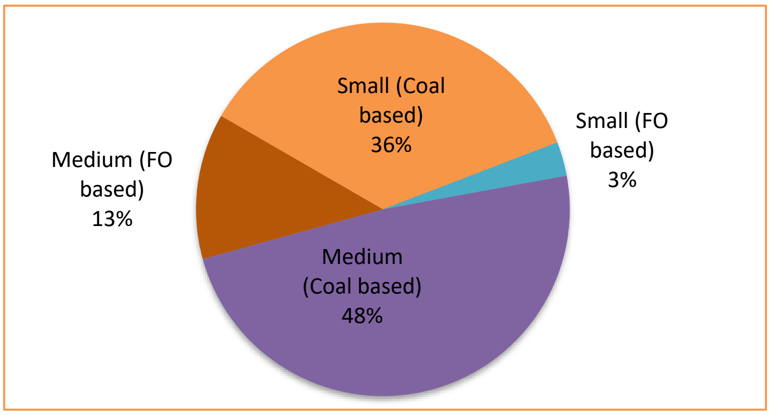


Figure 4.4.10.3b: Distribution of cluster level energy consumption

4.4.10.4 Performance of SRRM plants

The SEC for coal based units is in the range of 75- 90kg per tonne of metal, furnace oil based units is in the range of 45-55 litre per tonne metal and the SEC is in the range of 89 -120 kWh per tonne based on capacity of the unit. The overall SEC of SRRM plants is estimated to be 2.16 GJ per tonne (table 4.4.10.4).

Table 4.4.10.4: Performance of Non-DC SRRM plants - Tiruvallur

Type	SEC-Thermal (GJ/tonne)	SEC-Electrical (kWh/tonne)	SEC-Cluster (GJ/tonne)
Small (Coal based)	2.0	120	2.4
Small (FO based)	2.2	110	2.6
Medium (Coal based)	1.6	105	2.0
Medium (FO based)	1.8	89	2.1
Overall	1.8	108	2.2

The small (FO based) category units consumes maximum energy for producing per tonne of products, which is estimated to be 2.6 GJ per tonne (Figure 4.4.10.4).

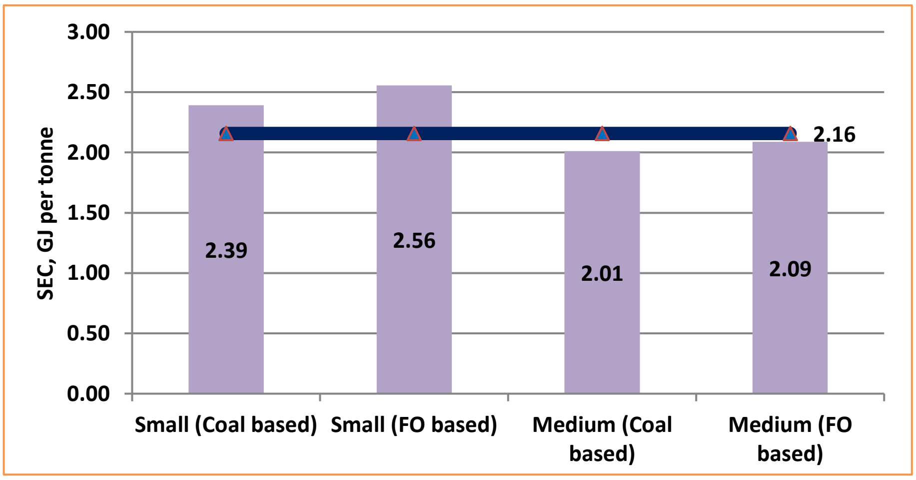


Figure 4.4.10.4: Performance of SRRM plants – Tiruvallur Cluster

4.4.10.5 Relevant institutions for SRRM sub-sector

There are no cluster specific industry associations. The details of state designated agencies (SDAs) are given in table 4.4.10.5.

Table 4.4.10.5: Institutions involved in Tiruvallur Clusters

Institution/ organization	Contact details	Objectives and roles
Chief Electrical Inspector to Govt. of Tamil Nadu	Electrical Inspectorate Department Government of Tamil Nadu Thiru Vi.Ka. Industrial Estate, Guindy, Chennai-600 032 Tel: 044 2250 0184 http://www.tnei.tn.gov.in/	• Coordinate, regulate and enforce efficient use of energy and its conservation

4.4.10.6 Other information

United Nations Development Program (UNDP) had implemented a project on “Removal of Barriers to Energy Efficiency Improvement in the Steel Re-Rolling Mill Sector in India” promoting energy efficiency in the cluster.

4.4.10.7 Summary of findings

The summary of findings in Tiruvallur is provided in table 4.4.10.7.

Table 4.4.10.7: Summary of findings in Tiruvallur

Parameter	Remarks
Number of Non-DC category SRRM plants	27
Operating plants of Non-DC category	25 (Excluding one large unit)
Total energy consumption	43,520 toe
SEC– Overall	2.2 GJ per tonne
GHG emissions	203,243 tonne CO_2 per year
Specific GHG emissions	0.2 tonne CO_2 per tonne
Other relevant information	UNDP conducted energy efficiency improvement study from 2004 to 2013

4.4.11 Others

4.4.11.1 Background

About 164 numbers of clusters where the number of units in operation is less than 20 are grouped under this section. There are 755 number of units of which 493 units are standalone units, 250 units are installed with EIF, 6 units with EAF and remaining 6 units with different upstream processes. Analysis of data from the cluster indicates that the energy consumption levels of 29 units fall above the threshold limit (20,000 toe) as set for PAT industries in the iron and steel sector. The energy consumption levels of these units are excluded from the analysis. The categorization of SRRM (Non-DCs) based on installed capacities is given in table 4.4.11.1.

Table 4.4.11.1: Production of Non-DC SRRM plants – Other clusters

Unit category	Installed units	Operating units	Temporarily closed units
Small (<240 TPD)	600	424	176
Medium (>240 & <=1,200 TPD)	126	107	19
Total	726	531	195
Production (million tonne)*	21.2	17.1	4.1

Source: Analysis of JPC data, 2020

4.4.11.2 Process technology

Most of the SRRM units use re-heating furnaces along with pulverized coal or furnace oil as fuel. The brief details of technology used in production are provided in table 4.4.11.2.

Table 4.4.11.2: Process technology used in SRRM plants – Other clusters

Technology	Purpose
Reheating furnace	Heating steel feedstock to about 1,200-1,250 °C for using in rolling process.
Rolling mill	Rolling slabs, ingots, billets, blooms to thinner and longer sizes through successive rolling mill stands driven by electric motors

4.4.11.3 Energy consumption analysis

Pulverized coal or FO are the major fuels used in re-heating furnaces which accounts for about 80-85% of total energy consumption in SRRM manufacturing and the remaining energy consumption is in form of electricity mainly to meet electrical loads of these plants. Some of the units are using producer gas as fuel for which the required data is not readily available. Since energy consumption details are not available for all clusters, the same was estimated assuming 90% of units are operating with pulverized coal and 10% of units on furnace oil.

The total energy consumption of SRRM plants under Non-DC category is 862,252 toe per year. This does not include energy consumption of induction furnaces which are exclusively used for production of raw materials used in steel rerolling mills. The equivalent GHG emissions are estimated to be 4.0 million tonne CO_2 per year (Table 4.4.11.3).

Table 4.4.11.3: Energy consumption of Non-DC SRRM plants – Other clusters

Fuel	Energy consumption		GHG emissions (million tonne CO_2/year)
	Quantity	Equivalent (toe/year)	
Coal	1,221,219 tonne	635,034	2.4
Furnace oil	88,542 kL	83,085	0.3
Electricity	1676 mil kWh/year	144,134	1.3
Total		862,252	4.0

Note: (1) Based on analysis of top 164 clusters; (2) 300 days of operation

4.4.11.4 Performance of SRRM plants

The specific fuel consumption for coal based units is in the range of 70-90 kg per tonne of metal, furnace oil based units is in the range of 50-60 litre per tonne of metal and the specific electricity consumption is in the range of 80 -110 kWh per tonne based on capacity of the unit. The overall specific energy consumption (SEC) is estimated to be 2.1 GJ per tonne as shown in table 4.4.11.4.

Table 4.4.11.4: Performance of Non-DC SRRM plants – Other clusters

Type	SEC-Thermal (GJ/tonne)	SEC-Electrical (kWh/tonne)	SEC-Cluster (GJ/tonne)
Small (Coal based)	2.0	110	2.4
Small (FO based)	2.4	100	2.7
Medium (Coal based)	1.5	90	1.9
Medium (FO based)	2.0	80	2.2
Overall	1.8	98	2.1

The small (FO based) category units consumes maximum energy for producing per tonne of products, which is estimated to be 2.7 GJ per tonne (Figure 4.4.9.1).

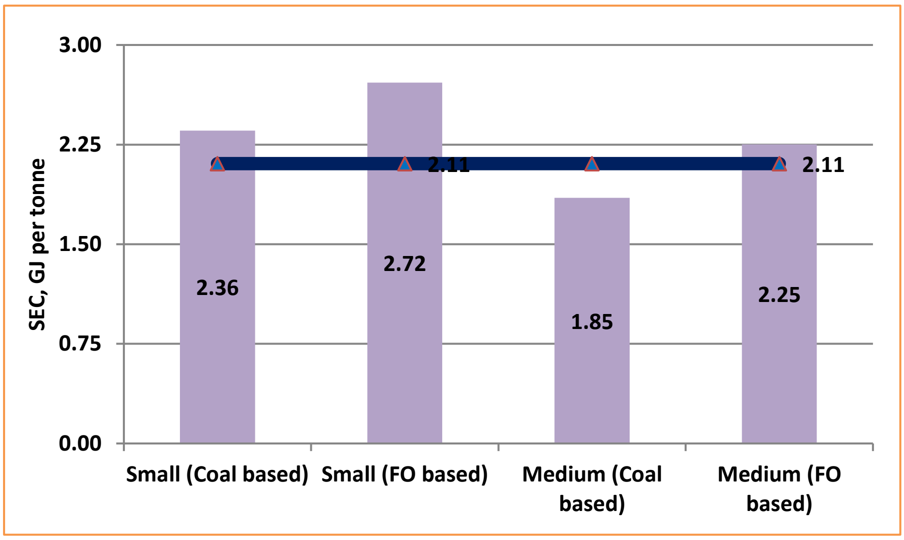


Figure 4.4.11.1: Performance of SRRM plants – Other Clusters

4.4.11.5 Relevant institutions for SRRM sub-sector

Since the industries are scattered in other clusters, details of institutions are not provided in this report.

4.4.11.6 Other information

United Nations Development Program (UNDP) has implemented a project on "Removal of Barriers to Energy Efficiency Improvement in the Steel Re-Rolling Mill Sector in India" which promotes energy efficiency in various clusters across India. Baseline audit was conducted for many clusters under this programme.

4.4.11.7 Summary of findings

The summary of findings for all other clusters is provided in table 4.4.11.7.

Table 4.4.11.7: Summary of findings – other clusters

Parameter	Remarks
Number of Non-DC category plants	726
Operating plants of Non-DC category	531 (excluding potential DCs)
Total energy consumption	862,252 toe
SEC– Overall	2.1 GJ per tonne
GHG emissions	4.0 million tonne CO_2 per year
Specific GHG emissions	0.2 tonne CO_2 per tonne
Other relevant information	UNDP conducted energy efficiency improvement study from 2004 to 2013

4.4.12 Summary of energy analysis of re-rolling plants

A study of re-rolling segment shows that there are a total of 1,313 re-rolling plants in India. About 1,257 units belong to Non-DC category. The total production of 972 working SRRM plants was 34.3 million tonne during 2019-20.The total energy consumption is estimated to be 3.0 million toe per year with an equivalent GHG emissions of 8.1 million tonne CO_2 (table 4.4.12).

The following considerations and assumptions were made while undertaking analysis of the sub-sector.

- The average capacity utilization of re-rolling sector is 69.8% (source: Analysis of JPC, 2020 data)
- The average specific electricity consumption of re-rolling units is about 100 kWh per tonne ranging between 60 to 120 kWh per tonne for different capacities of mills (source: Secondary data and interaction with stakeholders).
- Standard energy values and emission factors were used for estimating energy consumption and GHG emissions respectively.

Table 4.4.12: Summary of energy analysis of steel re-rolling plants

S No	Cluster	Number of Non-DC SRRM plants		Capacity (MTPA)	Production (MTPA)	Energy consumption (toe/year)	GHG emissions (tonne-CO_2/ year)
		Total	Operating				
1	Fatehgarh Sahib	142	132	4.0	2.7	129,510	572,245
2	Raipur	102	81	4.6	2.7	143,290	655,712
3	Ludhiana	81	72	2.8	1.7	89,504	412,275
4	Mehsana	32	28	0.6	0.4	25,674	119,826
5	Bhavnagar	46	22	0.6	0.3	19,587	92,370
6	Indore	22	22	0.2	0.1	16,474	73,967
7	Jalna	25	21	1.8	1.2	29,562	137,494
8	Tiruvallur	27	20	1.9	1.2	43,520	203,243

S No	Cluster	Number of Non-DC SRRM plants Total	Operating	Capacity (MTPA)	Production (MTPA)	Energy consumption (toe/year)	GHG emissions (tonne-CO_2/year)
9	Bardhaman	25	20	3.8	2.2	54,580	251,097
10	Others	755	554	39.2	21.7	862,252	3,979,963
	Total	1,257	972	59.4	34.3	1,413,954	6,498,193

The global SEC level of steel rerolling industries is reported to be 1.3 GJ per tonne (source: Industrial energy efficiency project: Benchmarking report for the iron and steel sector, UNIDO-GEF, 2014)

4.4.13 Cluster selection in steel re-rolling mills sub-sector

4.4.13.1 Selection matrix

The study considered a number of attributes with relevant criteria and score for ranking of the clusters. These attributes are provided in table 4.7.13.1. More details of selection matrix at cluster level are provided in annexure 2.

Table 4.4.13.1: Selection criteria for Steel Re-rolling Mills sub-sector

S No	Attribute	Criteria	Score
1	Number of units	• <= 20 • 21-30 • 31-40 • > 40	2.5 5.0 7.5 10.0
2	Specific energy consumption, GJ per tonne	• <1.50 • 1.51-2.00 • 2.01-2.50 • >2.50	2.5 5.0 7.5 10.0
3	Variability (raw material, technology, fuel, product, etc.)	• One variable • Two variables • Three variables • More than three variables	2.5 5.0 7.5 10.0
4	GHG emission share	• Less than 5% • 5-10% • 11-15% • > 15%	2.5 5.0 7.5 10.0
5	Prior/on-going activities on energy efficiency at cluster level	• Replication of EE measures • Demonstration undertaken • Cluster level studies conducted • No activities on energy efficiency	2.5 5.0 7.5 10.0
6	Availability of industry association in the cluster	• No industry association • One industry association • More than one association • Industry association, SPVs, etc.	2.5 5.0 7.5 10.0

4.4.13.2 Summary of findings

Based on the attributes and criteria, the project has short-listed Raipur (Chhattisgarh) and Mandi Gobindgarh (Punjab) for further planning and deep-diving on energy efficiency activities in SRRM industries (table 4.4.13.2). Mandi Gobindgarh has been given ranking "2" considering the number of units and total energy consumption as compared to Ludhiana.

Table 4.4.13.2: Shortlisted clusters for deep-diving in steel re-rolling mills sub-sector

Cluster	State	Score	Ranking
Raipur	Chhattisgarh	42.5	1
Mandi Gobindgarh	Punjab	40.0	2
Ludhiana	Punjab	40.0	2
Tiruvallur	Tamil Nadu	37.5	4
Bardhaman	West Bengal	37.5	4
Bhavnagar	Gujarat	35.0	6
Indore	Madhya Pradesh	35.0	6
Mehsana	Gujarat	35.0	6
Jalna	Maharashtra	32.5	9

4.5 Sponge iron industries

4.5.1 Background

The direct reduction of iron (DRI) is one of the routes used for steel manufacturing in India. The deployment of DRI technology in India is driven due to factors such as (i) availability of domestic coal reserves, (ii) lack of sufficient domestic natural gas supplies and (iii) availability of coking coal. The coal-based DRI process caters mainly to the localized steel demands of the country.

4.5.1.1 Spread of sponge iron plants, products and production

There are about 333 DRI based plants in India spread across 12 different states (JPC, 2019-20). Within each state, the DRI plants are scattered across the districts; and do not exist as clusters in majority of the states (table 4.5.1.1a).

Table 4.5.1.1a: Spread of sponge iron industries in India

S No	State	District/cluster	Number of plants
1.1	Andhra Pradesh	Ananthapur	3
1.2		Krishna	1
1.3		Others-AP	3
2.1	Chhattisgarh	Bilaspur	6
2.2		Durg	2
2.3		Raigarh	17
2.4		Raipur	45
2.5		Rajnandgaon	1
3.1	Goa	South Goa	3
4.1	Gujarat	Kutch	6
4.2		Surat	1
5.1	Jharkhand	Dhanbad	1
5.2		East Singhbhum	7
5.3		Giridih	9
5.4		Hazaribagh	4
5.5		Koderma	2
5.6		Lohardaga	1
5.7		Ramgarh	6
5.8		Ranchi	4
5.9		Seraikela	8
5.10		West Singhbhum	3
6.1	Karnataka	Bellary	26
6.2		Chitradurga	1
6.3		Koppal	9
6.4		Tumkur	1
7.1	Maharashtra	Bhandara	1
7.2		Chandrapur	3
7.3		Kolhapur	1
7.4		Nagpur	2
7.5		Raigad	1

S No	State	District/cluster	Number of plants
8.1	Odisha	Angul	2
8.2		Cuttack	3
8.3		Dhenkanal	3
8.4		Jajpur	4
8.5		Jharsuguda	9
8.6		Kendujhar	15
8.7		Sambalpur	6
8.8		Sunderghar	43
9.1	Tamil Nadu	Erode	2
9.2		Tiruvallur	4
9.3		Kanchipuram	1
10.1	Telangana	Medak	1
10.2		Mahbubnagar	6
10.3		Nalgonda	1
10.4		Hyderabad	4
10.5		Sangareddy	1
11.1	Uttar Pradesh	Uttar Pradesh	4
12.1	West Bengal	Bankura	7
12.2		Bardhaman	23
12.3		East Medinipur	2
12.4		Purulia	11
12.5		West Medinipur	2
12.6		Others	1
		Total	333

Source: Analysis of JPC data 2019-20

A majority of the DRI plants (284 plants) are concentrated in 5 states namely Chhattisgarh, Jharkhand, Odisha, Karnataka and West Bengal (table 4.5.1.1b). These states account for 85% of total population of DRI plants and about 73% of total installed capacity of sponge iron plants (Figure 4.5.1.1a).

