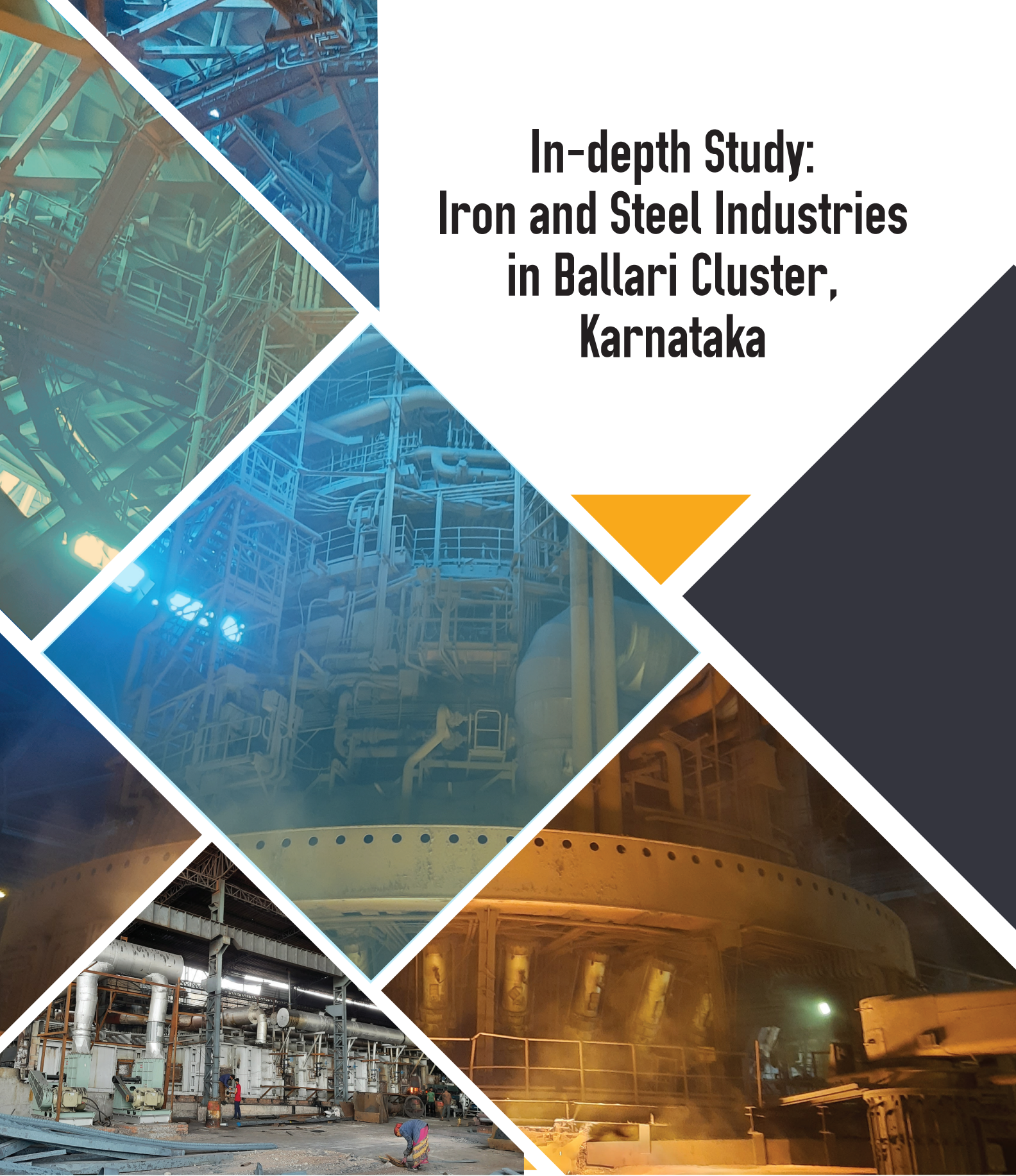




In-depth Study: Iron and Steel Industries in Ballari Cluster, Karnataka



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Abbreviations

BEE	Bureau of Energy Efficiency
BF	Blast Furnace
BOF	Basic Oxygen Furnace
CO₂	Carbon dioxide
DC	Designated Consumer
DRI	Direct Reduced Iron
EIF	Electric Induction Furnace
MSME	Micro, Small, and Medium Enterprises
mt	million tonne
mtoe	million tonne of oil equivalent
PAT	Perform, Achieve and Trade
SA	Stand-alone
SEC	Specific Energy Consumption
mtpy	million tonne per year
PAT	Perform, Achieve and Trade
PSU	Public Sector Undertaking
SAIL	Steel Authority of India Limited
SDA	State Designated Agency
SRRM	Steel Re-rolling Mill
VISL	Vishweshwaraiah Iron and Steel Limited
WHR	Waste Heat Recovery