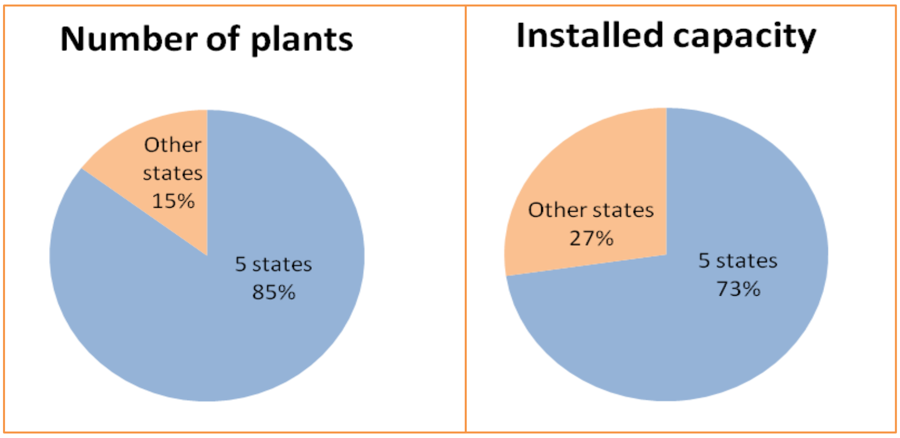


Figure 4.5.1.1a: Distribution of DRI plants

Table 4.5.1.1b: Details of sponge iron industries in identified states

Parameter	Details
States of major concentration of DRIs	Chhattisgarh, Jharkhand, Odisha, Karnataka and West Bengal
Total number of DRI plants in the five states	284 plants
Total number of DRI plants in the other states	49 plants
Total installed capacity of DRI plants in the five states	37.9 million tonne

Source: JPC, 2019-20

About 110 DRI plants are presently covered under the 'perform, achieve and trade' (PAT) scheme of the Bureau of Energy Efficiency (BEE). The threshold limit of energy consumption for iron & steel industry is presently 20,000 tonne of oil equivalent per year. The composite steel plants have employed downstream processes such as 'electric arc furnace' (EAF)/ 'electric induction furnace' (EIF) and/or rolling processes to manufacture various finish products (figure 4.5.1.1b). The energy consumption level of the downstream processes is dependent on type of product, process and technology use and production level, which may vary widely within different plants. Therefore, this mapping report shall be focusing only on direct reduction process i.e. sponge iron production for such integrated steel plants.

Figure 4.5.1.1b: Focus area in integrated steel plants

4.5.1.2 Process description and technology use

In DRI process, metallic iron is directly produced by reduction of iron ore in solid state at temperature below the melting point of iron. The reduction of iron ore is achieved using either carbon-bearing material (non-coking coal) or suitable reducing gas (natural gas). Most of the smaller capacity DRI plants in India use coal as fuel and reducing agent. The process steps involved in sponge iron production include (1) reduction of iron ore to sponge iron, (2) cooling of sponge iron, and (3) electro-magnetic separation and screening.

Reduction of iron ore to sponge iron

The iron ore and non-coking coal are reduced to the required size in crushers. The raw materials comprising iron ore, coal, and dolomite are fed into the kiln continuously from feed end. Fine coal is injected at the discharge end of the kiln to meet additional carbon requirements for the reactions. The feed mixture gradually picks up heat from the hot gases flowing in the opposite direction.

In the preheating zone, moisture and volatile matter in feed mixture are removed. In the reduction zone, oxygen present in the iron ore dissociates and oxidizes reducing carbon element in non-coking coal to form carbon monoxide, leaving the metallic iron. A temperature of about 900–1050 °C is maintained in the reduction zone. The reduction of iron ore occurs in solid state with the critical factor being 'controlled combustion of coal' towards formation of carbon monoxide. The residence time for iron ore inside the kiln is about 8–10 hours to form metallic iron. The rotation of the kiln and its slope ensure better mixing and movement of charge towards discharge end of the kiln at the required rate.

Cooling of sponge iron

The sponge iron with char, spent lime, and ash are transferred to a water-cooled rotary cooler, wherein the temperature of kiln discharge to about 100–120°C, which would help in avoiding re-oxidation of sponge iron.

Electro-magnetic separation and screening

The discharge material from the rotary cooler is transferred for screening of fines and coarse materials. The discharge material is passed through an electro-magnetic separator to separate out sponge iron from char and other impurities. It is screened in size fraction to separate lumps and fines.

4.5.1.3 Raw materials, products and production

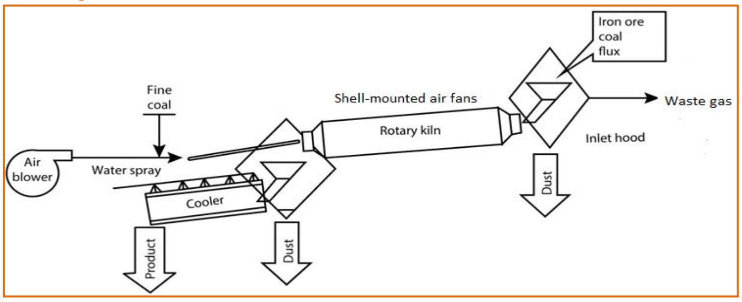


Figure 4.5.1.3 Coal based rotary kiln for sponge iron production

The raw materials used in DRI plants are iron ore (hematite - Fe_2O_3), non-coking coal and limestone/ dolomite. Hematite, rich in iron content of 65% or more is preferred in sponge iron plants. Iron ore is used in the form of lumps or pellets. Non-coking coal is used for heating and reduction reaction. Sponge iron produced through DRI process has an iron content of 80-85%. The average capacity utilization of DRI plants in India during 2019-20 was 77.7% (JPC, 2020). There are about 223 DRI plants which fall under Non-DC category. Of these, the number of operating industries was 181. The total estimated production of DRI plants of Non-DC category is estimated to be 14.14 million tonne (2019-20) as shown in table 4.5.1.3.

Table 4.5.1.3: Details of Non-DC DRI plants in India

Total number of plants	223
Plants in operation	181
Estimated production (million tonne)	14.1

Source: JPC data analysis, 2020

4.5.1.4 Other countries producing sponge iron

The major producing countries of sponge iron other than India are shown in table 4.5.1.4.

Table 4.5.1.4: Other sponge iron producing countries (2020)

Country	Sponge iron production (million tonne)
Iran	30.2
Russia	8.5
Mexico	5.2
Saudi Arabia	5.2
Egypt	4.8

Source: Word Steel Association

4.5.1.5 Institutions at national level

The Sponge Iron Manufacturers Association (SIMA) is the apex body at national level dealing with DRI plants. The roles of SIMA are shown in table 4.5.1.5.

Table 4.5.1.5: Roles of institutions

Organization	Contact details	Roles
Sponge iron manufacturers Association (SIMA)	1501, Hemkunt Tower, 98, Nehru Place, New Delhi - 110019 Tel: 011 41619204, 26294492 email: : dkashiva@sima.co.in http://www.spongeironindia.com/	• Establishing the leadership in sponge iron manufacturing. • Working towards projecting achievements, policy related problems & technological update of the Indian sponge iron industry on various forums. • Providing opportunities and exposure to its members in domestic and international technological developments/ innovations in manufacturing, raw materials, energy, environment, etc. related issues.

4.5.1.6 Coverage of states

An analysis of energy consumption estimates of DRI plants, which are not covered under PAT scheme is provided in following section. The analysis includes the following states:

1) Chhattisgarh
2) Jharkhand
3) Karnataka
4) Odisha
5) West Bengal
6) Others (include other states producing sponge iron)

4.5.2 Chhattisgarh state

4.5.2.1 Background

There are a total of 71 DRI plants of which 34 units are of Non-DC category type. The total production of sponge iron from 32 operating plants is estimated to be 1.7 million tonne considering 77.7% of capacity utilization (source: JPC, 2020) as shown in table 4.5.2.1.

Table 4.5.2.1: Production of Non-DC DRI plants (Chhattisgarh)

Parameters	Value
Total number of plants	71
Plants covered under PAT	37
Number of Non-DC plants	34
Non-DC plants (operating)	32
Estimated production (million tonne)	1.7

Source: Analysis of JPC data, 2020

4.5.2.2 Process technology

The DRI units use rotary kilns with non-coking coal used as fuel as well as reducing agent. The brief details of technology used in sponge iron production in Chhattisgarh state are provided in table 4.5.2.2.

Table 4.5.2.2: Process technology used in DRI plants (Chhattisgarh)

Technology	Purpose
Rotary kiln (coal fired)	Producing iron ore to sponge iron through direct reduction without melting at about 900-1050 °C.
Rotary cooler	Indirect water cooling of sponge iron to avoid re-oxidation
Electro-magnetic separator and screening	Separating sponge iron and sizing

4.5.2.3 Energy consumption analysis

Non-coking coal is used in the DRI process for heating and reduction processes in rotary kiln. The rotary kilns account for about 98% of total energy consumption in DRI manufacturing. Electricity is mainly used to meet electrical loads of these plants. The total energy consumption of DRI plants under Non-DC category is 0.9 million toe per year. The equivalent GHG emissions are estimated to be 3.6 million tonne CO_2 per year (Table 4.5.2.3).

Table 4.5.2.3: Energy consumption of Non-DC DRI plants (Chhattisgarh)

Fuel	Energy consumption		GHG emissions (million tonne CO_2/year)
	Quantity	Equivalent million toe/year	
Coal	1.7 million tonne	0.9	3.5
Electricity	118 mil kWh/year	0.01	0.1
	Total	0.9	3.6

4.5.2.4 Performance of DRI plants

The specific coal consumption of coal-based DRI plant varies between 0.9-1.1 tonne per tonne sponge iron with the average specific coal consumption of 1.0 tonne per tonne sponge iron. And, the average specific electricity consumption is 70 kWh per tonne of sponge iron. These values were arrived at based on interaction with industries, sectoral experts and technology suppliers. The overall specific energy consumption (SEC) of DRI plants is estimated to be 22.0 GJ per tonne as shown in table 4.5.2.4.

Table 4.5.2.4: Performance of Non-DC DRI plants (Chhattisgarh)

Parameter	Value
SEC- Thermal	21.8 GJ per tonne (or) 1 tonne coal* per tonne sponge iron
SEC – Electrical	70 kWh per tonne
SEC- Overall	22.0 GJ per tonne
Specific GHG emissions	2.1 tonne CO_2 per tonne sponge iron

* *considered 5200 kcal per kg as gross calorific value of coal*

4.5.2.5 Relevant institutions for DRI sub-sector

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to sponge iron industries in Chhattisgarh state are given in table 4.5.2.5.

Table 4.5.2.5: Institutions involved in Chhattisgarh state

Institution/ organization	Contact details	Objectives and roles
Chhattisgarh Sponge Iron Manufacturers Association	2nd floor, Room No. 208, Desbandhu press complex, Samta colony, Raipur, Chhattisgarh – 492001 Tel: 01481 4035590	• Welfare and grievances redressal of member industries
Chhattisgarh State Renewable Energy Development Agency(CREDA)	2ndfloor, CSERC Building Shanti Nagar, Raipur Tel: 83700 09931 email: contact.creda@gov.in http://www.creda.in	• Implementing schemes pertaining to renewable energy and energy conservation activities

4.5.2.6 Other information

There are no specific energy efficiency related studies carried out or on-going with a focus on sponge iron industries in Chhattisgarh state.

4.5.2.7 Summary of findings

The summary of findings of DRI plants in Chhattisgarh state is provided in table 4.5.2.7.

Table 4.5.2.7: Summary of findings of DRI plants in Chhattisgarh state

Parameter	Remarks
Number of Non-DC category DRI plants	34
Operating plants of Non-DC category	32
Total energy consumption	0.9 million toe
SEC– Overall	22.0 GJ per tonne
GHG emissions	3.6 million tonne CO_2 per year
Specific GHG emissions	2.1 tonne CO_2 per year
Other relevant information	No specific study conducted or on-going pertaining to energy efficiency improvements

4.5.3 Jharkhand state

4.5.3.1 Background

There are a total of 45 DRI plants of which 39 units are of Non-DC category type. The total production of sponge iron from 26 operating plants is estimated to be 2.4 million tonne considering 77.7% of capacity utilization (source: JPC, 2020) as shown in table 4.5.3.1.

Table 4.5.3.1: Production of Non-DC DRI plants (Jharkhand)

Parameters	Value
Total number of plants	45
Plants covered under PAT	6
Number of Non-DC plants	39
Non-DC plants (operating)	26
Estimated production (million tonne)	2.4

Source: Analysis of JPC data, 2020

4.5.3.2 Process technology

The DRI units use rotary kilns with non-coking coal used as fuel as well as reducing agent. The brief details of technology used in sponge iron production in Jharkhand state are provided in Table 4.5.3.2.

Table 4.5.3.2: Process technology used in DRI plants (Jharkhand)

Technology	Purpose
Rotary kiln(coal fired)	Producing iron ore to sponge iron through direct reduction without melting at about 900-1050 ˚C.
Rotary cooler	Indirect water cooling of sponge iron to avoid re-oxidation
Electro-magnetic separator and screening	Separating sponge iron and sizing

4.5.3.3 Energy consumption analysis

Non-coking coal is used in the DRI process for heating and reduction processes in rotary kiln. The rotary kilns account for about 98% of total energy consumption in DRI manufacturing. Electricity is mainly used to meet electrical loads of these plants. The total energy consumption of DRI plants under Non-DC category 1.3 million toe per year. The equivalent GHG emissions are estimated to be 5.1 million tonne CO_2 per year (Table 4.5.3.3).

Table 4.5.3.3: Energy consumption of Non-DC DRI plants (Jharkhand)

Fuel	Energy consumption		GHG emissions (million tonne CO_2/year)
	Quantity	Equivalent million toe/year	
Coal	2.4 million tonne	1.3	5.0
Electricity	169 mil kWh/year	0.01	0.1
	Total	1.3	5.1

4.5.3.4 Performance of DRI plants

The specific coal consumption of coal-based DRI plant varies between 0.9-1.1 tonne per tonne sponge iron with the average specific coal consumption of 1.0 tonne per tonne sponge iron. And, the average specific electricity consumption is 70 kWh per tonne of sponge iron. These values were arrived at based on interaction with industries, sectoral experts and technology suppliers. The overall specific energy consumption (SEC) of DRI plants is estimated to be 22.0 GJ per tonne as shown in table 4.5.3.4.

Table 4.5.3.4: Performance of Non-DC DRI plants (Chhattisgarh)

Parameter	Value
SEC- Thermal	21.8 GJ per tonne (or) 1 tonne coal* per tonne sponge iron
SEC – Electrical	70 kWh per tonne
SEC- Overall	22.0 GJ per tonne
Specific GHG emissions	2.1 tonne CO_2 per tonne sponge iron

* *considered 5200 kcal per kg as gross calorific value of coal*

4.5.3.5 Relevant institutions for DRI sub-sector

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to sponge iron industries in Jharkhand state are given in table 4.5.3.5.

Table 4.5.3.5: Institutions involved in Jharkhand state

Institution/ organization	Contact details	Objectives and roles
Jharkhand Small Industry Association	19A, Udyog Bhavan, Industrial Area, Kokar Ranchi – 834 001 Jharkhand Tel: 0651 254 5234 http://www.jsia.co.in/home-2	• Promote R&D, technological upgradation, qualitative improvement and utilization of state of art technologies to improve product, production and productivity.
Jharkhand Renewable Energy Development Agency (JREDA)	3rd floor, SLDC Building, Kusai Colony, Doranda, Ranchi – 834 002 Jharkhand Tel: 0651 249 1161 Email: info@jreda.com https://www.jreda.com	• Implementation and monitoring of energy efficiency projects • Promoting energy efficient technologies • Coordinating energy efficiency activities with state government departments and industry • Capacity building • Facilitating conduction of energy audits • Comply with energy consumption norms and standards • Preparing and implementing schemes for efficient use of energy and its conservation.

4.5.3.6 Other information

There are no specific energy efficiency related studies carried out or on-going with a focus on sponge iron industries in Jharkhand state.

4.5.3.7 Summary of findings

The summary of findings of DRI plants in Jharkhand state is provided in table 4.5.3.7.

Table 4.5.3.7: Summary of findings of DRI plants in Jharkhand state

Parameter	Remarks
Number of Non-DC category DRI plants	39
Operating plants of Non-DC category	26
Total energy consumption	1.3 million toe
SEC– Overall	22.0 GJ per tonne
GHG emissions	5.1 million tonne CO_2 per year
Specific GHG emissions	2.1 tonne CO_2 per year
Other relevant information	No specific study conducted or on-going pertaining to energy efficiency improvements

4.5.4 Karnataka state

4.5.4.1 Background

There are a total of 37 DRI plants of which 25 units are of Non-DC category type. The total production of sponge iron from 22 operating plants is estimated to be 1.1 million tonne considering 77.7% of capacity utilization (source: JPC, 2020) as shown in table 4.5.4.1.

Table 4.5.4.1: Production of Non-DC DRI plants (Karnataka)

Parameters	Value
Total number of plants	37
Plants covered under PAT	12
Number of Non-DC plants	25
Non-DC plants (operating)	22
Estimated production (million tonne)	1.1

Source: Analysis of JPC data, 2020

4.5.4.2 Process technology

The DRI units use rotary kilns with non-coking coal used as fuel as well as reducing agent. The brief details of technology used in sponge iron production in Karnataka state are provided in table 4.5.4.2.

Table 4.5.4.2: Process technology used in DRI plants (Karnataka)

Technology	Purpose
Rotary kiln (coal fired)	Producing iron ore to sponge iron through direct reduction without melting at about 900-1050 °C.
Rotary cooler	Indirect water cooling of sponge iron to avoid re-oxidation
Electro-magnetic separator and screening	Separating sponge iron and sizing

4.5.4.3 Energy consumption analysis

Non-coking coal is used in the DRI process for heating and reduction processes in rotary kiln. The rotary kilns account for about 98% of total energy consumption in DRI manufacturing. Electricity is mainly used to meet electrical loads of these plants. The total energy consumption of DRI plants under Non-DC category is 0.6 million toe per year. The equivalent GHG emissions are estimated to be 2.3 million tonne CO_2 per year (Table 4.5.4.3).

Table 4.5.4.3: Energy consumption of Non-DC DRI plants (Karnataka)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent, million toe/year	(million tonne CO_2/year)
Coal	1.1 million tonne	0.6	2.2
Electricity	74 mil kWh/year	0.01	0.1
	Total	0.6	2.3

4.5.4.4 Performance of DRI plants

The specific coal consumption of coal-based DRI plant varies between 0.9-1.1 tonne per tonne sponge iron with the average specific coal consumption of 1.0 tonne per tonne sponge iron. And, the average specific electricity consumption is 70 kWh per tonne of sponge iron. The overall specific energy consumption (SEC) of DRI plants is estimated to be 22.0 GJ per tonne as shown in table 4.5.4.4.

Table 4.5.4.4: Performance of Non-DC DRI plants (Karnataka)

Parameter	Value
SEC- Thermal	21.8 GJ per tonne (or) 1 tonne coal* per tonne sponge iron
SEC – Electrical	70 kWh per tonne
SEC- Overall	22.0 GJ per tonne
Specific GHG emissions	2.1 tonne CO_2 per tonne sponge iron

* *considered 5200 kcal per kg as gross calorific value of coal*

4.5.4.5 Relevant institutions for DRI sub-sector

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to sponge iron industries in Karnataka state are given in table 4.5.4.5.

Table 4.5.4.5: Institutions involved in Karnataka state

Institution/ organization	Contact details	Objectives and roles
Karnataka Sponge Iron Manufacturers' Association	Details not available	• Welfare and grievance redressal of member industries
Karnataka Renewable Energy Development Limited (KREDL)	39, Shanthi Gruha, Bharath Scouts & Guides Building, Palace Road, Bengaluru – 560 001, Tel: 080 2220 7851 email: kredl09ec@gmail.com http://www.kredlinfo.in	• To conserve energy through energy efficiency and energy conservation measures in all sectors.

4.5.4.6 Other information

There are no specific energy efficiency related studies carried out or on-going with a focus on sponge iron industries in Karnataka state.

4.5.4.7 Summary of findings

The summary of findings of DRI plants in Karnataka state is provided in table 4.5.4.7.

Table 4.5.4.7: Summary of findings of DRI plants in Karnataka state

Parameter	Remarks
Number of Non-DC category DRI plants	25
Operating plants of Non-DC category	22
Total energy consumption	0.6 million toe
SEC– Overall	22.0 GJ per tonne
GHG emissions	2.3 million tonne CO_2 per year
Specific GHG emissions	2.1 tonne CO_2 per year
Other relevant information	No specific study conducted or on-going pertaining to energy efficiency improvements

4.5.5 Odisha state

4.5.5.1 Background

There are a total of 85 DRI plants of which 58 units are of Non-DC category type. The total production of sponge iron from 51 operating plants is estimated to be 4.0 million tonne considering 77.7% of capacity utilization (source: JPC, 2020) as shown in table 4.5.5.1.

Table 4.5.5.1: Production of Non-DC DRI plants (Odisha)

Parameters	Value
Total number of plants	85
Plants covered under PAT	27
Number of Non-DC plants	58
Non-DC plants (operating)	51
Estimated production (million tonne)	4.0

Source: Analysis of JPC data, 2020

4.5.5.2 Process technology

The DRI units use rotary kilns with non-coking coal used as fuel as well as reducing agent. The brief details of technology used in sponge iron production in Odisha state are provided in table 4.5.5.2.

Table 4.5.5.2: Process technology used in DRI plants (Odisha)

Technology	Purpose
Rotary kiln(coal fired)	Producing iron ore to sponge iron through direct reduction without melting at about 900-1050 ^{0}C.
Rotary cooler	Indirect water cooling of sponge iron to avoid re-oxidation
Electro-magnetic separator and screening	Separating sponge iron and sizing

4.5.5.3 Energy consumption analysis

Non-coking coal is used in the DRI process for heating and reduction processes in rotary kiln. The rotary kilns account for about 98% of total energy consumption in DRI manufacturing. Electricity is mainly used to meet electrical loads of these plants. The total energy consumption of DRI plants under Non-DC category is 2.1 million toe per year. The equivalent GHG emissions are estimated to be 8.5 million tonne CO_2 per year (Table 4.5.5.3).

Table 4.5.5.3: Energy consumption of Non-DC DRI plants (Odisha)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent million toe/year	(million tonne CO_2/year)
Coal	4.0 million tonne	2.1	8.3
Electricity	279 mil kWh/year	0.02	0.2
	Total	2.1	8.5

4.5.5.4 Performance of DRI plants

The specific coal consumption of coal-based DRI plant varies between 0.9-1.1 tonne per tonne sponge iron with the average specific coal consumption of 1.0 tonne per tonne sponge iron. And, the average specific electricity consumption is 70 kWh per tonne of sponge iron. These values were arrived at based on interaction with industries, sectoral experts and technology suppliers. The overall SEC of DRI plants is estimated to be 22.0 GJ per tonne as shown in table 4.5.5.4.

Table 4.5.5.4: Performance of Non-DC DRI plants (Odisha)

Parameter	Value
SEC- Thermal	21.8 GJ per tonne (or) 1 tonne coal* per tonne sponge iron
SEC – Electrical	70 kWh per tonne
SEC- Overall	22.0 GJ per tonne
Specific GHG emissions	2.1 tonne CO_2 per tonne sponge iron

* *considered 5200 kcal per kg as gross calorific value of coal*

4.5.5.5 Relevant institutions for DRI sub-sector

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to sponge iron industries in Odisha state are given in table 4.5.5.5.

Table 4.5.5.5: Institutions involved in Odisha state

Institution/ organization	Contact details	Objectives and roles
Orissa Sponge iron manufacturers' Association	A/8,Palashpalli, Bhubaneswar- 751 020	• Welfare activities and grievance redressal of member industries
Department of Energy, Government of Odisha	2nd Floor, Kharavel Bhawan Gopabandhu Marg, Keshari Nagar, Bhubaneswar, Odisha 751001	• Aims at planning, developing, managing and advising the

	Tel: 0674 2536960, 2396605, 2322240 https://energy.odisha.gov.in	government scheme under Department of Energy. • Establish policies necessary for effective and efficient implementation of the government programme.

4.5.5.6 Other information

There are no specific energy efficiency related studies carried out or on-going with a focus on sponge iron industries in Odisha state.

4.5.5.7 Summary of findings

The summary of findings of DRI plants in Odisha state is provided in table 4.5.5.7.

Table 4.5.5.7: Summary of findings of DRI plants in Odisha state

Parameter	Remarks
Number of Non-DC category DRI plants	58
Operating plants of Non-DC category	51
Total energy consumption	2.1 million toe
SEC– Overall	22.0 GJ per tonne
GHG emissions	8.5 million tonne CO_2 per year
Specific GHG emissions	2.1 tonne CO_2 per year
Other relevant information	No specific study conducted or on-going pertaining to energy efficiency improvements

4.5.6 West Bengal state

4.5.6.1 Background

There are a total of 46 DRI plants of which 37 units are of Non-DC category type. The total production of sponge iron from 27 operating plants is estimated to be 1.9million tonne considering 77.7% of capacity utilization (source: JPC, 2020) as shown in table 4.5.6.1.

Table 4.5.6.1: Production of Non-DC DRI plants (West Bengal)

Parameters	Value
Total number of plants	46
Plants covered under PAT	9
Number of Non-DC plants	37
Non-DC plants (operating)	27
Estimated production (million tonne)	1.9

Source: Analysis of JPC data, 2020

4.5.6.2 Process technology

The DRI units use rotary kilns with non-coking coal used as fuel as well as reducing agent. The brief details of technology used in sponge iron production in West Bengal state are provided in Table 4.5.6.2.

Table 4.5.6.2: Process technology used in DRI plants (West Bengal)

Technology	Purpose
Rotary kiln(coal fired)	Producing iron ore to sponge iron through direct reduction without melting at about 900-1050 ^{0}C.
Rotary cooler	Indirect water cooling of sponge iron to avoid re-oxidation
Electro-magnetic separator and screening	Separating sponge iron and sizing

4.5.6.3 Energy consumption analysis

Non-coking coal is used in the DRI process for heating and reduction processes in rotary kiln. The rotary kilns account for about 98% of total energy consumption in DRI manufacturing. Electricity is mainly used to meet electrical loads of these plants. The total energy consumption of DRI plants under Non-DC category is 1.0 million toe per year. The equivalent GHG emissions are estimated to be 4.1 million tonne CO_2 per year (Table 4.5.6.3).

Table 4.5.6.3: Energy consumption of Non-DC DRI plants (West Bengal)

Fuel	Energy consumption		GHG emissions (million tonne CO_2/year)
	Quantity	Equivalent million toe/year	
Coal	1.9 million tonne	1.0	4.0
Electricity	136 mil kWh/year	0.01	0.1
	Total	1.0	4.1

4.5.6.4 Performance of DRI plants

The specific coal consumption of coal-based DRI plant varies between 0.9-1.1 tonne per tonne sponge iron with the average specific coal consumption of 1.0 tonne per tonne sponge iron. And, the average specific electricity consumption is 70 kWh per tonne of sponge iron. These values were arrived at based on interaction with industries, sectoral experts and technology suppliers. The overall specific energy consumption (SEC) of DRI plants is estimated to be 22.0 GJ per tonne as shown in table 4.5.6.4.

Table 4.5.6.4: Performance of Non-DC DRI plants (West Bengal)

Parameter	Value
SEC- Thermal	21.8 GJ per tonne (or) 1 tonne coal* per tonne sponge iron
SEC – Electrical	70 kWh per tonne
SEC- Overall	22.0 GJ per tonne
Specific GHG emissions	2.1 tonne CO_2 per tonne sponge iron

* *considered 5200 kcal per kg as gross calorific value of coal*

4.5.6.5 Relevant institutions for DRI sub-sector

The details of industry associations and other relevant government departments like state designated agencies (SDAs) pertaining to sponge iron industries in West Bengal state are given in table 4.5.6.5.

Table 4.5.6.5: Institutions involved in West Bengal state

Institution/ organization	Contact details	Objectives and roles
West Bengal Sponge Iron Manufacturers Association	46A Rafi Ahmed Kidwai Road Kolkata – 700 016 Tel: 033 2258 1392	• Welfare activities and grievance redressal of member industries
West Bengal State Electricity Distribution Company Limited– (WBSDA)	Chief Engineer & Nodal officer, Planning, Investigation & Design Department, Vidyut Bhavan, 5th floor, B-Block, Idhan nagar, Block - DJ, Sector - II, Kolkata – 700091 https://www.wbsedcl.in/irj/go/km/docs/internet/new_website/WBSDA_New.html	• Establishing and promoting the energy conservation ethic within the government and all consumer classes in the state of West Bengal

4.5.6.6 Other information

There are no specific energy efficiency related studies carried out or on-going with a focus on sponge iron industries in West Bengal state.

4.5.6.7 Summary of findings

The summary of findings of DRI plants in West Bengal state is provided in table 4.5.6.7.

Table 4.5.2.7: Summary of findings of DRI plants in West Bengal state

Parameter	Remarks
Number of Non-DC category DRI plants	37
Operating plants of Non-DC category	27
Total energy consumption	1.0 million toe
SEC– Overall	22.0 GJ per tonne
GHG emissions	4.1 million tonne CO_2 per year
Specific GHG emissions	2.1 tonne CO_2 per year
Other relevant information	No past or on-going studies on energy efficiency

4.5.7 Other states

4.5.7.1 Background

Other states in which DRI plants are present include Andhra Pradesh, Goa, Gujarat, Maharashtra, Tamil Nadu, Telangana and Uttar Pradesh. There are a total of 49 DRI plants in these states of which 30 units are of Non-DC category. The total production of sponge iron from 23 operating plants is estimated to be 3.0 million tonne considering 77.7% of capacity utilization as shown in table 4.5.7.1 (source: JPC, 2020).

Table 4.5.7.1: Production of Non-DC DRI plants (Other states)

Parameters	Value
Total number of plants	49
Plants covered under PAT	19
Number of Non-DC plants	30

Non-DC plants (operating)	23
Estimated production (million tonne)	3.0

Source: Analysis of JPC data, 2020

4.5.7.2 Process technology

The DRI units use rotary kilns with non-coking coal used as fuel as well as reducing agent. The brief details of technology used in sponge iron production in other states are provided in table 4.5.7.2.

Table 4.5.7.2: Process technology used in DRI plants (other states)

Technology	Purpose
Rotary kiln(coal fired)	Producing iron ore to sponge iron through direct reduction without melting at about 900-1050 ^oC.
Rotary cooler	Indirect water cooling of sponge iron to avoid re-oxidation
Electro-magnetic separator and screening	Separating sponge iron and sizing

4.5.7.3 Energy consumption analysis

Non-coking coal is used in the DRI process for heating and reduction processes in rotary kiln. The rotary kilns account for about 98% of total energy consumption in DRI manufacturing. Electricity is mainly used to meet electrical loads of these plants. The total energy consumption of DRI plants under Non-DC category is 1.6 million toe per year. The equivalent GHG emissions are estimated to be 6.5 million tonne CO_2 per year (Table 4.5.7.3).

Table 4.5.7.3: Energy consumption of Non-DC DRI plants (other states)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent (million toe/year)	(million tonne CO_2/year)
Coal	3.0 million tonne	1.6	6.3
Electricity	213 million kWh/year	0.02	0.2
	Total	1.6	6.5

4.5.7.4 Performance of DRI plants

The specific coal consumption of coal-based DRI plant varies between 0.9-1.1 tonne per tonne sponge iron with the average specific coal consumption of 1.0 tonne per tonne sponge iron. The average specific electricity consumption is 70 kWh per tonne of sponge iron. The overall SEC of DRI plants is estimated to be 22.0 GJ per tonne as shown in table 4.5.7.4.

Table 4.5.7.4: Performance of Non-DC DRI plants (other states)

Parameter	Value
SEC- Thermal	21.8 GJ per tonne (or) 1 tonne coal* per tonne sponge iron
SEC – Electrical	70 kWh per tonne
SEC- Overall	22.0 GJ per tonne
Specific GHG emissions	2.1 tonne CO_2 per tonne sponge iron

* *considered 5200 kcal per kg as gross calorific value of coal*

4.5.7.5 Relevant institutions for DRI sub-sector

There are no separate industry associations in the other states category.

4.5.7.6 Other information

There are no specific energy efficiency related studies carried out or on-going with a focus on sponge iron industries in other states.

4.5.7.7 Summary of findings

The summary of findings of DRI plants in other states is provided in table 4.5.7.7.

Table 4.5.7.7: Summary of findings of DRI plants in other states

Parameter	Remarks
Number of Non-DC category DRI plants	30
Operating plants of Non-DC category	23
Total energy consumption	1.6 million toe
SEC– Overall	22.0 GJ per tonne
GHG emissions	6.5 million tonne CO_2 per year
Specific GHG emissions	2.1 tonne CO_2 per year
Other relevant information	No specific study conducted or on-going pertaining to energy efficiency improvements

4.5.8 Summary of energy analysis of sponge iron sector

A study of sponge iron sector shows that there are a total of 333 DRI plants in India. Five states namely, Chhattisgarh, Jharkhand, Karnataka, Odisha ad West Bengal, account for about 85% of total DRI industries and 73% of total sponge iron production. Out of total, 223 plants fall under Non-DC category and 181 plants were operating during the study period. The total production from DRI plants of Non-DC category is estimated to be 14.1 million tonne. The total energy consumption is estimated to be 7.4 million toe per year with an equivalent GHG emissions of 30.0 million tonne CO_2 (table 4.5.8.1).

The following considerations and assumptions were made while undertaking analysis of the sub-sector.

- The average capacity utilization of DRI sector is 77.7% (source: Analysis of JPC, 2020 data)
- Specific energy consumption of coal is 1 tonne and electricity is 70 kWh per tonne sponge iron in rotary kiln based DRI plants (source: Technology compendium on energy efficient technology options for direct reduction of iron process (sponge iron plants), TERI, 2021)
- Standard energy values and emission factors were used for estimating energy consumption and GHG emissions respectively.

Table 4.5.8.1: Summary of energy analysis of sponge iron industries

S No	State	Number of Non-DC DRI plants		Production Non-DC (million tonne/yr)	Energy consumption (mtoe/year)	GHG emissions (mt-CO_2/year)
		Total	Operating			
1	Chhattisgarh	34	32	1.7	0.9	3.6
2	Jharkhand	39	26	2.4	1.3	5.1
3	Karnataka	25	22	1.1	0.6	2.3
4	Odisha	58	51	4.0	2.1	8.5
5	West Bengal	37	27	1.9	1.0	4.1
6	Others	30	23	3.0	1.6	6.5
	Total	223	181	14.1	7.4	30.0

The global SEC level of sponge iron industries is reported to be 10.5-12.6 GJ per tonne (source: Industrial energy efficiency project: Benchmarking report for the iron and steel sector, UNIDO-GEF, 2014)

4.5.9 Cluster selection in sponge iron industries

4.5.9.1 Selection matrix

The study considered a number of attributes with relevant criteria and score for ranking of the states. These attributes are provided in table 4.5.9.1. More details of selection matrix at cluster level are provided in annexure 2.

Table 4.5.9.1: Selection criteria for Sponge iron sub-sector

S No	Attribute	Criteria	Score
1	Number of units	• <= 25 • 26-35 • 36-50 • >50	2.5 5.0 7.5 10.0
2	Specific energy consumption(GJ per tonne)	• Average • 5% below average • 10% below average • < More than 10%	2.5 5.0 7.5 10.0
3	Variability (technology, fuel, etc.)	• One variable • Two variables • Three variables • More than three variables	2.5 5.0 7.5 10.0
4	GHG emission share	• Less than 10% • 11-15% • 16-20% • >20%	2.5 5.0 7.5 10.0
5	Prior/on-going activities on energy efficiency at cluster level	• Replication of EE measures • Demonstration undertaken • Cluster level studies conducted	2.5 5.0 7.5 10.0

S No	Attribute	Criteria	Score
		• No activities on energy efficiency	
6	Availability of industry association in the cluster	• No industry association • One industry association • More than one association • Industry association, SPVs, etc.	2.5 5.0 7.5 10.0

4.5.9.2 Summary of findings

Based on the attributes and criteria, the project has short-listed Odisha and Jharkhand states for further planning and deep-diving on energy efficiency activities in sponge iron industries (table 4.5.9.2).

Table 4.5.9.2: Shortlisted states for deep-diving in DRI sub-sector

State	Score	Ranking
Odisha	40.0	1
Jharkhand	32.5	2
Chhattisgarh	30.0	3
West Bengal	30.0	3
Karnataka	25.0	5

4.6 Electric arc furnace plants

4.6.1 Background

Electric arc furnaces (EAF) are used to produce various grades or steel (Figure 4.6.1). The details of EAF plants used in India are provided in the following sections.

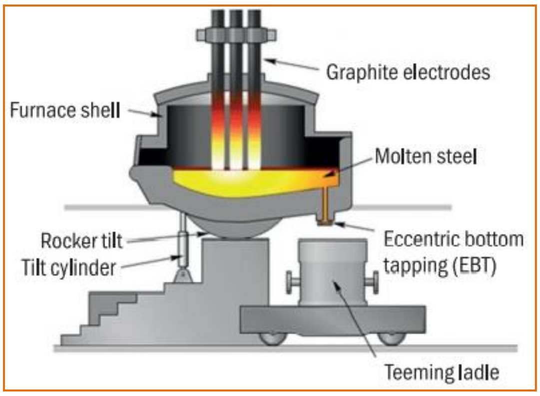


Figure 4.6.1 Electric arc furnace

4.6.1.1 Spread of EAF plants

The electric arc furnace plants are located in 14 states (JPC, 2020), which are scattered across different states in India (table 4.6.1.1). There are 55 EAF plants which include both composite plants (43 no.) and standalone plants (12 no.). Of these, only 4 standalone plants are in operation. About 18 EAF plants are covered under PAT and 37 EAF plants are Non-DC units.