1. Steel Industries in Karnataka



1.1 Background

The state of Karnataka has vast iron ore and mineral reserves with abundant mining potential. It is one of the five states having a significant share of the national iron and steel industry. The primary areas of iron ore mines in Karnataka include Ballari, Chitradurga, Koppal and Tumakuru districts. Karnataka is home to around 74% magnetite and 11% hematite resources of India.ⁱ The state also possesses other minerals like limestone, silica, manganese, etc., which are essential in steel production.

The state has a large number of iron and steel industries including public sector undertakings (PSUs), namely Vishweshwaraiah Iron and Steel Limited (VISL), Steel Authority of India Limited (SAIL), Bhadravathi, Shimoga, an integrated steel plant. Some of the major steel manufacturers in Karnataka include JSW Steel, Kalyani Steels and Mukund Steels. JSW Steel's plant at Vijayanagar, Ballari is the single largest location steel producing facility in India with a capacity of 12 million tonnes per annum (Mtpa).

1.2 Steel production

The route followed for crude steel production in Karnataka mainly consists of BOF (4), EAF (1) and IF (22).ⁱⁱ The BOF route contributes to about 72% of total steel production in the state (Figure 1).

The concentration of steel manufacturing industries in Karnataka is largely influenced by the local availability of iron ores. The Ballari district is the primary source of iron ore mining in Karnataka. There are 32 large iron and steel industries in Karnataka, which are covered as Designated Consumer (DC) under the Perform, Achieve and Trade (PAT) scheme of the Bureau of Energy Efficiency (BEE).ⁱⁱⁱ ¹

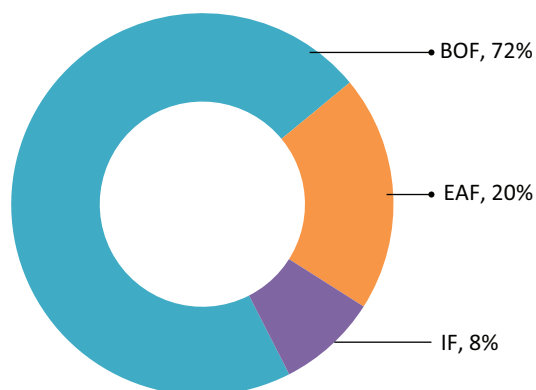


FIGURE 1: Share of crude steel production

¹ Gate to gate energy consumption is equal or more than 20,000 tonnes of oil equivalent

Of these, there are 20 DCs in Ballari district, including JSW, which is the largest manufacturer with 12 Mtpa capacity. Further, there are 79 iron and steel plants with 60 plants being stand-alone type (Figure 2) having only one manufacturing process and about 19 plants having more than one process connected with the manufacturing chain (Figure 2). The detailed distribution of the composite industries indicates that the re-rolling process is most common in 14 plants, followed by induction melting furnaces in 10 plants (Figure 3).

The steel production in Karnataka stood at 13.8 million tonne (Mt) in 2023–24, with an overall share of 9.5% of India's steel production during 2023–24 (JPC Report, 2023–24).^{iv} A marginal CAGR of 2% was witnessed between 2021 to 2024 period (Figure 4).

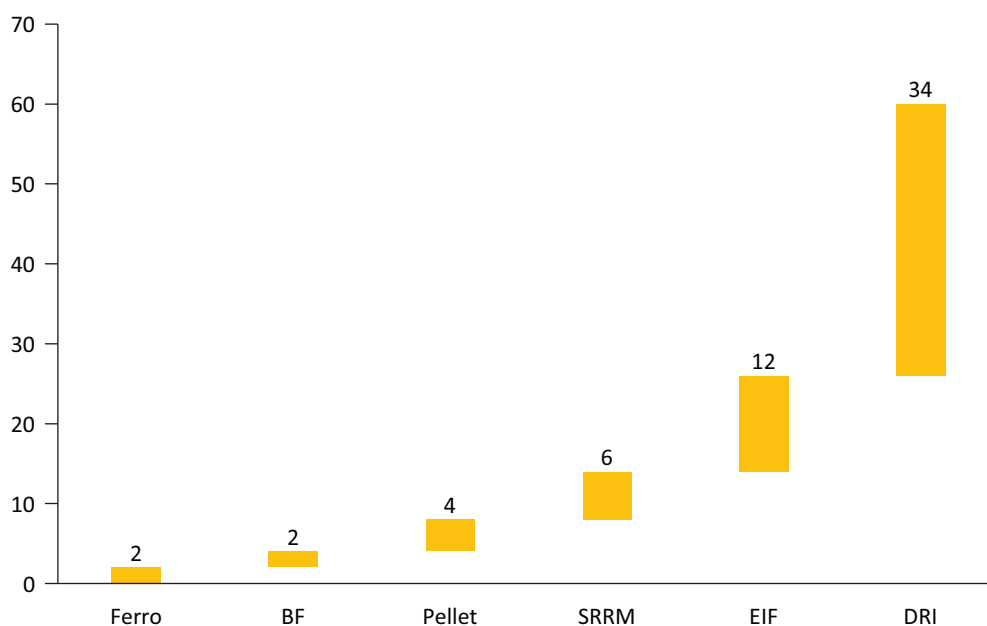


FIGURE 2: Stand-alone iron and steel industries in Karnataka

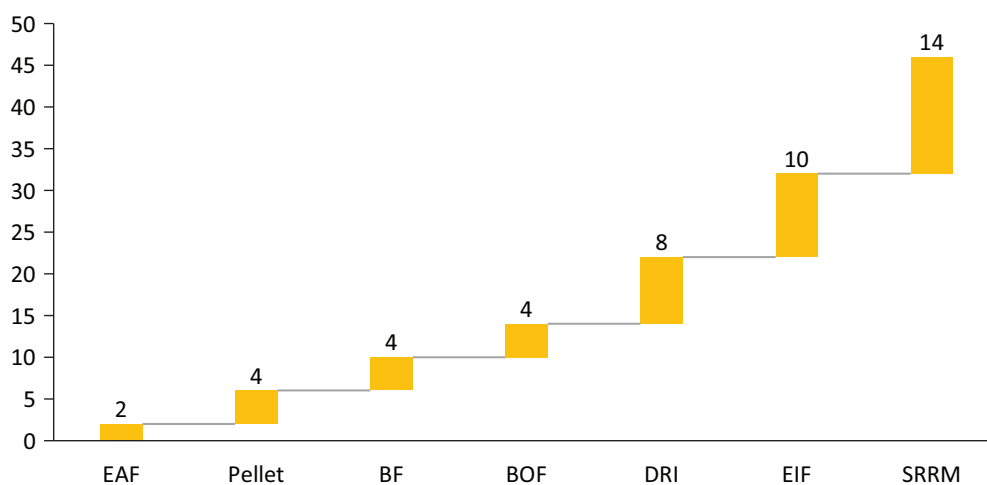


FIGURE 3: Distribution of composite steel industries in Karnataka

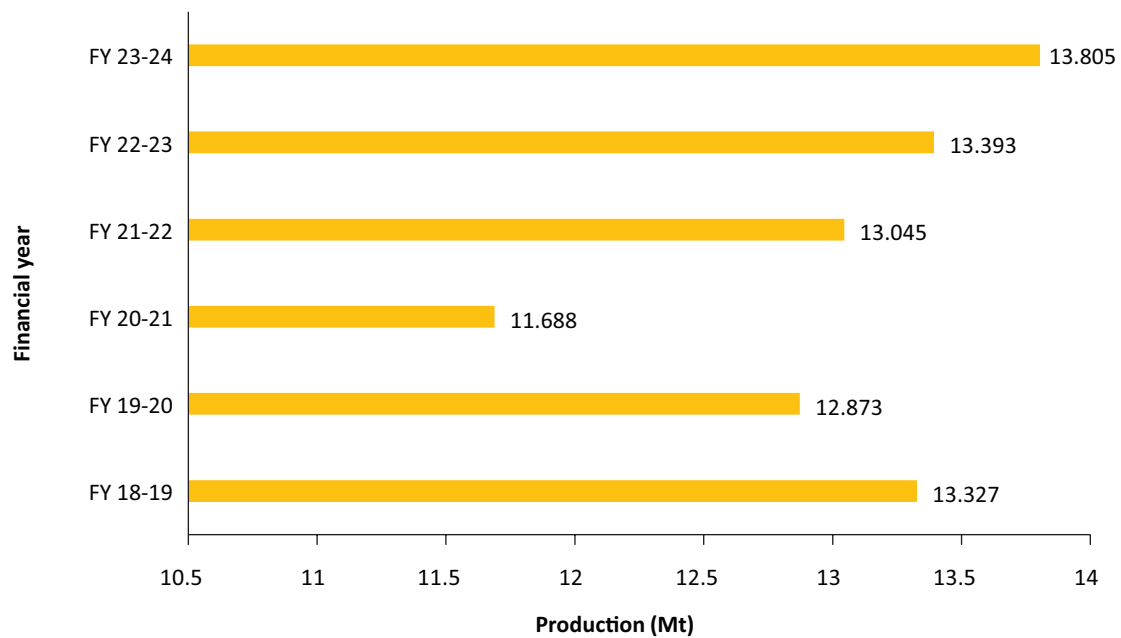


FIGURE 4: Growth of steel production in Karnataka (2018–2024)

2. Overview of Ballari Cluster



Ballari is also known as the 'Steel city of South India', rich in mineral resources like iron ore, manganese ore, red oxide and ferrous oxide, quartz, and granite. The iron and steel industries in Ballari cluster include pellet, direct reduced iron (DRI), electric induction furnace (EIF), steel re-rolling, blast furnace (BF), and BF-basic oxygen furnace (BOF) (Figure 5).

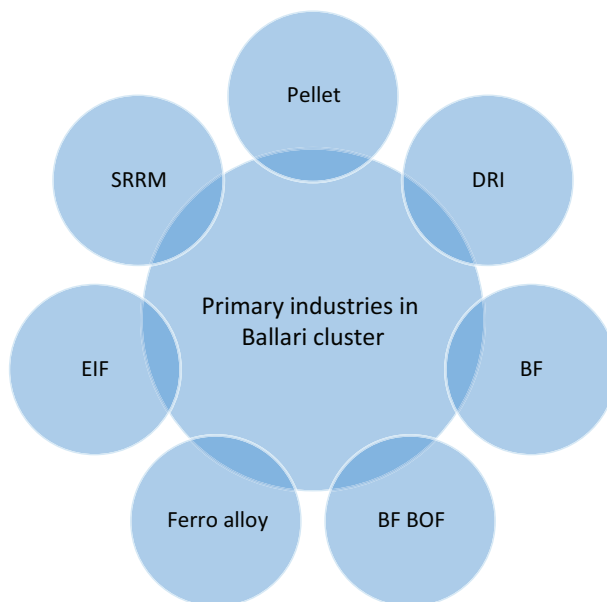