Table 4.6.1.1: Installed capacities of all EAF plants in India

S No	State	Total EAF units	Non-DC units	
			Total	Operating
1	Chhattisgarh	6	3	3
2	Goa	1	1	-
3	Gujarat	3	2	2
4	Haryana	3	2	2
5	Jharkhand	3	2	-
6	Karnataka	2	1	-
7	Kerala	1	1	-
8	Madhya Pradesh	1	1	-
9	Maharashtra	10	5	4
10	Odisha	9	4	3
11	Punjab	5	5	4
12	Uttar Pradesh	1	1	-
13	Tamil Nadu	1	-	-
13	West Bengal	9	9	4
	Total	55	37	22

Source: JPC, 2020

The energy consumption level of the downstream processes in a composite type EAF plant is dependent on factors such as type of product, process involved, technology use and production level, which may vary widely within different plants. Therefore, the following sections of the mapping report shall be focusing only on electric arc furnace section for such steel plants.

4.6.1.2 Process description and technology use

The process steps involved in EAF plants include (1) charging of raw materials, (2) complete meltdown, (3) oxidation and refining, (4) de-oxidation, and (5) tapping of liquid metal.

Charging

The first step in a batch furnace is charging of raw material into the furnace. A schedule is generally established by the plant prior to each production shift for which the charge is prepared in the charge buckets. The preparation of charge bucket is a key step to ensure proper chemistry and confirm good melting conditions.

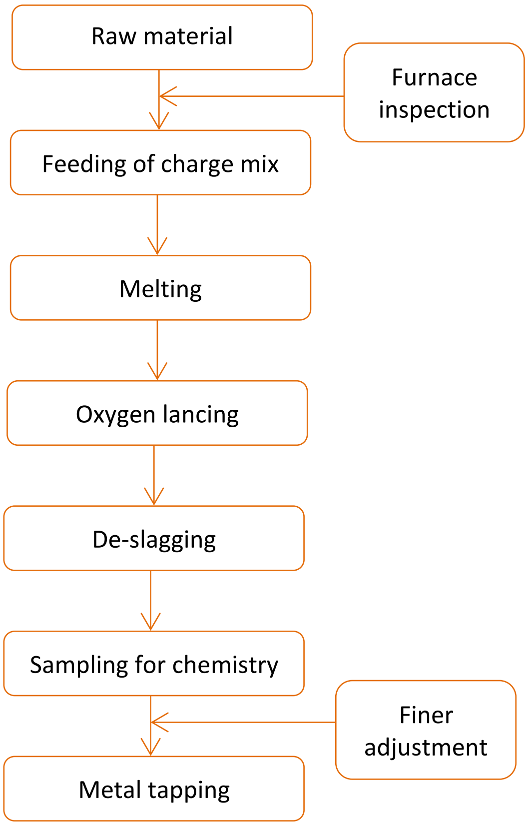


Figure 4.6.1.2 Process flow diagram in EAF

Complete meltdown

Melting process is heart of the furnace operation. Energy required for melting includes electrical and chemical. Electricity is fed through graphite electrodes which is the major energy input. Upon melting of sufficient quantity of scrap, the charging process is repeated.

Oxidation and refining

Upon forming of liquid steel, oxygen is directly lanced into the bath to accelerate oxidation of solutes, starting with carbon in the bath followed by oxidation of iron, silicon, manganese and phosphorous. These reactions are exothermic and provide additional energy in melting process. The carbon monoxide escapes as gas and produces the 'carbon boil' in the melt, which is an essential part of the refining process.

De-oxidation

The bath is de-oxidised before pouring into transfer ladle, which otherwise results in formation of oxides again and may go into final products. After removal of first slag, the power is switched off. De-oxidation is carried out using specific de-oxidisers having high affinity towards oxygen in the bath compared to iron e.g. ferro-manganese or ferro-silicon. Aluminium is typically added at the end which is the most powerful de-oxidising agent as compared to ferro-alloys.

Tapping of liquid metal

Once required temperature is achieved (~ 1650 °C), a sample is drawn from the bath for ascertaining the chemistry of molten bath; finer corrections are made to chemistry based on requirements. The molten steel is poured into a pre-heated ladle either by tilting or using 'eccentric bottom taphole' (EBT) mechanism. The slag in the ladle is removed by adding adequate quantities of lime.

4.6.1.3 Raw materials, products and production

The raw materials used in EAF plants include pig iron, sponge iron, and scrap. Ferro alloys are used in the process for de-oxidising. The melt from electric arc furnace is used to produce various finished steel products like plates, strips, rods & bars, sections, wires and tubes.

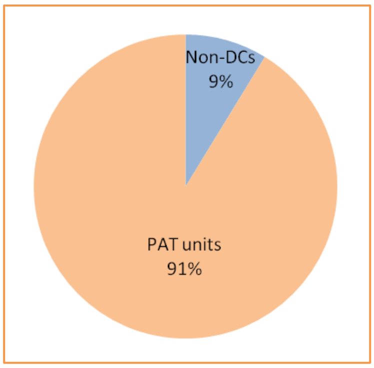


Figure 4.6.1.3 Production share

The total production from all EAF plants together during 2019-20 was 28.4 million tonne (JPC, 2020). The average capacity utilization of EAF plants in India during 2019-20 was estimated to be 67.8%. The total production from 22 Non-DC units is estimated to be 2.4 million tonne (2019-20) accounting for about 9% of the total production in the sector as shown in figure 4.6.1.3.

Table 4.6.1.3: Production from EAF plants

Parameter	Unit	PAT	Non-DC	Total
Number of plants		18	37	55
Operating units		17	22	39
Installed capacity (including non-operating units)	million tonne	37.5	4.4	41.8
Production (operating units)	million tonne	25.1	2.4	27.5

Source: JPC, 2020

4.6.1.4 Other countries having EAF plants

Some of the countries which use EAF route for steel production include Italy, Mexico, Spain, Turkey, USA, Canada and Poland (source: https://www.globalefficiencyintel.com).

4.6.1.5 Coverage of clusters/states

An analysis of energy consumption of EAF plants other than covered under PAT was carried out. With scattered nature of units, EAF based plants are not located as clusters. Therefore, this report covers the analysis of EAF plants at state level. The following states were covered considering number of industries and energy consumption level in the sector.

1) Maharashtra
2) Odisha
3) Punjab
4) West Bengal
5) Others (include other states having EAF plants)

4.6.2 Maharashtra state

4.6.2.1 Background

There are a total of 10 electric arc furnace (EAF) plants located in the state of Maharashtra of which 5 units are of Non-DC category. The total production of crude steel from 4 operating plants is estimated to be 0.6 million tonne considering 67.8% of capacity utilization (source: JPC, 2020) as shown in table 4.6.2.1.

Table 4.6.2.1: Production of Non-DC EAF plants (Maharashtra)

Total number of plants	10
Plants covered under PAT	5
Number of Non-DC plants	5
Non-DC plants (operating)	4
Installed capacity of Non-DC plants – operating (million tonne)	0.9
Estimated production (million tonne)	0.6

Source: Analysis of JPC data, 2020

4.6.2.2 Process technology

Electric arc furnaces are used for melting of iron and scrap. The process steps involved in EAF plants include (1) charging of raw materials, (2) complete meltdown, (3) oxidation and refining, (4) De-oxidation, and (5) tapping of liquid metal. The technologies used in EAF plants in Maharashtra are provided in Table 4.6.2.2.

Table 4.6.2.2: Process technology used in EAF plants in Maharashtra

Technology	Purpose
Electric arc furnace	Melting of iron and scrap

4.6.2.3 Energy consumption analysis

The EAF plants use electricity for melting of iron and scrap. The electric arc furnace is the major consumer of energy in an EAF based plant. The total energy consumption of EAF plants under Non-DC category in Maharashtra state is estimated to be 26,565 toe per year. The equivalent GHG emissions are estimated to be 244,023 tonne CO_2 per year (Table 4.6.2.3).

Table 4.6.2.3: Energy consumption of Non-DC EAF plants (Maharashtra)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent toe/year	(tonne CO_2/year)
Electricity	309 mil kWh/year	26,565	244,023
	Total	26,565	244,023

4.6.2.4 Performance of EAF plants

The average specific electricity consumption of electric arc furnace plants is about 527 kWh per tonne liquid steel production with SEC ranging from 454 to 775 kWh per tonne production for different capacities of electric arc furnaces. The energy consumption of other related operations followed in electric arc furnace units are not readily available. The overall specific energy consumption (SEC) of EAF plants is estimated to be 1.9 GJ per tonne as shown in table 4.6.2.4.

Table 4.6.2.4: Performance of Non-DC EAF plants (Maharashtra)

Parameter	Value
SEC – Electrical	527 kWh per tonne liquid steel
SEC- Overall	1.9 GJ per tonne liquid steel
Specific GHG emissions	0.4 tonne CO_2 per tonne liquid steel

4.6.2.5 Relevant institutions for EAF industries

There are no specific industry associations for EAF units at the state level. The details of state designated agencies (SDAs) in Maharashtra are given in table 4.6.2.5.

Table 4.6.2.5: Institutions involved in Maharashtra

Institution/ organization	Contact details	Objectives and roles
Maharashtra Energy Development Agency (MEDA)	MHADA Commercial Complex, 2nd floor, Opp. Tridal Nagar, Yerwada, Pune – 411 006 Tel: 020-35000450 email: meda@mahaurja.com https://www.mahaurja.com/meda/	• Regulating energy conservation and promoting the development of renewable energy • Taking concrete steps for conventional energy conservation measures including industries

4.6.2.6 Other information

There are no specific studies focusing on adoption of energy efficiency in EAF plants in Maharashtra.

4.6.2.7 Summary of findings

The summary of findings of EAF plants in Maharashtra is provided in table 4.6.2.7.

Table 4.6.2.7: Summary of findings of EAF plants in Maharashtra

Parameter	Remarks
Number of Non-DC category EAF plants	5
Operating plants of Non-DC category	4
Total energy consumption	26,565 toe per year
SEC– Overall	1.9 GJ per tonne liquid steel
GHG emissions	244,023 tonne CO_2 per year
Specific GHG emissions	0.4 tonne CO_2 per tonne liquid steel
Other relevant information	No specific study conducted or on-going pertaining to implementation of energy efficient technologies in the state

4.6.3 Odisha state

4.6.3.1 Background

There are a total of 9 electric arc furnace (EAF) plants located in the state of Odisha of which 4 units are of Non-DC category. The total production of crude steel from 3 operating plants is estimated to be 0.6 million tonne considering 67.8% of capacity utilization (source: JPC, 2020) as shown in table 4.6.3.1.

Table 4.6.3.1: Production of Non-DC EAF plants (Odisha)

Total number of plants	9
Plants covered under PAT	5
Number of Non-DC plants	4
Non-DC plants (operating)	3
Installed capacity of Non-DC plants – operating (million tonne)	0.9
Estimated production (million tonne)	0.6

Source: Analysis of JPC data, 2020

4.6.3.2 Process technology

Electric arc furnaces are used for melting of iron and scrap. The process steps involved in EAF plants include (1) charging of raw materials, (2) complete meltdown, (3) oxidation and refining, (4) de-oxidation, and (5) tapping of liquid metal. The technologies used in EAF plants in Odisha are provided in Table 4.6.3.3.

Table 4.6.3.3: Process technology used in EAF plants in Odisha

Technology	Purpose
Electric arc furnace	Melting of iron and scrap

4.6.3.3 Energy consumption analysis

The EAF plants use electricity for melting of iron and scrap. The electric arc furnace is the major consumer of energy in an EAF based plant. The total energy consumption of EAF plants under Non-DC category in Odisha state is estimated to be 28,639 toe per year. The equivalent GHG emissions are estimated to be 263,076 tonne CO2 per year (Table 4.6.3.3).

Table 4.6.3.3: Energy consumption of Non-DC EAF plants (Odisha)

Fuel	Energy consumption		GHG emissions(tonne CO_2/year)
	Quantity	Equivalent toe/year	
Electricity	333 mil kWh/year	28,639	263,076
	Total	28,639	263,076

4.6.3.4 Performance of EAF plants

The average specific electricity consumption of electric arc furnace plants is about 527 kWh per tonne liquid steel with SEC ranging from 454 kWh per tonne to 775 kWh per tonne for different capacities of electric arc furnaces. The energy consumption of other related operations followed in electric arc furnace units are not readily available. The overall specific energy consumption (SEC) of EAF plants is estimated to be 1.9 GJ per tonne as shown in table 4.6.3.4.

Table 4.6.3.4: Performance of Non-DC EAF plants (Odisha)

Parameter	Value
SEC – Electrical	527 kWh per tonne liquid steel
SEC- Overall	1.9 GJ per tonne liquid steel
Specific GHG emissions	0.4 tonne CO_2 per tonne liquid steel

4.6.3.5 Relevant institutions for EAF industries

There are no specific industry associations for EAF units at the state level. The details of state designated agencies (SDAs) in Odisha are given in table 4.6.3.5.

Table 4.6.3.5: Institutions involved in Odisha

Institution/ organization	Contact details	Objectives and roles
Department of Energy, Government of Odisha	Power house square, Bidyutmarg, Bhubaneswar – 751 001 Tel: 0674 2536960, 2396605 https://energy.odisha.gov.in	• Aims at planning, developing, managing and advising the government scheme under Department of Energy. • Establish policies necessary for effective and efficient implementation of the government programme.

4.6.3.6 Other information

There are no specific studies focusing on adoption of energy efficiency in EAF plants in Odisha.

4.6.3.7 Summary of findings

The summary of findings of EAF plants in Odisha is provided in table 4.6.3.7.

Table 4.6.3.7: Summary of findings of EAF plants in Odisha

Parameter	Remarks
Number of Non-DC category EAF plants	4
Operating plants of Non-DC category	3
Total energy consumption	28,639 toe per year
SEC– Overall	1.9 GJ per tonne liquid steel
GHG emissions	263,076 tonne CO_2 per year
Specific GHG emissions	0.4 tonne CO_2 per tonne liquid steel
Other relevant information	No specific study conducted or on-going pertaining to implementation of energy efficient technologies in the state

4.6.4 Punjab state

4.6.4.1 Background

There are a total of 5 electric arc furnace (EAF) plants located in the state of Punjab of which all the units are of Non-DC category. The total production of crude steel from 4 operating plants is estimated to be 0.5 million tonne considering 67.8% of capacity utilization as shown in table 4.6.4.1 (source: JPC, 2020).

Table 4.6.4.1Production of Non-DC EAF plants (Punjab)

Total number of plants	5
Plants covered under PAT	0
Number of Non-DC plants	5
Non-DC plants (operating)	4
Installed capacity of Non-DC plants – operating (million tonne)	0.6
Estimated production (million tonne)	0.5

Source: Analysis of JPC data, 2020

4.6.4.2 Process technology

Electric arc furnaces are used for melting of iron and scrap. The process steps involved in EAF plants include (1) charging of raw materials, (2) complete meltdown, (3) oxidation and refining, (4) De-oxidation, and (5) tapping of liquid metal. The technologies used in EAF plants in Punjab are provided in Table 4.6.4.3.

Table 4.6.4.3: Process technology used in EAF plants in Punjab

Technology	Purpose
Electric arc furnace	Melting of iron and scrap

4.6.4.3 Energy consumption analysis

The EAF plants use electricity for melting of iron and scrap. The electric arc furnace is the major consumer of energy in an EAF based plant. The total energy consumption of EAF plants under Non-DC category in Punjab state is estimated to be 23,415 toe per year. The equivalent GHG emissions are estimated to be 215,090 tonne CO_2 per year (Table 4.6.4.3).

Table 4.6.4.3: Energy consumption of Non-DC EAF plants (Punjab)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent toe/year	(tonne CO_2/year)
Electricity	272 mil kWh/year	23,415	215,090
	Total	23,415	215,090

4.6.4.4 Performance of EAF plants

The average specific electricity consumption of electric arc furnace plants is about 527 kWh per tonne liquid steel with SEC ranging from 454 kWh per tonne to 775 kWh per tonne for different capacities of electric arc furnaces. The energy consumption of other related operations followed in electric arc furnace units are not readily available. The overall SEC of EAF plants is estimated to be 1.9 GJ per tonne (table 4.6.4.4).

Table 4.6.4.4: Performance of Non-DC EAF plants (Punjab)

Parameter	Value
SEC – Electrical	527 kWh per tonne liquid steel
SEC- Overall	1.9 GJ per tonne liquid steel
Specific GHG emissions	0.4 tonne CO_2 per tonne liquid steel

4.6.4.5 Relevant institutions for EAF industries

There are no specific industry associations for EAF units at the state level. The details of state designated agencies (SDAs) in Punjab are given in table 4.6.4.5.

Table 4.6.4.5: Institutions involved in Punjab

Institution/ organization	Contact details	Objectives and roles
Punjab Energy Development Agency (PEDA)	Solar Passive Complex Plot No. 1-2, Sector 33-D, Chandigarh – 160 034 Tel: 0172 266 3382 Email: ceo@peda.gov.in https://www.peda.gov.in/	• Implementation of Energy Conservation Act • Creating awareness to adopt non-conventional energy sources and energy saving /Conservation

4.6.4.6 Other information

There are no specific studies focusing on adoption of energy efficiency in EAF plants in Punjab.

4.6.4.7 Summary of findings

The summary of findings of EAF plants in Punjab is provided in table 4.6.4.7.

Table 4.6.4.7: Summary of findings of EAF plants in Punjab

Parameter	Remarks
Number of Non-DC category EAF plants	5
Operating plants of Non-DC category	4
Total energy consumption	23,415 toe per year
SEC– Overall	1.9 GJ per tonne liquid steel
GHG emissions	215,090 tonne CO_2 per year
Specific GHG emissions	0.4 tonne CO_2 per tonne liquid steel
Other relevant information	No specific study conducted or on-going pertaining to implementation of energy efficient technologies in the state

4.6.5 West Bengal state

4.6.5.1 Background

There are a total of 5 electric arc furnace (EAF) plants located in the state of West Bengal of which all the units are of Non-DC category. The total production of crude steel from 4 operating plants is estimated to be 0.4 million tonne considering 67.8% of capacity utilization (source: JPC, 2020) as shown in table 4.6.5.1.

Table 4.6.5.1: Production of Non-DC EAF plants (West Bengal)

Total number of plants	5
Plants covered under PAT	0
Number of Non-DC plants	5
Non-DC plants (operating)	4
Installed capacity of Non-DC plants – operating (million tonne)	0.6
Estimated production (million tonne)	0.4

Source: Analysis of JPC data, 2020

4.6.5.2 Process technology

Electric arc furnaces are used for melting of iron and scrap. The process steps involved in EAF plants include (1) charging of raw materials, (2) complete meltdown, (3) oxidation and refining, (4) de-oxidation, and (5) tapping of liquid metal. The technologies used in EAF plants in West Bengal are provided in Table 4.6.5.3.

Table 4.6.5.3: Process technology used in EAF plants in West Bengal

Technology	Purpose
Electric arc furnace	Melting of iron and scrap

4.6.5.3 Energy consumption analysis

The EAF plants use electricity for melting of iron and scrap. The electric arc furnace is the major consumer of energy in an EAF based plant. The total energy consumption of EAF plants under Non-DC category in West Bengal state is estimated to be 17,841 toe per year. The equivalent GHG emissions are estimated to be 163,886tonne CO_2 per year (Table 4.6.5.3).

Table 4.6.5.3: Energy consumption of Non-DC EAF plants (West Bengal)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent toe/year	(tonne CO_2/year)
Electricity	207 mil kWh/year	17,481	163,886
	Total	17,481	163,886

4.6.5.4 Performance of EAF plants

The average specific electricity consumption of electric arc furnace plants is about 527 kWh per tonne liquid steel with SEC ranging from 454 kWh per tonne to 775 kWh per tonne for different capacities of electric arc furnaces. The energy consumption of other related operations followed in electric arc furnace units are not readily available. The overall specific energy consumption (SEC) of EAF plants is estimated to be 1.9 GJ per tonne as shown in table 4.6.5.4.

Table 4.6.5.4: Performance of Non-DC EAF plants (West Bengal)

Parameter	Value
SEC – Electrical	527 kWh per tonne liquid steel
SEC- Overall	1.9 GJ per tonne liquid steel
Specific GHG emissions	0.4 tonne CO_2 per tonne liquid steel

4.6.5.5 Relevant institutions for EAF industries

There are no specific industry associations for EAF units at the state level. The details of state designated agencies (SDAs) in West Bengal are given in table 4.6.5.5.

Table 4.6.5.5: Institutions involved in West Bengal

Institution/ organization	Contact details	Objectives and roles
West Bengal State Electricity Distribution Company Limited(WBSDA)	Chief Engineer & Nodal officer, Planning, Investigation & Design Department, Vidyut Bhavan, 5th floor, B-Block, Bidhan nagar, Sector-II Kolkata – 700091 https://www.wbsedcl.in/irj/go/km/docs/internet/new_website/WBSDA_New.html	• Establishing and promoting the energy conservation ethic within the government and all consumer classes

4.6.5.6 Other information

There are no specific studies focusing on adoption of energy efficiency in EAF plants in West Bengal.

4.6.5.7 Summary of findings

The summary of findings of EAF plants in West Bengal is provided in table 4.6.5.7.

Table 4.6.5.7: Summary of findings of EAF plants in West Bengal

Parameter	Remarks
Number of Non-DC category EAF plants	9
Operating plants of Non-DC category	4
Total energy consumption	17,841 toe per year
SEC– Overall	1.9 GJ per tonne liquid steel
GHG emissions	163,886 tonne CO_2 per year
Specific GHG emissions	0.4 tonne CO_2 per tonne liquid steel
Other relevant information	No past or on-going study pertaining to energy efficiency projects

4.6.6 Other states

4.6.6.1 Background

Other states in which EAF plants are located include Chhattisgarh, Gujarat, Haryana, Jharkhand, Karnataka and Tamil Nadu. There are a total of 22 EAF plants located in these states of which 14 units are of Non-DC category. The total production of crude steel from 7 operating plants is estimated to be 0.3 million tonne considering 67.8% of capacity utilization (source: JPC, 2020) as shown in table 4.6.6.1.

Table 4.6.6.1: Production of Non-DC EAF plants (other states)

Total number of plants	22
Plants covered under PAT	8
Number of Non-DC plants	14
Non-DC plants (operating)	7
Installed capacity of Non-DC plants – operating (million tonne)	0.4
Estimated production (million tonne)	0.3

Source: Analysis of JPC data, 2020

4.6.6.2 Process technology

Electric arc furnaces are used for melting of iron and scrap. The process steps involved in EAF plants include (1) charging of raw materials, (2) complete meltdown, (3) oxidation and refining, (4) de-oxidation, and (5) tapping of liquid metal. The technologies used in EAF plants in other states are provided in Table 4.6.6.2.

Table 4.6.6.2: Process technology used in EAF plants in other states

Technology	Purpose
Electric arc furnace	Melting of iron and scrap

4.6.6.3 Energy consumption analysis

The EAF plants use electricity for melting of iron and scrap. The electric arc furnace is the major consumer of energy in an EAF based plant. The total energy consumption of EAF plants under Non-DC category in other states is estimated to be 12,470 toe per year. The equivalent GHG emissions are estimated to be 114,545 tonne CO2 per year (Table 4.6.6.3).

Table 4.6.6.3: Energy consumption of Non-DC EAF plants (other states)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent toe/year	(tonne CO_2/year)
Electricity	207 mil kWh/year	17,481	163,886
	Total	17,481	163,886

4.6.6.4 Performance of EAF plants

The average specific electricity consumption of electric arc furnace plants is about 527 kWh per tonne liquid steel with SEC ranging from 454 kWh per tonne to 775 kWh per tonne for different capacities of electric arc furnaces. The energy consumption of other related operations followed in electric arc furnace units are not readily available. The overall specific energy consumption (SEC) of EAF plants is estimated to be 1.9 GJ per tonne as shown in table 4.6.6.4.

Table 4.6.6.4: Performance of Non-DC EAF plants (other states)

Parameter	Value
SEC – Electrical	527 kWh per tonne liquid steel
SEC- Overall	1.9 GJ per tonne liquid steel

Specific GHG emissions	0.4 tonne CO_2 per tonne liquid steel

4.6.6.5 Relevant institutions for EAF industries

With the number of operating EAF plants are 5 or less in these states, information specific to industry associations or state designated agencies (SDAs) are not provided.

4.6.6.6 Other information

There are no specific studies focusing on adoption of energy efficiency in EAF plants in other states as discussed in the report.

4.6.6.7 Summary of findings

The summary of findings of EAF plants in other states is provided in table 4.6.6.7.

Table 4.6.6.7: Summary of findings of EAF plants in other states

Parameter	Remarks
Number of Non-DC category EAF plants	14
Operating plants of Non-DC category	7
Total energy consumption	12,470 toe per year
SEC– Overall	1.9 GJ per tonne liquid steel
GHG emissions	114,545 tonne CO_2 per year
Specific GHG emissions	0.4 tonne CO_2 per tonne liquid steel
Other relevant information	No specific study conducted or on-going pertaining to implementation of energy efficient technologies in the state

4.6.7 Summary of energy analysis of EAF sub-sector

A study electric arc furnace sector shows that there are 55 EAF plants in India of which 39 plants are operating at present. There are EAF plants which are covered under PAT scheme. About 37 plants are Non-DC industries of which 22 were in operation. Non-DC industries account for about 9% of total production in the country. Within Non-DC EAF plants, four states Maharashtra, Odisha, Punjab and West Bengal accounted for about 89% of total steel production (figure 4.6.7). The total production from EAF plants of Non-DC category is estimated to be 2.4 million tonne. The total energy consumption of Non-DC category of EAF sector is estimated to be 108, 928 toe per year with an equivalent GHG emissions of 1.0 million tonne CO_2 (table 4.6.7).

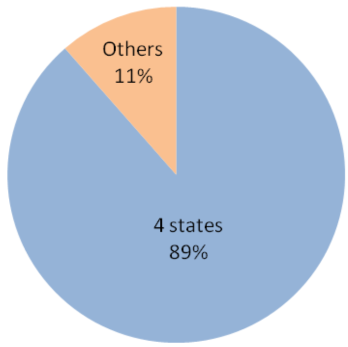


Figure 4.6.7: Production share

The following considerations and assumptions were made while undertaking analysis of the sub-sector.

- The average capacity utilization of electric arc furnace industries is 67.8% (source: Analysis of JPC, 2020 data)

- Specific energy consumption of 527 kWh per tonne of liquid steel with SEC ranging from 454 kWh per tonne to 775 kWh per tonne for different capacities of electric arc furnaces(source: Compendium - Energy efficient technology packages for electric arc furnace, TERI)
- Standard energy values and emission factors were used for estimating energy consumption and GHG emissions respectively.

Table 4.6.7: Summary of energy analysis of Non-DC EAF plants

S No	State	Number of Non-DC EAF plants		Production Non-DC (million tpy)	Energy consumption (toe/year)	GHG emissions (t-CO_2/year)
		Total	Operating			
1	Maharashtra	5	4	0.6	26,565	244,023
2	Odisha	4	3	0.6	28,639	263,076
3	Punjab	5	4	0.5	23,415	215,090
4	West Bengal	9	4	0.4	17,841	163,886
5	Other states	14	7	0.3	12,470	114,545
	Total	37	22	2.4	108,928	1,000,622

The SEC level of electric arc furnace industries is reported to be 2.4-2.5 GJ per tonne (source: Industrial energy efficiency project: Benchmarking report for the iron and steel sector, UNIDO-GEF, 2014)

4.6.8 Cluster selection in EAF sub-sector

4.6.8.1 Selection matrix

The study considered a number of attributes with relevant criteria and score for ranking of the states. These attributes are provided in table 4.6.8.1. More details of selection matrix at cluster level are provided in annexure 2.

Table 4.6.8.1: Shortlisted EAF units for deep-diving

S No	Attribute	Criteria	Score
1	Number of units	• <= 5 • 6-10 • 11-15 • > 15	2.5 5.0 7.5 10.0
2	Specific energy consumption/ Energy consumption share	• <20,000 • 20,001-25,000 • 25,001-30,000 • <30,000	2.5 5.0 7.5 10.0
3	Variability (raw material, technology, fuel, product, etc.)	• One variable • Two variables • Three variables • More than three variables	2.5 5.0 7.5 10.0
4	GHG emission share	• Less than 15% • 16-20% • 21-25% • >25%	2.5 5.0 7.5 10.0

S No	Attribute	Criteria	Score
5	Prior/on-going activities on energy efficiency at cluster level	• Replication of EE measures • Demonstration undertaken • Cluster level studies conducted • No activities on energy efficiency	2.5 5.0 7.5 10.0
6	Availability of industry association in the cluster	• No industry association • One industry association • More than one association • Industry association, SPVs, etc.	2.5 5.0 7.5 10.0

4.6.8.2 Summary of findings

Based on the attributes and criteria, the project has short-listed Odisha and Maharashtra states for further planning and deep-diving on energy efficiency activities in electric arc furnace plants (table 4.6.8.2).

Table 4.6.8.2: Shortlisted states for deep-diving

State	Score	Ranking
Odisha	35.0	1
Maharashtra	32.5	2
Punjab	30.0	3
West Bengal	25.0	4

4.7 Induction furnace plants

4.7.1 Background

The electric induction furnace (EIF) plants are important mid-stream segment used for melting and produce crude steel of required composition used in other downstream processes. Induction furnace plants exist as both stand-alone units and composite plants. Induction furnace units use electricity to meet thermal energy requirements.

4.7.1.1 Spread of induction furnace plants, products and production

There are about 1,103 induction furnace plants in India (JPC data) spread across 29 states/ union territories (JPC, 2020). The spread of induction furnace plants are shown in table 4.7.1.1. Out of total 1,103 induction furnace plants, 644 units are of standalone type.

Table 4.7.1.1 Spread of induction furnace plants in India

S No	State	District	Total units
1	Andhra Pradesh	Ananthapur	13
		Chittoor	4
		East Godavari	1
		Krishna	3
		Nellore	5
		Prakasam	1
		Visakhapatnam	1
		Vizianagaram	2
		West Godavari	1
2	Arunachal Pradesh	Papum Pare	3
3	Assam	Cachar	1
		Dibrugarh	1
		Kamrup	8
		KarbiAnglong	1
		Sivasagar	1
		Tinsukia	1
4	Bihar	Begusarai	1
		Lakhisarai	1
		Muzaffarpur	1
		Patna	20
		Purnia	1
		West Champaran	1
5	Chhattisgarh	Bilaspur	2
		Durg	6
		Raigarh	16
		Raipur	69
		Rajnandgaon	1
6	Dadra and Nagar Haveli	Dadra and Nagar Haveli	20
7	Daman and Diu	Daman	3
8	Delhi	North-West Delhi	2

S No	State	District	Total units
9	Goa	North Goa	8
		South Goa	7
10	Gujarat	Ahmedabad	12
		Anand	3
		Bhavnagar	15
		Gandhinagar	3
		Kutch	8
		Mehsana	7
		Panchmahals	5
		Rajkot	8
		Surendranagar	1
		Vadodara	1
		Valsad	2
11	Haryana	Faridabad	4
		Hisar	1
		Panchkula	1
		Yamunanagar	1
12.1	Himachal Pradesh	Kangra	1
		Sirmaur	12
		Solan	10
		Una	2
13	Jammu and Kashmir	Samba	8
14	Jharkhand	Bokaro	3
		Dhanbad	1
		East Singhbhum	13
		Giridih	17
		Hazaribagh	4
		Jamtara	2
		Koderma	5
		Ramgarh	6
		Ranchi	6
		Seraikela	20
15	Karnataka	Bellary	3
		Belgaum	7
		Bangalore	4
		Bangalore Rural	1
		Chickballapur	1
		Chitradurga	1
		Dakshina Kannada	1
		Dharwad	2
		Kolar	1
		Koppal	1
		Mysore	1

S No	State	District	Total units
		Shimoga	1
		Tumkur	1
16	Kerala	Alappuzha	2
		Ernakulam	3
		Kasargod	1
		Kollam	1
		Kozhikode	3
		Palakkad	25
		Thrissur	1
17	Madhya Pradesh	Bhopal	1
		Dhar	6
		Gwalior	1
		Indore	2
		Mandsaur	1
		Morena	1
		Raisen	1
		Satna	1
18	Maharashtra	Ahmednagar	2
		Aurangabad	1
		Chandrapur	2
		Jalna	13
		Kolhapur	4
		Nagpur	4
		Nashik	6
		Palghar	13
		Pune	6
		Raigad	3
		Sangli	5
		Solapur	1
		Thane	2
		Wardha	1
19	Meghalaya	Ribhoi (Byrnihat)	13
20	Odisha	Cuttack	1
		Dhenkanal	2
		Kendujhar	9
		Jajpur	2
		Jharsuguda	6
		Sambalpur	4
		Sunderghar	34
21	Puducherry	Puducherry	9
		Karaikal	8
22	Punjab	Bathinda	1
		Fatehgarh Sahib	64

S No	State	District	Total units
		Hoshiarpur	1
		Jalandhar	2
		Ludhiana	46
		Patiala	2
		Rupnagar	1
		Sangrur	2
		Sas nagar	2
23	Rajasthan	Alwar	17
		Ajmer	1
		Bhilwara	3
		Jaipur	17
		Jalore	1
		Kota	1
		Naguar	1
		Sikar	2
24	Tamil Nadu	Chennai	4
		Coimbatore	55
		Dindigul	4
		Erode	3
		Kanchipuram	3
		Karur	1
		Krishnagiri	7
		Madurai	1
		Namakkal	2
		Pudukkottai	1
		Salem	7
		Tiruchirappalli	2
		Tiruvallur	18
		Vellore	3
		Thoothukudi	1
25	Telangana	Hyderabad	6
		Medak	12
		Mehbub Nagar	14
		Nalgonda	1
		Rangareddy	4
26	Tripura	West Tripura	1
27	Uttar Pradesh	Aligarh	4
		Bijnor	1
		Bulandshahr	1
		Chandauli	1
		Etah	1
		Fatehpur	3
		Firozabad	1

S No	State	District	Total units
		Gautam Buddha Nagar	1
		Ghaziabad	16
		Gorakhpur	2
		Hamirpur	1
		Jaunpur	1
		Jhansi	2
		Kanpur	2
		Lucknow	1
		Mirzapur	2
		Muzaffarnagar	18
		Rae bareli	1
28	Uttarakhand	Haridwar	19
		Pauri Garhwal	15
		Udham Singh Nagar	9
29	West Bengal	Bankura	10
		Bardhaman	43
		Birbhum	1
		Darjeeling	1
		Hooghly	4
		Howrah	4
		North 24 Parganas	1
		Purulia	5
		South 24 Parganas	1
		West Medinipur	3

4.7.1.2 Process description and technology use

Induction furnace is the main technology/ equipment used in induction furnace plants for melting. The major steps involved in induction furnaces include (i) preparation of charge material, (ii) melting, and (iii) pouring and finishing (Figure 4.7.1.2).

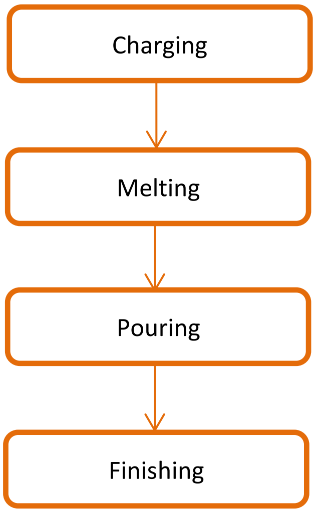


Figure 4.7.1.2: Process flow in induction furnace unit

Preparation of charge material

This involves preparation of charge (metals and alloys). Measured quantities of metal scrap, pig iron, and other alloys are loaded into the furnace for melting. The ratio between raw materials depends on final casting properties.

Melting

The charge is melted in the induction furnace. The temperature requirement for the casting varies between 1,500 to 1,650 °C, depending on grade of steel.

Pouring and Finishing

Once melt attained required temperature and metallurgy, the liquid melt is poured into sand moulds / moulding machines using ladles and shaped into desired product. It also undergoes machining, if required.

4.7.1.3 Raw materials, products and production

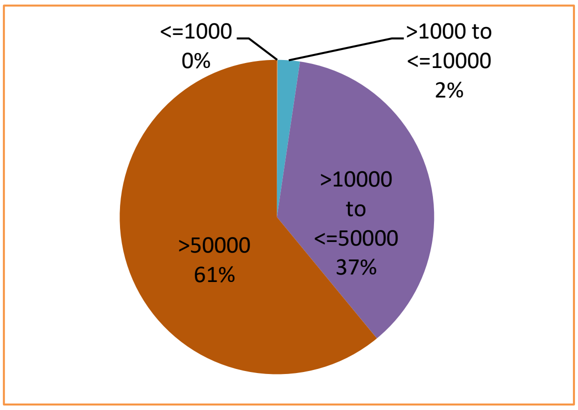
The raw materials used in electric induction furnaces mainly depend on the product chemistries. The base raw materials include pig iron, sponge iron, iron scrap, steel, and in-house returns. Alloying elements like ferro-silicon, ferro-manganese, silicon carbide, etc., are also dozed to achieve required product quality to improve machinability. The melt from induction furnace is used to produce billets of various sizes, castings, rolled products, etc. The total installed capacity of induction furnace plants in India is estimated to be 52,140 million tonne (JPC, 2020). The average capacity utilization of induction furnace plants in India during 2019-20 was 72.2% (JPC, 2020). There are about 1,037 induction furnace plants which fall under Non-DC category of which 801 was operational. The total estimated production from Non-DC EIF plants is estimated to be 24.9 million tonne (2019-20) as shown in Table 4.7.1.3.