FIGURE 5: Primary industries in Ballari cluster

The large number of industries are located in primary industrial estates in Ballari district, namely Ballari, Huvina Hadagali, Hospet, Mundaragi and Siraguppa (Figure 6).^v

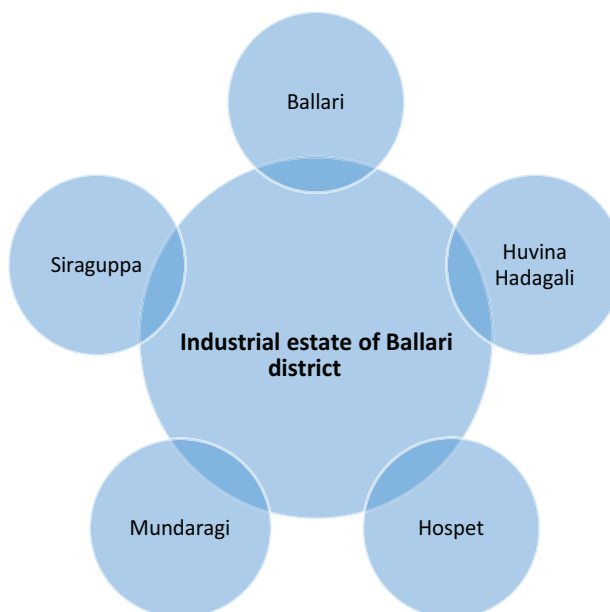


FIGURE 6: Primary industrial areas of Ballari district

3. Technology, Energy Consumption and Emissions in Ballari Steel Cluster



3.1 Industry distribution

There are about 42 iron and steel-based industries operating in the Ballari cluster, including both composite and stand-alone plants (Table 1).^{vi 2} DRI plants account for major share both in stand-alone type (23 industries) and composite plants (4 plants) as shown in Figure 7 and Figure 9, respectively.

There are around 32 independent iron and steel plants in Ballari with 27 plants being stand-alone plants (Figure 7). A majority of the DRI industries are of stand-alone type (Figure 8). The number of individual plants with multiple connected processes in its manufacturing chain is limited to only 5 in the cluster. The detailed distribution of the composite industries indicates that the DRI process is most common in 4 plants, followed by induction melting furnaces, pellets and steel re-rolling mills that are having 3 plants under each category (Figure 9). DRI process is predominant with a 27% share among the composite industries (Figure 10).

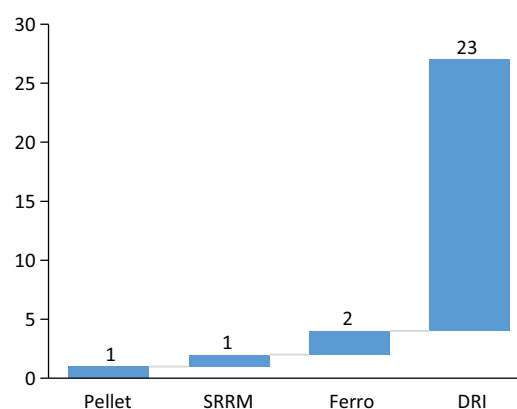
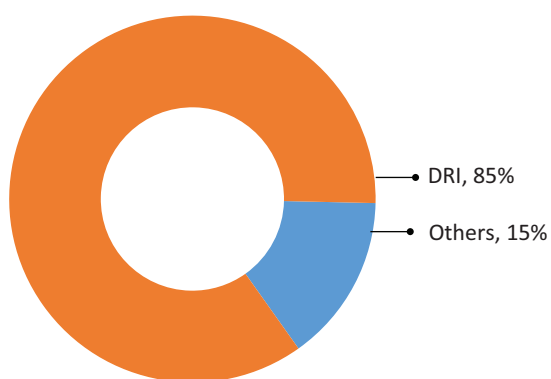


FIGURE 7: Distribution of SA industries in Ballari **FIGURE 8:** Share of stand-alone industries in Ballari

Table 1: Details of iron and steel industries in Ballari cluster

Description	Operating No	Stand-alone /Independent unit	Composite unit	DCs	Non-DCs
Sponge iron	27	23	4	18	9
Pellets	4	1	3	3	1
EIF	3	0	3	3	0
SRRM	4	1	3	3	1
BOF	1	0	1	1	0
BF	1	0	1	1	0
Ferro	2	2	0	0	2
Total	42	27	15	29	13

² Composite plants – Industries with multiple process steps covering backward and forward chains of operations. Stand-alone industries – have single process step.

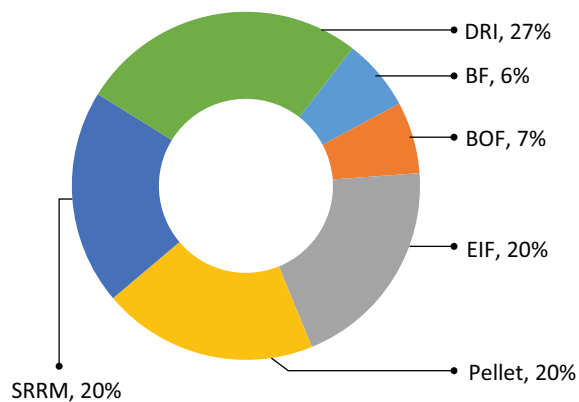


FIGURE 9: Distribution of composite industries in Ballari

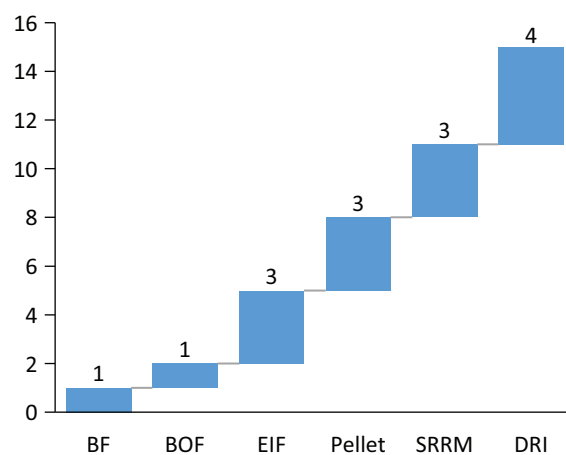


FIGURE 10: Details of composite industries in Ballari

Out of the 32 iron and steel industries in Ballari cluster, 27 industries (84%) have DRI process (Figure 11). The industries in other categories include BOF, BF, pellet, and Ferro alloy, etc.