Table 4.7.1.3: Details of Non-DC EIF plants in India

Parameters	Value
Total number of plants	1,037
Plants in operation	801
Estimated production (million tonne)	24.9

Source: JPC data analysis, 2020

Based on the available installed capacity data from JPC2020, the induction furnace segment has been categorized into the following: (i) Up to 1,000 tpa, (ii) 1,000 to 10,000 tpa, (iii) 10,000 to 50,000 tpa and (iv) more than 50,000 tpa. Figure 4.7.1.3 shows the breakup of number of units and total installed capacity for induction furnace units operating under non-PAT category.



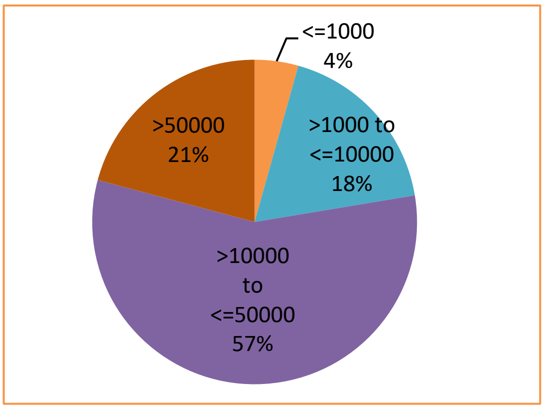


Figure 4.7.1.3 Breakup of non-PAT operating induction furnace units (number and installed capacity)

4.7.1.4 Other countries using induction furnace based plants

China, Japan, United States, and South Korea are the largest producers of crude steel using induction furnace.

4.7.1.5 Institutions at national level

The All India Induction Furnaces Association (AIIFA) is the apex body at national level dealing with induction furnace segment. The roles of AIIFA are shown in table 4.7.1.5.

Table 4.7.1.5: Roles of institutions

Organization	Contact address	Roles
All India Induction Furnaces Association	504, Tower - I, Pearls Omaxe, Netaji Subhash Place, Pitampura, New Delhi-110034	• Sharing information and knowledge pertaining to steel sector

4.7.1.6 Coverage of states

An analysis of energy consumption estimates of EIF plants, which are not covered under PAT scheme is provided in following section. The analysis includes the following clusters:

1) Bardhaman (West Bengal)
2) Fatehgarh Sahib (Punjab)
3) Coimbatore (Tamil Nadu)
4) Dadra Nagar Haveli
5) Ludhiana (Punjab)
6) Palakkad (Kerala)
7) Patna (Bihar)
8) Raipur (Chhattisgarh)
9) Seraikela (Jharkhand)
10) Sunderghar (Odisha)
11) Other clusters

4.7.2 Bardhaman cluster

4.7.2.1 Cluster background

Bardhaman cluster is located in West Bengal. There are a total of 43 electric induction furnace (EIF) plants located in the cluster of which 37 plants are of Non-DC category. The total production of steel from 18 operating units is estimated to be 1.4 million tonne considering 72.2% of capacity utilization (source: JPC, 2020) as shown in table 4.7.2.1.

Table 4.7.2.1: Production of Non-DC induction furnace plants (Bardhaman)

Parameters	Value
Total number of plants	43
Plants covered under PAT	6
Number of Non-DC plants	37
Non-DC plants (operating)	18
Estimated production (million tonne)	1.4

Source: Analysis of JPC data, 2020

4.7.2.2 Process technology

Induction furnaces are used for melting of iron and scrap. The process steps involved in induction furnace plants include (1) preparation of moulds and charge material, (2) melting, and (3) finishing. The technologies used in induction furnace plants in Bardhaman cluster are provided in Table 4.7.2.2.

Table 4.7.2.2: Process technology used in induction furnace plants

Technology	Purpose
Induction furnace	Melting of iron and scrap

4.7.2.3 Energy consumption analysis

The induction furnace plants use electricity for melting of iron and scrap. The induction furnace is the major consumer of energy in an EIF based plant. The total energy consumption of induction furnaces under Non-DC category in Bardhaman cluster is estimated to be 82,263 toe per year. The equivalent GHG emissions are estimated to be 755,674 tonne CO_2 per year (Table 4.7.2.3).

Table 4.7.2.3: Energy consumption of Non-DC induction furnace plants (Bardhaman)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent toe/year	(tonne CO_2/year)
Electricity	956 mil kWh/year	82,263	755,674
	Total	82,263	755,674

4.7.2.4 Performance of induction furnace plants

The average specific electricity consumption of induction furnaces for melting operation is about 680 kWh per tonne liquid steel with SEC ranging from 580 kWh per tonne to 769 kWh per tonne for different capacities of furnaces. The energy consumption of other related operations followed in EIF units are not readily available. The overall specific energy consumption (SEC) of induction furnace plants in the cluster is estimated to be 2.4 GJ per tonne as shown in table 4.7.2.4.

Table 4.7.2.4: Performance of Non-DC induction furnace plants (Bardhaman)

Parameter	Value
SEC – Electrical	680 kWh per tonne liquid steel
SEC- Overall	2.4 GJ per tonne liquid steel
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel

4.7.2.5 Relevant institutions for induction furnace plants

The details of relevant institutions and state designated agencies in West Bengal are given in table 4.7.2.5.

Table 4.7.2.5: Institutions involved in Bardhaman cluster

Institution/ organization	Contact details	Objectives and roles
Durgapur Chamber of Commerce and Industries	Nachan Road, Benachity, Durgapur, West Bengal 713213 Tel: 0343 258 2342	• Welfare activities and grievances redressal of member industries

	email: info@dcci.co.in http://www.dcci.org.in/	
West Bengal State Electricity Distribution Company Limited (WBSDA)	Chief Engineer & Nodal officer, Planning, Investigation & Design Department Vidyut Bhavan, 5th floor, B-Block Bidhan nagar, Sector - II, Kolkata – 700091 https://www.wbsedcl.in/irj/go/km/docs/internet/new_website/WBSDA_New.html	• Establishing and promoting the energy conservation ethic within the government and all consumer classes in the state of West Bengal

4.7.2.6 Other information

There are no specific studies focusing on adoption of energy efficiency in IF plants in the cluster.

4.7.2.7 Summary of findings

The summary of findings of induction furnace plants in Bardhaman cluster is provided in table 4.7.2.7.

Table 4.7.2.7: Summary of findings of induction furnace plants in Bardhaman cluster

Parameter	Remarks
Number of Non-DC category IF plants	37
Operating plants of Non-DC category	18
Total energy consumption	82,263 toe per year
SEC– Overall	2.4 GJ per tonne liquid steel
GHG emissions	757,903 tonne CO_2 per year
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel
Other relevant information	No specific study conducted or on-going pertaining to implementation of energy efficient technologies in the state

4.7.3 Fatehgarh Sahib (Mandi Gobindgarh) Cluster

4.7.3.1 Cluster background

Fatehgarh Sahib cluster is located in Punjab. There are a total of 64 electric induction furnace (EIF) plants located in the cluster all of which belong to Non-DC category. The total production of steel from 60 operating units is estimated to be 1.6 million tonne considering 72.2% of capacity utilization (source: JPC, 2020) as shown in table 4.7.3.1.

Table 4.7.3.1: Production of Non-DC induction furnace plants (Fatehgarh Sahib)

Parameters	Value
Total number of plants	64
Plants covered under PAT	-
Number of Non-DC plants	64
Non-DC plants (operating)	60
Estimated production (million tonne)	1.6

Source: Analysis of JPC data, 2020

4.7.3.2 Process technology

Induction furnaces are used for melting of iron and scrap. The process steps involved in induction furnace plants include (1) preparation of moulds and charge material, (2) melting, and (3) finishing. The technologies used in induction furnace plants in Fatehgarh Sahib cluster are provided in Table 4.7.3.2.

Table 4.7.3.2: Process technology used in induction furnace plants

Technology	Purpose
Induction furnace	Melting of iron and scrap

4.7.3.3 Energy consumption analysis

The induction furnace plants use electricity for melting of iron and scrap. The induction furnace is the major consumer of energy in an EIF based plant. The total energy consumption of induction furnaces under Non-DC category in Fatehgarh Sahib Cluster is estimated to be 93,180 toe per year. The equivalent GHG emissions are estimated to be 855,956tonne CO_2 per year (Table 4.7.3.3).

Table 4.7.3.3: Energy consumption of Non-DC induction furnace plants (Fatehgarh Sahib)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent toe/year	(tonne CO_2/year)
Electricity	1083 mil kWh/year	93,180	855,956
	Total	93,180	855,956

4.7.3.4 Performance of induction furnace plants

The average specific electricity consumption of induction furnaces for melting operation is about 680 kWh per tonne liquid steel with SEC ranging from 580 kWh per tonne to 769 kWh per tonne for different capacities of furnaces. The energy consumption of other related operations followed in EIF units are not readily available. The overall specific energy consumption (SEC) of induction furnace plants in the cluster is estimated to be 2.4 GJ per tonne as shown in table 4.7.3.4.

Table 4.7.3.4: Performance of Non-DC induction furnace plants (Fatehgarh Sahib)

Parameter	Value
SEC – Electrical	680 kWh per tonne liquid steel
SEC- Overall	2.4 GJ per tonne liquid steel
Specific GHG emissions	0.5 tonne CO2 per tonne liquid steel

4.7.3.5 Relevant institutions for induction furnace plants

The details of relevant institutions and state designated agencies (SDAs) in Punjab are given in table 4.7.3.5.

Table 4.7.3.5: Institutions involved in Fatehgarh Sahib Cluster

Institution/ organization	Contact details	Objectives and roles

All India Steel Re-rollers Association	Ram Bhawan, GT Road Mandi Gobindhgarh-147 301 Punjab	• Welfare activities and grievances redressal of member industries • Promoting energy efficiency in member industries
Punjab Energy Development Agency (PEDA)	Solar Passive Complex, Plot No. 1-2, Sector 33-D, Chandigarh – 160 034/ Tel: 0172 266 3382 email: ceo@peda.gov.in https://www.peda.gov.in	• Implementation of Energy Conservation Act • Creating awareness to adopt non-conventional energy sources and energy saving / Conservation

4.7.3.6 Other information

There was no significant activity undertaken in induction furnace segment in the cluster.

4.7.3.7 Summary of findings

The summary of findings of induction furnace plants in Fatehgarh Sahib Cluster is provided in table 4.7.3.7.

Table 4.7.3.7: Summary of findings of induction furnace plants in Fatehgarh Sahib Cluster

Parameter	Remarks
Number of Non-DC category IF plants	64
Operating plants of Non-DC category	60
Total energy consumption	93,180 toe per year
SEC– Overall	2.4 GJ per tonne liquid steel
GHG emissions	757,903 tonne CO_2 per year
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel
Other relevant information	No past initiatives

4.7.4 Coimbatore Cluster

4.7.4.1 Cluster background

Coimbatore cluster is located in Tamil Nadu. There are a total of 55 electric induction furnace (EIF) plants located in the cluster all of which are of Non-DC category. The total production of steel from 49 operating units is estimated to be 0.2 million tonne considering 72.2% of capacity utilization (source: JPC, 2020) as shown in table 4.7.4.1.

Table 4.7.4.1: Production of Non-DC induction furnace plants (Coimbatore)

Parameters	Value
Total number of plants	55
Plants covered under PAT	-
Number of Non-DC plants	55
Non-DC plants (operating)	49
Estimated production (million tonne)	0.2

Source: Analysis of JPC data, 2020

4.7.4.2 Process technology

Induction furnaces are used for melting of iron and scrap. The process steps involved in induction furnace plants include (1) preparation of moulds and charge material, (2) melting, and (3) finishing. The technologies used in induction furnace plants in Coimbatore cluster are provided in Table 4.7.4.2.

Table 4.7.4.2: Process technology used in induction furnace plants

Technology	Purpose
Induction furnace	Melting of iron and scrap

4.7.4.3 Energy consumption analysis

The induction furnace plants use electricity for melting of iron and scrap. The induction furnace is the major consumer of energy in an EIF based plant. The total energy consumption of induction furnaces under Non-DC category in Coimbatore cluster is estimated to be 9,805 toe per year. The equivalent GHG emissions are estimated to be 90,073 tonne CO_2 per year (Table 4.7.4.3).

Table 4.7.4.3: Energy consumption of Non-DC induction furnace plants (Coimbatore)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent toe/year	(tonne CO_2/year)
Electricity	114 mil kWh/year	9,805	90,073
	Total	9,805	90,073

4.7.4.4 Performance of induction furnace plants

The average specific electricity consumption of induction furnaces for melting operation is about 680 kWh per tonne liquid steel with SEC ranging from 580 kWh per tonne to 769 kWh per tonne for different capacities of furnaces. The energy consumption of other related operations followed in EIF units are not readily available. The overall SEC of IF plants in the cluster is estimated to be 2.4 GJ per tonne as shown in table 4.7.4.4.

Table 4.7.4.4: Performance of Non-DC induction furnace plants (Coimbatore)

Parameter	Value
SEC – Electrical	680 kWh per tonne liquid steel
SEC- Overall	2.4 GJ per tonne liquid steel
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel

4.7.4.5 Relevant institutions for induction furnace plants

The details of relevant institutions and SDAs in Coimbatore cluster are given in table 4.7.4.5.

Table 4.6.4.5: Institutions involved in Coimbatore cluster

Institution/ organization	Contact details	Objectives and roles
Southern India Engineering Manufacturers' Association (SIEMA)	41, Race Course Rd, Race Course, Gopalapuram, Coimbatore-641018 Tel: 0422222 0014, 4514014 email: siema@siema.org https://www.siema.org/index.php	• Promoting energy efficiency in industries • Awareness creation on energy conservation
Chief Electrical Inspector to Govt. of Tamil Nadu	Electrical Inspectorate Department Government of Tamil Nadu Thiru Vi.Ka. Industrial Estate, Guindy, Chennai-600 032 Tel: 044 2250 0184 http://www.tnei.tn.gov.in	• Coordinate, regulate and enforce efficient use of energy and its conservation

4.7.4.6 Other information

There are no specific studies focusing on adoption of energy efficiency in induction furnace units in the cluster.

4.7.4.7 Summary of findings

The summary of findings of induction furnace plants in Coimbatore cluster is provided in table 4.7.4.7.

Table 4.7.4.7: Summary of findings of induction furnace plants in Coimbatore cluster

Parameter	Remarks
Number of Non-DC category IF plants	55
Operating plants of Non-DC category	49
Total energy consumption	9,805 toe per year
SEC– Overall	2.4 GJ per tonne liquid steel
GHG emissions	90,073 tonne CO_2 per year
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel
Other relevant information	No specific studies on energy efficiency improvements

4.7.5 Dadra Nagar Haveli cluster

4.7.5.1 Cluster background

There are a total of 20 electric induction furnace (EIF) plants located in Dadra Nagar Haveli cluster of which 20 plants are of Non-DC category. The total production of steel from 19 operating units is estimated to be 0.2 million tonne considering 72.2% of capacity utilization as shown in table 4.7.5.1 (source: JPC, 2020).

Table 4.7.5.1: Production of Non-DC induction furnace plants (Dadra Nagar Haveli)

Parameters	Value
Total number of plants	20
Plants covered under PAT	-
Number of Non-DC plants	20
Non-DC plants (operating)	19
Estimated production (million tonne)	0.2

Source: Analysis of JPC data, 2020

4.7.5.2 Process technology

Induction furnaces are used for melting of iron and scrap. The process steps involved in induction furnace plants include (1) preparation of moulds and charge material, (2) melting, and (3) finishing. The technologies used in induction furnace plants in Dadra Nagar Haveli cluster are provided in Table 4.7.5.2.

Table 4.7.5.2: Process technology used in induction furnace plants

Technology	Purpose
Induction furnace	Melting of iron and scrap

4.7.5.3 Energy consumption analysis

The induction furnace plants use electricity for melting of iron and scrap. The induction furnace is the major consumer of energy in an EIF based plant. The total energy consumption of induction furnaces under Non-DC category in Dadra Nagar Haveli cluster is estimated to be 12,501 toe per year. The equivalent GHG emissions are estimated to be 114,836 tonne CO_2 per year (Table 4.7.5.3).

Table 4.7.5.3: Energy consumption of Non-DC induction furnace plants (Dadra Nagar Haveli)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent toe/year	(tonne CO_2/year)
Electricity	145 mil kWh/year	12,501	114,836
	Total	12,501	114,836

4.7.5.4 Performance of induction furnace plants

The average specific electricity consumption of induction furnaces for melting operation is about 680 kWh per tonne liquid steel with SEC ranging from 580 kWh per tonne to 769 kWh per tonne for different capacities of furnaces. The energy consumption of other related operations followed in EIF units are not readily available. The overall specific energy consumption (SEC) of induction furnace plants in the cluster is estimated to be 2.4 GJ per tonne as shown in table 4.7.5.4.

Table 4.7.5.4: Performance of Non-DC induction furnace plants (Dadra Nagar Haveli)

Parameter	Value
SEC – Electrical	680 kWh per tonne liquid steel
SEC- Overall	2.4 GJ per tonne liquid steel
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel

4.7.5.5 Relevant institutions for induction furnace plants

The details of relevant institutions and state designated agencies (SDAs) in Dadra Nagar Haveli are given in table 4.7.5.5.

Table 4.7.5.5: Institutions involved in Dadra Nagar Havel cluster

Institution/ organization	Contact details	Objectives and roles
Dadra & Nagar Haveli Industries Association	Office No. 10, 1st Floor, Dan Udyog Shopping Centre Opp. Piparia Garden Silvassa-396230 Tel: 02602644166, 8238551290 email: dnhmfrs.2009@gmail.com https://www.ut-dnhindass.org/	• Welfare activities and grievances redressal of member industries • Facilitating training and skill development programmes
Dadra Nagar Haveli Power Distribution Corporation Limited	Vidyut Bhavan, Near Secretariat, 66KV Road, Amli, Silvassa–396230 Tel: 0260 240 6500 email: se.dnhpdcl@gov.in https://www.dnhpdcl.in/	• Promoting the energy conservation activities in different end-use sectors

4.7.5.6 Other information

There are no specific studies focusing on adoption of energy efficiency in induction furnace plants in the cluster.