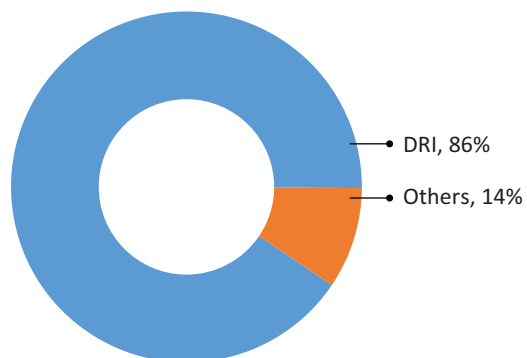


FIGURE 11: Share of DRI industries in Ballari cluster

The profile of connected process chains of primary industry sub-sectors in the Ballari cluster is presented in Figure 12 for DRI, Figure 13 for pellet and Figure 14 for SRRM.

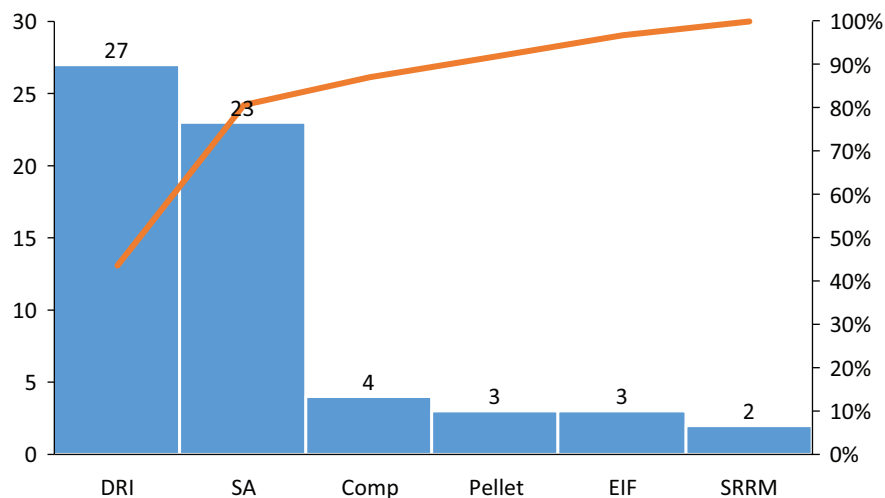


FIGURE 12: Profile of DRI industries

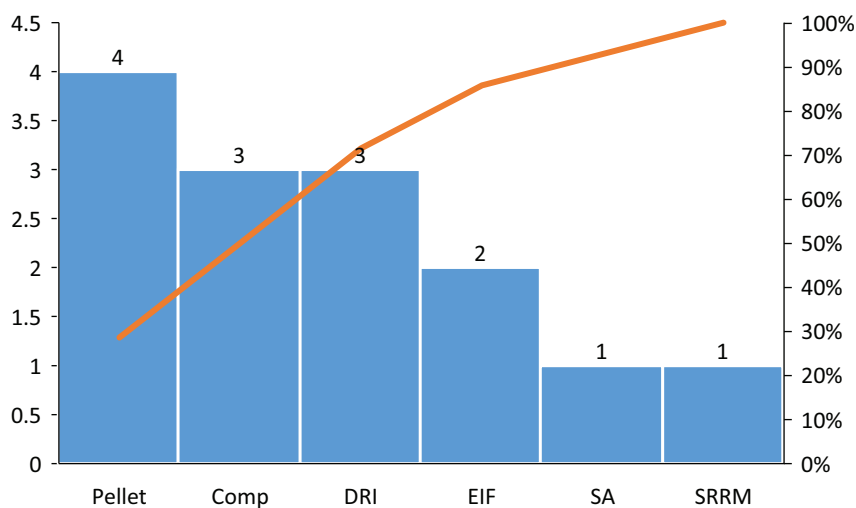


FIGURE 13: Profile of Pellet industries

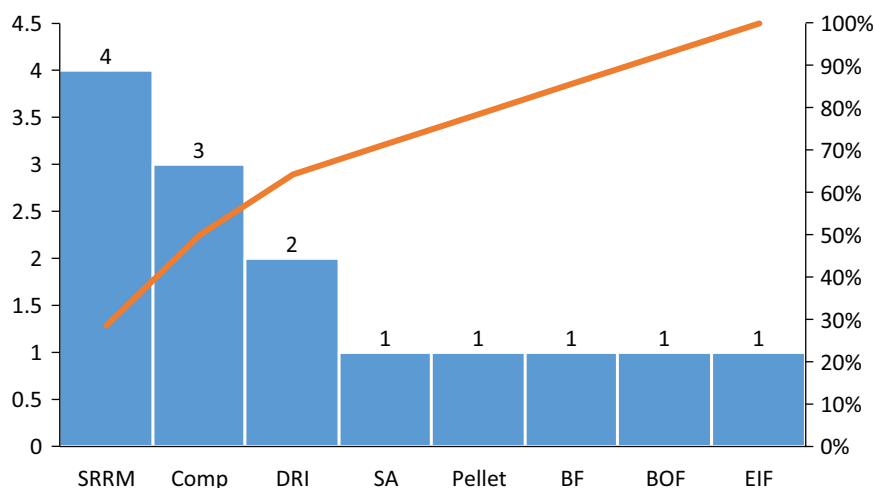


FIGURE 14: Profile of SRRM industries

Out of 32 iron and steel industries in the Ballari cluster, 19 industries (59%) are DCs (Figure 15); it excludes JSW, which is the only integrated steel plant in the cluster.

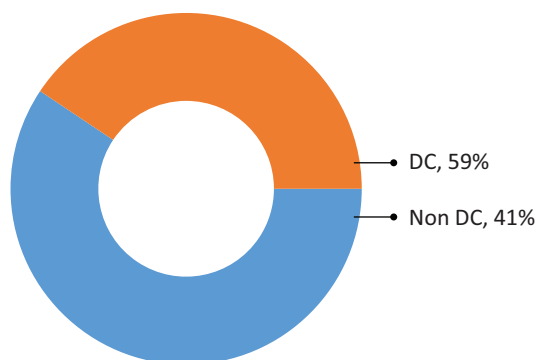


FIGURE 15: Share of DC industries in Ballari cluster

3.2 Technology use

An in-depth study of the Ballari cluster indicates that the end products from a process step within a plant are either one of the input raw materials in subsequent process steps or final products for marketing (Table 2). Further, most of these units use age-old and inefficient technologies except a few large DCs which have adopted state-of-the-art technologies.

Table 2: Technology, energy, and raw material of Ballari steel cluster

Technology	Industry	Raw material	Process step	Energy type	End-product
Induration furnace	Pellet	Iron ore	Heating	FO, coke, coal, electricity	Pellet