4.7.5.7 Summary of findings

The summary of findings of induction furnace plants in Dadra Nagar Haveli cluster is provided in table 4.7.5.7.

Table 4.7.5.7: Summary of findings of induction furnace plants in Dadra Nagar Havel cluster

Parameter	Remarks
Number of Non-DC category IF plants	10
Operating plants of Non-DC category	19
Total energy consumption	12,501 toe per year
SEC– Overall	2.4 GJ per tonne liquid steel
GHG emissions	114,836 tonne CO_2 per year
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel
Other relevant information	No specific study conducted or on-going pertaining to implementation of energy efficient technologies in the state

4.7.6 Ludhiana Cluster

4.7.6.1 Cluster background

Ludhiana cluster is located in Punjab. There are a total of 46 electric induction furnace (EIF) plants located in the cluster all of which are of Non-DC category. The total production of steel from 44 operating units is estimated to be 1.0 million tonne considering 72.2% of capacity utilization (source: JPC, 2020) as shown in table 4.7.6.1.

Table 4.7.6.1: Production of Non-DC induction furnace plants (Ludhiana)

Parameters	Value
Total number of plants	46
Plants covered under PAT	-
Number of Non-DC plants	46
Non-DC plants (operating)	44
Estimated production (million tonne)	1.0

Source: Analysis of JPC data, 2020

4.7.6.2 Process technology

Induction furnaces are used for melting of iron and scrap. The process steps involved in induction furnace plants include (1) preparation of moulds and charge material, (2) melting, and (3) finishing. The technologies used in induction furnace plants in Ludhiana cluster are provided in Table 4.7.6.2.

Table 4.7.6.2: Process technology used in induction furnace plants

Technology	Purpose
Induction furnace	Melting of iron and scrap

4.7.6.3 Energy consumption analysis

The induction furnace plants use electricity for melting of iron and scrap. The induction furnace is the major consumer of energy in an EIF based plant. The total energy consumption of induction furnaces under Non-DC category in Ludhiana cluster is estimated to be 61,047 toe per year. The equivalent GHG emissions are estimated to be 560,781 tonne CO_2 per year (Table 4.7.6.3).

Table 4.7.6.3: Energy consumption of Non-DC induction furnace plants (Ludhiana)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent toe/year	(tonne CO_2/year)
Electricity	710 mil kWh/year	61,047	560,781
	Total	61,047	560,781

4.7.6.4 Performance of induction furnace plants

The average specific electricity consumption of induction furnaces for melting operation is about 680 kWh per tonne liquid steel with SEC ranging from 580 kWh per tonne to 769 kWh per tonne for different capacities of furnaces. The energy consumption of other related operations followed in EIF units are not readily available. The overall specific energy consumption (SEC) of induction furnace plants in the cluster is estimated to be 2.4 GJ per tonne as shown in table 4.7.6.4.

Table 4.7.6.4: Performance of Non-DC induction furnace plants (Ludhiana)

Parameter	Value

SEC – Electrical	680 kWh per tonne liquid steel
SEC- Overall	2.4 GJ per tonne liquid steel
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel

4.7.6.5 Relevant institutions for induction furnace plants

The details of relevant institutions and state designated agencies (SDAs) in Ludhiana are given in table 4.7.6.5.

Table 4.7.6.5: Institutions involved in Ludhiana cluster

Institution/ organization	Contact details	Objectives and roles
North India Induction Furnace Association	212, 2nd floor,Savitri Complex G T Road, Ludhiana-141003 Tel: 0161 253 797	• Welfare activities and grievances redressal of members industries • Promoting energy efficiency in member industries
Punjab Energy Development Agency (PEDA)	Solar Passive Complex, Plot No. 1-2, Sector 33-D, Chandigarh – 160 034 Tel: 0172 266 3382 Email: ceo@peda,gov.in https://www.peda.gov.in/	• Implementation of Energy Conservation Act • Creating awareness to adopt non-conventional energy sources and energy conservation

4.7.6.6 Other information

There are no specific studies focusing on adoption of energy efficiency in IF plants in the cluster.

4.7.6.7 Summary of findings

The summary of findings of induction furnace plants in Ludhiana cluster is provided in table 4.7.6.7.

Table 4.7.6.7: Summary of findings of induction furnace plants in Ludhiana cluster

Parameter	Remarks
Number of Non-DC category IF plants	46
Operating plants of Non-DC category	44
Total energy consumption	61,047 toe per year
SEC– Overall	2.4 GJ per tonne liquid steel
GHG emissions	560,781 tonne CO_2 per year
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel
Other relevant information	No specific studies on energy efficiency improvements

4.7.7 Palakkad cluster

4.7.7.1 Cluster background

Palakkad cluster is located in Kerala. There are a total of 25 electric induction furnace (EIF) plants located in the cluster all of which are of Non-DC category. The total production of steel from 20 operating units is estimated to be 0.2 million tonne considering 72.2% of capacity utilization (source: JPC, 2020) as shown in table 4.7.7.1.

Table 4.7.7.1: Production of Non-DC induction furnace plants (Palakkad)

Parameters	Value
Total number of plants	25
Plants covered under PAT	-
Number of Non-DC plants	25
Non-DC plants (operating)	20
Estimated production (million tonne)	0.2

Source: Analysis of JPC data, 2020

4.7.7.2 Process technology

Induction furnaces are used for melting of iron and scrap. The process steps involved in induction furnace plants include (1) preparation of moulds and charge material, (2) melting, and (3) finishing. The technologies used in induction furnace plants in Palakkad cluster are provided in Table 4.7.7.2.

Table 4.7.7.2: Process technology used in induction furnace plants

Technology	Purpose
Induction furnace	Melting of iron and scrap

4.7.7.3 Energy consumption analysis

The induction furnace plants use electricity for melting of iron and scrap. The induction furnace is the major consumer of energy in an EIF based plant. The total energy consumption of induction furnaces under Non-DC category in Palakkad cluster is estimated to be 14,494 toe per year. The equivalent GHG emissions are estimated to be 133,142 tonne CO_2 per year (Table 4.7.7.3).

Table 4.7.7.3: Energy consumption of Non-DC induction furnace plants (Palakkad)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent toe/year	(tonne CO_2/year)
Electricity	168.5 mil kWh/year	14,494	133,142
	Total	14,494	133,142

4.7.7.4 Performance of induction furnace plants

The average specific electricity consumption of induction furnaces for melting operation is about 680 kWh per tonne liquid steel with SEC ranging from 580 kWh per tonne to 769 kWh per tonne for different capacities of furnaces. The energy consumption of other related operations followed in EIF units are not readily available. The overall specific energy consumption (SEC) of induction furnace plants in the cluster is estimated to be 2.4 GJ per tonne as shown in table 4.7.7.4.

Table 4.7.7.4: Performance of Non-DC induction furnace plants (Palakkad)

Parameter	Value
SEC – Electrical	680 kWh per liquid steel
SEC- Overall	2.4 GJ per tonne liquid steel
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel

4.7.7.5 Relevant institutions for induction furnace plants

The details of relevant institutions and state designated agencies (SDAs) in Kerala are given in table 4.7.7.5.

Table 4.7.7.5: Institutions involved in Palakkad cluster

Institution/ organization	Contact details	Objectives and roles
Steel Manufactures Association of Kerala	MPS complex, Para Road, Kanjikode, Palakkad - 678621 Tel: 9388399882, 0491-3265000 email: mmquickerala@gmail.com	• Welfare activities and grievance redressal of member industries
Energy Management Centre (EMC) - Kerala,	Sreekrishna Nagar, Sreekaryam, Thiruvananthapuram – 695 017 Tel: 0471 259 4922 email: emck@keralaenergy.gov.in https://www.keralaenergy.gov.in	• Promoting energy efficiency in different end-use sectors including industries

4.7.7.6 Other information

There are no specific studies focusing on adoption of energy efficiency in IF plants in the cluster.

4.7.7.7 Summary of findings

The summary of findings of induction furnace plants in Palakkad cluster is provided in table 4.7.7.7

Table 4.7.7.7: Summary of findings of induction furnace plants in Palakkad cluster

Parameter	Remarks
Number of Non-DC category induction furnace plants	25
Operating plants of Non-DC category	20
Total energy consumption	14,494 toe per year
SEC– Overall	2.4 GJ per tonne liquid steel
GHG emissions	133,142 tonne CO_2 per year
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel
Other relevant information	No specific studies pertaining to energy efficiency improvements

4.7.8 Patna Cluster

4.7.8.1 Cluster background

Patna cluster is located in Bihar. There are a total of 20 electric induction furnace (EIF) plants located in the cluster all of which are of Non-DC category. The total production of steel from 18 operating units is estimated to be 0.5 million tonne considering 72.2% of capacity utilization (source: JPC, 2020) as shown in table 4.7.8.1.

Table 4.7.8.1: Production of Non-DC induction furnace plants (Patna)

Parameters	Value
Total number of plants	20
Plants covered under PAT	-
Number of Non-DC plants	20
Non-DC plants (operating)	12
Estimated production (million tonne)	0.5

Source: Analysis of JPC data, 2020

4.7.8.2 Process technology

Induction furnaces are used for melting of iron and scrap. The process steps involved in induction furnace plants include (1) preparation of moulds and charge material, (2) melting, and (3) finishing. The technologies used in induction furnace plants in Patna cluster are provided in Table 4.7.8.2.

Table 4.7.8.2: Process technology used in induction furnace plants

Technology	Purpose
Induction furnace	Melting of iron and scrap

4.7.8.3 Energy consumption analysis

The induction furnace plants use electricity for melting of iron and scrap. The induction furnace is the major consumer of energy in an EIF based plant. The total energy consumption of induction furnaces under Non-DC category in Patna cluster is estimated to be 31,800 toe per year. The equivalent GHG emissions are estimated to be 292,113 tonne CO_2 per year (Table 4.7.8.3).

Table 4.7.8.3: Energy consumption of Non-DC induction furnace plants (Patna)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent toe/year	(tonne CO_2/year)
Electricity	370 mil kWh/year	31,800	292,113
	Total	31,800	292,113

4.7.8.4 Performance of induction furnace plants

The average specific electricity consumption of induction furnaces for melting operation is about 680 kWh per tonne liquid steel with SEC ranging from 580 kWh per tonne to 769 kWh per tonne for different capacities of furnaces. The energy consumption of other related operations followed in EIF units are not readily available. The overall specific energy consumption (SEC) of induction furnace plants in the cluster is estimated to be 2.4 GJ per tonne as shown in table 4.7.8.4.

Table 4.7.8.4: Performance of Non-DC induction furnace plants (Patna)

Parameter	Value
SEC – Electrical	680 kWh per tonne liquid steel
SEC- Overall	2.4 GJ per tonne liquid steel
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel

4.7.8.5 Relevant institutions for induction furnace plants

The details of relevant institutions and state designated agencies (SDAs) in Bihar are given in table 4.7.8.5.

Table 4.7.8.5: Institutions involved in Patna cluster

Institution/ organization	Contact details	Objectives and roles
Bihar Industries Association	Industry House Sinha Library Road Patna- 800017 Tel : 0612 222 6642 email: biapatna1@gmail.com http://www.biabihar.com/index.php	• Facilitates skill development programmes • Welfare activities and grievance redressal of member industries
Bihar Renewable Energy Development Agency (BREDA)	2nd Floor, Vidhyut Bhawan-II, Bailey Road, Patna – 800001 Tel: 0612 250 7734 email: breda@breda.in https://www.breda.bih.nic.in	• Formulate and implement a broad based energy conservation program • Develop and support documentation services in area of energy and renewable energy • Develop communication and education projects for wide spread dissemination of energy and environmental issues.

4.7.8.6 Other information

There are no specific studies focusing on adoption of energy efficiency in IF plants in the cluster.

4.7.8.7 Summary of findings

The summary of findings of induction furnace plants in Patna cluster is provided in table 4.7.8.7.

Table 4.7.8.7: Summary of findings of induction furnace plants in Patna cluster

Parameter	Remarks
Number of Non-DC category IF plants	20
Operating plants of Non-DC category	12
Total energy consumption	31,800 toe per year
SEC– Overall	2.4 GJ per tonne liquid steel
GHG emissions	292,113 tonne CO_2 per year
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel
Other relevant information	No specific studies on energy efficiency improvements

4.7.9 Raipur Cluster

4.7.9.1 Cluster background

Raipur cluster is located in Chhattisgarh. There are a total of 69 electric induction furnace (EIF) plants located in the cluster of which 50 plants are of Non-DC category. The total production of steel from 34 operating units is estimated to be 1.3 million tonne considering 72.2% of capacity utilization (source: JPC, 2020) as shown in table 4.7.9.1.

Table 4.7.9.1Production of Non-DC induction furnace plants (Raipur)

Parameters	Value
Total number of plants	69
Plants covered under PAT	19
Number of Non-DC plants	50
Non-DC plants (operating)	34
Estimated production (million tonne)	1.3

Source: Analysis of JPC data, 2020

4.7.9.2 Process technology

Induction furnaces are used for melting of iron and scrap. The process steps involved in induction furnace plants include (1) preparation of moulds and charge material, (2) melting, and (3) finishing. The technologies used in induction furnace plants in Raipur cluster are provided in Table 4.7.9.2.

Table 4.7.9.2: Process technology used in induction furnace plants

Technology	Purpose
Induction furnace	Melting of iron and scrap

4.7.9.3 Energy consumption analysis

The induction furnace plants use electricity for melting of iron and scrap. The induction furnace is the major consumer of energy in an EIF based plant. The total energy consumption of induction furnaces under Non-DC category in Raipur cluster is estimated to be 75,640 toe per year. The equivalent GHG emissions are estimated to be 694,835 tonne CO_2 per year (Table 4.7.9.3).

Table 4.7.9.3: Energy consumption of Non-DC induction furnace plants (Raipur)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent toe/year	(tonne CO_2/year)
Electricity	879 mil kWh/year	75,640	694,835
	Total	75,640	694,835

4.7.9.4 Performance of induction furnace plants

The average specific electricity consumption of induction furnaces for melting operation is about 680 kWh per tonne liquid steel with SEC ranging from 580 kWh per tonne to 769 kWh per tonne for different capacities of furnaces. The energy consumption of other related operations followed in EIF units are not readily available. The overall specific energy consumption (SEC) of induction furnace plants in the cluster is estimated to be 2.4 GJ per tonne as shown in table 4.7.9.4.

Table 4.7.2.4: Performance of Non-DC induction furnace plants (Raipur)

Parameter	Value
SEC – Electrical	680 kWh per tonne liquid steel
SEC- Overall	2.4 GJ per tonne liquid steel
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel

4.7.9.5 Relevant institutions for induction furnace plants

The details of relevant institutions and SDAs in Chhattisgarh cluster are given in table 4.7.9.5.

Table 4.7.9.5: Institutions involved in Raipur cluster

Institution/ organization	Contact details	Objectives and roles
Raipur Iron & Steel Trade Association	RISTA C/o.308, 3rd floor, Samta Shopping arcade, Samta colony, Raipur-492001	• Welfare activities and grievances redressal of member industries
Urla Industries Association	Urla industrial complex, Raipur 493221 Tel: 0771 2323850	• Welfare activities and grievances redressal of member industries
Chhattisgarh State Renewable Energy Development Agency (CREDA)	2ndfloor, CSERC Building Shanti Nagar, Raipur Tel: 83700 09931 email: contact.creda@gov.in http://www.creda.in	• Implementing schemes pertaining to renewable energy and energy conservation activities

4.7.9.6 Other information

There are no specific studies focusing on adoption of energy efficiency in induction furnace plants in the cluster.

4.7.9.7 Summary of findings

The summary of findings of induction furnace plants in Raipur cluster is provided in table 4.7.9.7.

Table 4.7.9.7: Summary of findings of induction furnace plants in Raipur cluster

Parameter	Remarks
Number of Non-DC category IF plants	50
Operating plants of Non-DC category	34
Total energy consumption	75,640 toe per year
SEC– Overall	2.4 GJ per tonne liquid steel
GHG emissions	694,835 tonne CO_2 per year
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel
Other relevant information	No specific studies related to energy efficiency

4.7.10 Seraikela cluster

4.7.10.1 Cluster background

Seraikela cluster is located in Jharkhand. There are a total of 20 electric induction furnace (EIF) plants located in the cluster all of which are of Non-DC category. The total production of steel from 14 operating units is estimated to be 0.8 million tonne considering 72.2% of capacity utilization as shown in table 4.7.10.1 (source: JPC, 2020).

Table 4.7.10.1: Production of Non-DC induction furnace plants (Seraikela)

Parameters	Value
Total number of plants	20
Plants covered under PAT	-
Number of Non-DC plants	20
Non-DC plants (operating)	14
Estimated production (million tonne)	0.8

Source: Analysis of JPC data, 2020

4.7.10.2 Process technology

Induction furnaces are used for melting of iron and scrap. The process steps involved in induction furnace plants include (1) preparation of moulds and charge material, (2) melting, and (3) finishing. The technologies used in induction furnace plants in Seraikela cluster are provided in Table 4.7.10.2.

Table 4.7.10.2: Process technology used in induction furnace plants

Technology	Purpose
Induction furnace	Melting of iron and scrap

4.7.10.3 Energy consumption analysis

The induction furnace plants use electricity for melting of iron and scrap. The induction furnace is the major consumer of energy inan EIF based plant. The total energy consumption of induction furnaces under Non-DC category in Seraikela cluster is estimated to be 45,449 toe per year. The equivalent GHG emissions are estimated to be 417,498 tonne CO_2 per year (table 4.7.10.3).

Table 4.7.10.3: Energy consumption of Non-DC induction furnace plants (SeraIkela)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent toe/year	(tonne CO_2/year)
Electricity	528 mil kWh/year	45,449	417,498
	Total	45,449	417,498

4.7.10.4 Performance of induction furnace plants

The average specific electricity consumption of induction furnaces for melting operation is about 680 kWh per tonne liquid steel with SEC ranging from 580 kWh per tonne to 769 kWh per tonne for different capacities of furnaces. The energy consumption of other related operations followed in EIF units are not readily available.The overall SEC of IF plants in the cluster is estimated to be 2.4 GJ per tonne (table 4.7.10.4).

Table 4.7.10.4: Performance of Non-DC induction furnace plants (Seraikela)

Parameter	Value
SEC – Electrical	680 kWh per tonne liquid steel
SEC- Overall	2.4 GJ per tonne liquid steel
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel

4.7.10.5 Relevant institutions for induction furnace plants

The details of relevant institutions and state designated agencies (SDAs) in Jharkhand are given in table 4.7.10.5.