Rotary kiln	DRI	Iron ore/ pellet	Heating and reduction	Coal, electricity	Sponge iron
Blast furnace	Iron and steel	Sintered iron ore/sponge iron/pellet	Heating and reduction	Coal, electricity	Liquid iron/pig iron
Submerged arc furnace	Ferro alloy	Mineral ore	Heating and reduction	Coal, electricity	Alloying compound
Electric induction furnace	SMS	Sponge iron, pellet/ scrap	Melting of raw material	Electricity	Liquid metal /ingots and billets
Reheating furnace	SRRM	Ingots and billets	Heating	Coal, electricity	Heated feedstock for milling
Continuous casting machine	Casting	Liquid metal	Casting	Electricity	Hot billets for milling
Rolling mill	Rolling	Hot ingots and billets	Rolling	Electricity	Rolled products

3.3 Major products

Steel industries of these clusters produce a wide range of products (Figure 16), which find applications across different end-use sectors like industries, domestic, construction sectors, medical, and academic institutions, etc.

3.4 Energy consumption and CO₂ emissions

The iron and steel industries in Ballari cluster use coal, coke, and electricity depending upon the process employed. The total energy consumption of the cluster (excluding the integrated steel plant) for the production of 8.71 mtpy is estimated to be 1.84 million tonnes of oil equivalent (Mtoe) per year with the corresponding emissions of 8.34 million tonnes of carbon dioxide (Mt-CO₂) per year (Table 3).