Table 4.7.10.5: Institutions involved in Seraikela cluster

Institution/ organization	Contact details	Objectives and roles
Jharkhand Small Industries Association	19A, Udyog Bhavan, Kokar Industrial Area, Kokar, Ranchi-834 001 Jharkhand Tel: 0651 254 5234 email: ossia@satyam.net.in http://www.jsia.co.in/home-2/	• Welfare activities and grievances redressal of member industries
Jharkhand Renewable Energy Development Agency (JREDA)	3rd floor, SLDC Building, Kusai Colony, Doranda, Ranchi – 834 002 Jharkhand Tel: 0651 249 1161 Email: info@jreda.com https://www.jreda.com	• Implement and monitor energy efficiency projects • Promote energy efficient technologies • Coordinating energy efficiency activities with state government departments and industry • Facilitate energy audits • Comply with energy consumption norms and standards • Prepare and implement schemes for efficient use of energy

4.7.10.6 Other information

There are no specific studies focusing on adoption of energy efficiency in IF plants in the cluster.

4.7.10.7 Summary of findings

The summary of findings of induction furnace plants in Seraikela cluster is provided in table 4.7.10.7.

Table 4.7.10.7: Summary of findings of induction furnace plants in Seraikela cluster

Parameter	Remarks
Number of Non-DC category plants	20
Operating plants of Non-DC category	14
Total energy consumption	45,449 toe per year
SEC– Overall	2.4 GJ per tonne liquid steel
GHG emissions	417,498 tonne CO_2 per year
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel
Other relevant information	No specific studies in induction furnaces

4.7.11 Sunderghar Cluster

4.7.11.1 Cluster background

Sunderghar cluster is located in Odisha. There are a total of 34 electric induction furnace (EIF) plants located in the cluster of which 29 plants are of Non-DC category. The total production of steel from 23 operating units is estimated to be 0.6 million tonne considering 72.2% of capacity utilization (source: JPC, 2020) as shown in table 4.7.11.1.

Table 4.7.11.1: Production of Non-DC induction furnace plants (Sunderghar)

Parameters	Value
Total number of plants	34
Plants covered under PAT	5
Number of Non-DC plants	29
Non-DC plants (operating)	23
Estimated production (million tonne)	0.6

Source: Analysis of JPC data, 2020

4.7.11.2 Process technology

Induction furnaces are used for melting of iron and scrap. The process steps involved in induction furnace plants include (1) preparation of moulds and charge material, (2) melting, and (3) finishing. The technologies used in induction furnace plants in Sunderghar cluster are provided in Table 4.7.11.2.

Table 4.7.11.2: Process technology used in induction furnace plants

Technology	Purpose
Induction furnace	Melting of iron and scrap

4.7.11.3 Energy consumption analysis

The induction furnace plants use electricity for melting of iron and scrap. The induction furnace is the major consumer of energy in an EIF based plant. The total energy consumption of induction furnaces under Non-DC category in Sunderghar cluster is estimated to be 36,965 toe per year. The equivalent GHG emissions are estimated to be 339,564 tonne CO2 per year (Table 4.7.11.3).

Table 4.7.11.3: Energy consumption of Non-DC induction furnace plants (Sunderghar)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent toe/ year	(tonne CO_2/year)
Electricity	429.8 mil kWh/year	36,965	339,564
	Total	36,965	339,564

4.7.11.4 Performance of induction furnace plants

The average specific electricity consumption of induction furnaces for melting operation is about 680 kWh per tonne liquid steel with SEC ranging from 580 kWh per tonne to 769 kWh per tonne for different capacities of furnaces. The energy consumption of other related operations followed in EIF units are not readily available.The overall SEC of induction furnace plants in the cluster is estimated to be 2.4 GJ per tonne (table 4.7.11.4).

Table 4.7.11.4: Performance of Non-DC induction furnace plants (Sunderghar)

Parameter	Value
SEC – Electrical	680 kWh per tonne liquid steel
SEC- Overall	2.4 GJ per tonne liquid steel
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel

4.7.11.5 Relevant institutions for induction furnace plants

The details of relevant institutions and state designated agencies (SDAs) in Odisha are given in table 4.7.11.5.

Table 4.7.11.5: Institutions involved in Odisha cluster

Institution/ organization	Contact details	Objectives and roles
District small scale industries association - Sundargarh chapter	Industrial Estate, Rourkela – 769004 Tel: 0661 2507832 email: info@rourkeladssia.com http://www.rourkeladssia.com/fair-contact.html	• Welfare industries and grievances redressal of member industries
Department of Energy, Government of Odisha	Power house square, Bidyutmarg, Bhubaneswar – 751 001 Tel: 0674 2536960, 2396605 https://energy.odisha.gov.in	• Aims at planning, developing, managing and advising the government scheme under Department of Energy • Establish policies necessary for effective and efficient implementation of the government programme.

4.7.11.6 Other information

There are no specific studies focusing on adoption of energy efficiency in induction furnace plants in the cluster.

4.7.11.7 Summary of findings

The summary of findings of induction furnace plants in Sunderghar cluster is provided in table 4.7.11.7.

Table 4.7.11.7: Summary of findings of induction furnace plants in Sunderghar cluster

Parameter	Remarks
Number of Non-DC category induction furnace plants	29
Operating plants of Non-DC category	23
Total energy consumption	36,965 toe per year
SEC– Overall	2.4 GJ per tonne liquid steel
GHG emissions	339,564 tonne CO_2 per year
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel
Other relevant information	No specific studies on energy efficiency improvements in induction furnace

4.7.12 Other clusters

4.7.12.1 Cluster background

There are a total of 707 electric induction furnace (EIF) plants located in the cluster of which 671 plants are of Non-DC category. The total production of steel from 508 operating units is estimated to be 17.0 million tonne considering 72.2% of capacity utilization (source: JPC, 2020) as shown in table 4.7.12.1.

Table 4.7.12.1: Production of Non-DC induction furnace plants (other clusters)

Parameters	Value
Total number of plants	707
Plants covered under PAT	36
Number of Non-DC plants	671
Non-DC plants (operating)	508
Estimated production (million tonne)	17.0

Source: Analysis of JPC data, 2020

4.7.12.2 Process technology

Induction furnaces are used for melting of iron and scrap. The process steps involved in induction furnace plants include (1) preparation of moulds and charge material, (2) melting, and (3) finishing. The technologies used in induction furnace plants in other clusters are provided in Table 4.7.12.2.

Table 4.7.12.2: Process technology used in induction furnace plants

Technology	Purpose
Induction furnace	Melting of iron and scrap

4.7.12.3 Energy consumption analysis

The induction furnace plants use electricity for melting of iron and scrap. The induction furnace is the major consumer of energy in an EIF based plant. The total energy consumption of induction furnaces under Non-DC category in other clusters is estimated to be 994,537 toe per year. The equivalent GHG emissions are estimated to be 9.1 million tonne CO_2 per year (Table 4.7.12.3).

Table 4.7.12.3: Energy consumption of Non-DC induction furnace plants (other clusters)

Fuel	Energy consumption		GHG emissions
	Quantity	Equivalent toe/year	(million tonne CO_2/year)
Electricity	11,564 mil kWh/year	994,537	9.1
	Total	994,537	9.1

4.7.12.4 Performance of induction furnace plants

The average specific electricity consumption of induction furnaces for melting operation is about 680 kWh per tonne liquid steel with SEC ranging from 580 kWh per tonne to 769 kWh per tonne for different capacities of furnaces. The energy consumption of other related operations followed in EIF units are not readily available.The overall specific energy consumption (SEC) of induction furnace plants in the cluster is estimated to be 2.4 GJ per tonne as shown in table 4.7.12.4.

Table 4.7.12.4: Performance of Non-DC induction furnace plants (other clusters)

Parameter	Value
SEC – Electrical	680 kWh per tonne liquid steel
SEC- Overall	2.4 GJ per tonne liquid steel
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel

4.7.12.5 Relevant institutions for induction furnace plants

Since the industries are scattered in other clusters, details of institutions are not provided in this report.

4.7.12.6 Other information

There are no specific studies focusing on adoption of energy efficiency in IF plants in these clusters.

4.7.12.7 Summary of findings

The summary of findings of induction furnace plants in other clusters is provided in table 4.7.12.7.

Table 4.7.12.7: Summary of findings of induction furnace plants in other clusters

Parameter	Remarks
Number of Non-DC category IF plants	671
Operating plants of Non-DC category	508
Total energy consumption	994,537 toe per year
SEC– Overall	2.4 GJ per tonne liquid steel

Parameter	Remarks
GHG emissions	9.1 million tonne CO_2 per year
Specific GHG emissions	0.5 tonne CO_2 per tonne liquid steel
Other relevant information	No specific study conducted or on-going pertaining to implementation of energy efficient technologies in the state

4.7.13 Summary of energy analysis of induction furnace plants

A study of induction furnace segment shows that there are a total of 1,103 induction furnace plants in India. About 1,037 induction furnace plants belong to Non-DC category. The overall capacity utilization of EIF plants was 72.2% during 2019-20 with a production of 24.9 million tonne during 2019-20 from Non-DC EIF plants. The total energy consumption of Non-DC plants is estimated to be 1.5 million toe per year with an equivalent GHG emissions of 13.4 million tonne CO_2 (table 4.7.13).

The following considerations and assumptions were made while undertaking analysis of the sub-sector.

- The average capacity utilization of EIF sector is 72.2% (source: Analysis of JPC, 2020 data)
- The average specific electricity consumption of induction furnaces is about 680 kWh per tonne of liquid steel ranging from 580 kWh per tonne to 769 kWh per tonne for different capacities of furnaces (source: Compendium on induction furnace, UNDP).
- Standard energy values and emission factors were used for estimating energy consumption and GHG emissions respectively.

Table 4.7.13: Summary of energy analysis of induction furnace plants

S No	Cluster	Number of Non-DC EIF plants		Production (million tonne/yr)	Energy consumption (toe/year)	GHG emissions (tonne-CO_2/year)
		Total	Operating			
1	Patna	20	12	0.5	31,800	292,113
2	Raipur	50	34	1.3	75,640	694,835
3	Dadra and Nagar Haveli	20	19	0.2	12,501	114,836
4	Seraikela	20	14	0.8	45,449	417,498
5	Palakkad	25	20	0.2	14,494	133,142
6	Sunderghar	29	23	0.6	36,965	339,564
7	Fatehgarh Sahib	64	60	1.6	93,180	855,956
8	Ludhiana	46	44	1.0	61,047	560,781
9	Coimbatore	55	49	0.2	9,805	90,073
10	Bardhaman	37	18	1.4	82,506	757,903
11	Other clusters	671	508	17.0	994,537	9,135,867
	Total	1,037	801	24.9	1,457,925	13,392,569

The global SEC level of induction furnace plants is reported to be 1.8-2.9 GJ per tonne (source: Global Industrial Energy Efficiency Benchmarking: An Energy Policy Tool)

4.7.14 Cluster selection in induction furnace sub-sector

4.7.14.1 Selection matrix

The study considered a number of attributes with relevant criteria and score for ranking of the clusters. These attributes are provided in table 4.7.14.1. More details of selection matrix at cluster level are provided in annexure 2.

Table 4.7.14.1: Selection criteria for induction furnace sub-sector

S No	Attribute	Criteria	Score
1	Number of units	• <= 20 • 21-30 • 31-50 • > 50	2.5 5.0 7.5 10.0
2	Specific energy consumption, GJ per tonne	• <=15,000 • 15,001-50,000 • 50,001-85,000 • > 85000	2.5 5.0 7.5 10.0
3	Variability (technology, fuel, etc.)	• One variable • Two variables • Three variables • More than three variables	2.5 5.0 7.5 10.0
4	GHG emission share	• Less than 5% • 6-10% • 11-15% • >15%	2.5 5.0 7.5 10.0
5	Prior/on-going activities on energy efficiency at cluster level	• Replication of EE measures • Demonstration undertaken • Cluster level studies conducted • No activities on energy efficiency	2.5 5.0 7.5 10.0
6	Availability of industry association in the cluster	• No industry association • One industry association • More than one association • Industry association, SPVs, etc.	2.5 5.0 7.5 10.0

4.7.14.2 Summary of findings

Based on the attributes and criteria, the project has short-listed Raipur (Chhattisgarh) and Fatehgarh Sahib (Punjab) for further planning and deep-diving on energy efficiency activities in sponge iron industries (table 4.7.14.2). Fatehgarh Sahib is given ranking “2” considering the number of units and total energy consumption as compared to Ludhiana.

Table 4.7.14.2: Shortlisted clusters for deep-diving in induction furnace sub-sector

Cluster	State	Score	Ranking
Raipur	Chhattisgarh	45.0	1
Fatehgarh Sahib	Punjab	40.0	2
Ludhiana	Punjab	40.0	2
Bardhaman	West Bengal	37.5	4
Patna	Bihar	30.0	5
Sunderghar	Odisha	30.0	5
Seraikela	Jharkhand	27.5	7
Coimbatore	Tamil Nadu	25.0	8
Dadra	Dadra	25.0	8
Palakkad	Kerala	25.0	8

Chapter 5

5.0 Conclusions

5.1 Summary of energy analysis of secondary steel sector

The iron and steel industry forms a key role in Indian economy, contributing to about 2% to the country's GDP. The Indian steel industry comprises both primary producers and secondary producers. A majority of the large industries in steel sector (mainly primary producers) are covered under PAT scheme to improve their energy performance. A large number of secondary producers are presently not covered under the PAT scheme but consume significant energy and have a large scope for energy efficiency improvements.

In order to improve the energy performance, a baseline data is pre-requisite for which an energy analysis using secondary data was undertaken to assess energy consumption, energy performance and GHG emissions. The study covered (1) foundry, (2) forging industry, (3) steel re-rolling mill, (4) sponge iron (direct reduction of iron), (5) electric arc furnace and (6) electric induction furnace sub-sectors. The total energy consumption covering these secondary steel sub-sectors is estimated to be 11.8 mtoe and the equivalent GHG emissions are 58.2 million tonne CO_2 per year (table 5.1).

Table 5.1 Summary of energy consumption of secondary steel sub-sectors (Non-DC)

S No	Sub-sector	Number of Industries		Production (Non-DC) (mtpa)	Energy consumption (mtoe/yr)	Average SEC (GJ/t)	GHG emissions (mt-CO_2/yr)	Specific GHG emissions (t-CO_2/t)
		Total	Non-DC					
1	Foundry	5,000	5,000	10.1	0.9	3.6	6.6	0.6
2	Forging	705	705	2.4	0.3	5.9	1.6	0.78
3	Steel re-rolling	1,313	1,257	34.1	1.7	2.1	6.5	0.2
4	Sponge iron	333	223	14.1	7.4	22.0	30.0	2.1
5	Electric arc furnace	55	37	0.3	0.1	1.9	0.1	0.4
6	Induction furnace	1,103	1,037	24.9	1.4	2.4	13.4	0.5
	Total			85.9	11.8		58.2	

Note: Indicated total number of forging units in four clusters

5.2 Selected clusters in steel sub-sectors

Based on total energy consumption and other energy related parameters, the following clusters/ states in each sub-sector have been short-listed for undertaking further study (table 5.2).

Table 5.2: Clusters short-listed in secondary steel sub-sector for deep-diving

S No	Sub-sector	Cluster/state	State	Number of Non-DC industries	Production (tpy)	Energy consumption (toe)	GHG emissions (t-CO_2/yr)
1	Foundry	Ahmedabad	Gujarat	450	543,600	46,098	346,435
		Rajkot	Gujarat	700	537,000	51,219	364,703
2	Forging	Rajkot	Gujarat	90	268,548	46,559	183,642
		Ludhiana	Punjab	510	372,000	58,496	281,565
3	Steel re-rolling	Raipur	Chhattisgarh	81	2,747,700	143,290	655,712
		Fategarh Sahib (Mandi Gobindgarh)	Punjab	132	2,634,600	129,510	572,245
4	Sponge iron	Odisha	Odisha	51	3,989,000	2,098,521	8,478,741
		Jharkhand	Jharkhand	26	2,413,000	1,269,045	5,127,372
5	Electric arc furnace	Odisha	Odisha	3	631,894	28,639	263,076
		Maharashtra	Maharashtra	4	586,129	26,565	244,023
6	Induction furnace	Fategarh Sahib (Mandi Gobindgarh)	Punjab	60	1,593,366	93,180	855,956
		Raipur	Chhattisgarh	34	1,293,437	75,640	694,835

5.3 Way forward

The study reveals significant energy consumption and higher SEC levels by the secondary steel sector. Therefore, it will be beneficial that detailed energy audit studies may be undertaken in the short-listed clusters/ states in each sub-sector to evaluate energy saving potential and assess investment requirements for energy efficiency improvements. Based on study results, a suitable energy efficiency programme may be formulated for providing technical assistance in the steel sub-sectors for large scale adoption of energy efficiency measures in the secondary steel sector.

5.4 Reference

(1) An overview of steel sector, JPC, updated March 2019 (https://steel.gov.in/sites/default/files/An%20_Overview%20_of_Steel_Sector_mar2019.pdf)

(2) Annual report, Ministry of Steel, 2020-21

(3) Energy statistics 2019, Ministry of Statistics and Programme Implementation

(4) The Indian iron & steel database 2019-20, Joint Plant Committee

(5) Association of Indian Forging Industry (AIFI); https://www.indianforging.org/indian-forging-industry/

(6) CO_2baseline database for the Indian power sector user guide (version 16.0), March, 2021

(7) Compendium: Energy efficient technology packages for electric arc furnace, TERI, 2017

(8) Compendium of energy efficient technology measures for secondary steel electric induction furnace sector, UNDP

(9) Cluster profiles –SAMEEEKSHA

(10) Financing Energy Efficiency at MSMEs, WB-GEF-SIDBI project

(11) Life cycle assessment of coal based direct-reduced iron production in India, Sabarish Elango, 2020

(12) Performance Review : Iron & Steel 2019-20, JPC

(13) Technology compendium on energy efficient technology options for direct reduction of iron process (sponge iron plants), TERI, 2021

(14) Towards Low Carbon Steel Sector, TERI 2020

(15) The Indian steel industry: Growth, challenges and digital disruption, PWC, 2019 https://www.pwc.in/assets/pdfs/consulting/technology/the-indian-steel-industry-growth-challenges-and-digital-disruption.pdf

(16) Foundries Global Market Report 2021: COVID 19 Impact and Recovery to 2030, https://www.globenewswire.com/news-release/2021/02/09/2172270/0/en/Foundries-Global-Market-Report-2021-COVID-19-Impact-and-Recovery-to-2030.html

(17) MODERN CASTING January 2021 https://www.thewfo.com/contentfiles/downloads/51.pdf

(18) http://www.foundryinfo-india.org/profile_of_indian.aspx

(19) http://www.felezatonline.ir/enNews_8962_India,-Iran,-and-Russia-were-the-largest-producers-of-sponge-iron-in-2018_theme/en/?id=8962

(20) https://www.globalefficiencyintel.com/new-blog/2020/9/2/part-2-cleanest-and-dirtiest-countries-for-secondary-eaf-steel-production

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