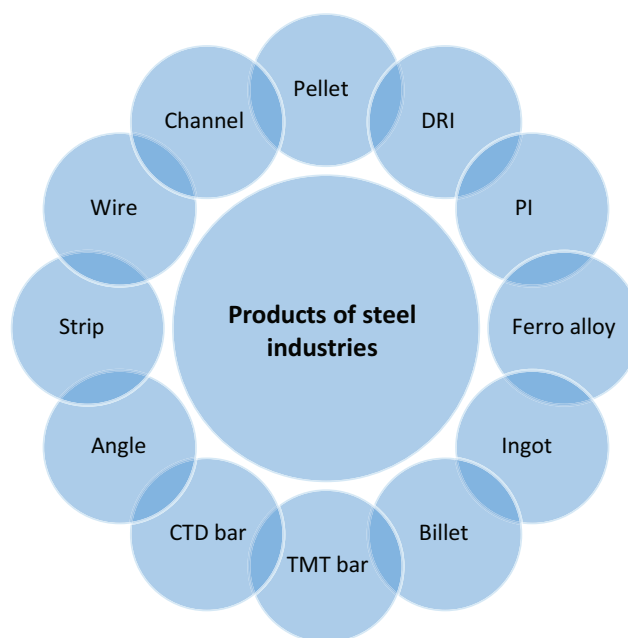


FIGURE 16: Products of steel industries

Table 3: Details of energy consumption and CO₂ emissions

Industry	Number	Production	Annual energy consumption				Total (unit/year)	
			Thermal [#]		Electricity		Energy (mtoe)	Emission (mt-CO ₂)
		(mtpy)	(mt/year)	(mtoe/year)	(m kWh/year)	(mtoe/year)		
Pellet	4	4.54	0.25	0.12	159	0.01	0.14	0.64
DRI	27	2.616	2.62	1.31	209	0.02	1.33	5.64
BF	1	0.24	0.16	0.12	24	0.002	0.12	0.49
BF-BOF	1	0.30	0.19	0.146	30	0.003	0.149	0.61
EIF	3	0.3	0	0	300	0.03	0.03	0.21
SRRM	4	0.572	0.06	0.003	60	0.005	0.01	0.16
Ferro	2	0.137	0.07	0.026	548	0.047	0.073	0.60
Total	42	8.71	3.34	1.72	1330	0.11	1.84	8.34

[#]includes coal and coke consumption in the process as applicable

Thermal energy accounts for about 94% of the total energy consumption while the share of electricity is about 6% (Figure 17). The corresponding CO₂ emissions from thermal energy and electricity are 89% and 11%, respectively (Figure 18).

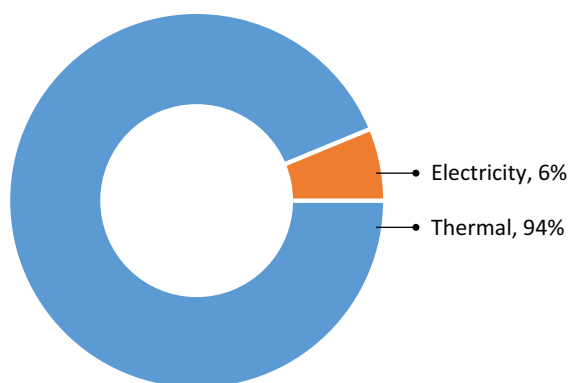


FIGURE 17: Share of energy consumption

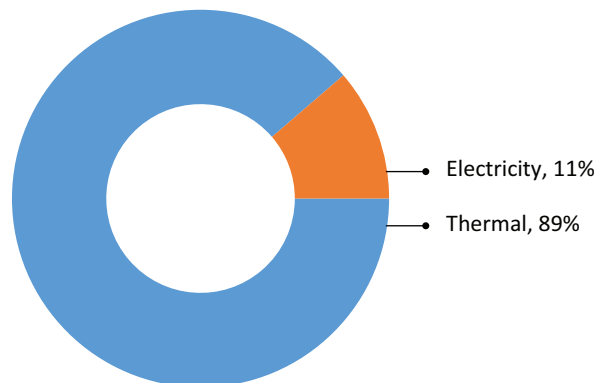


FIGURE 18: Share of CO₂ emission

DRI industries account for about 72.1% (1.33 Mtoe/year) of energy consumption (Figure 19). The share of CO₂ emissions from DRI in the cluster is 67.6% (5.64 MtCO₂/year) (Figure 20).

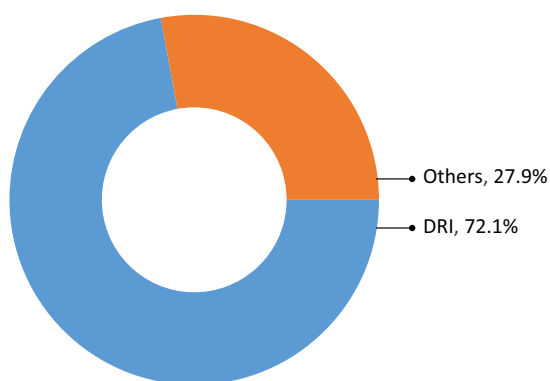


FIGURE 19: Share of energy consumption by DRI industries

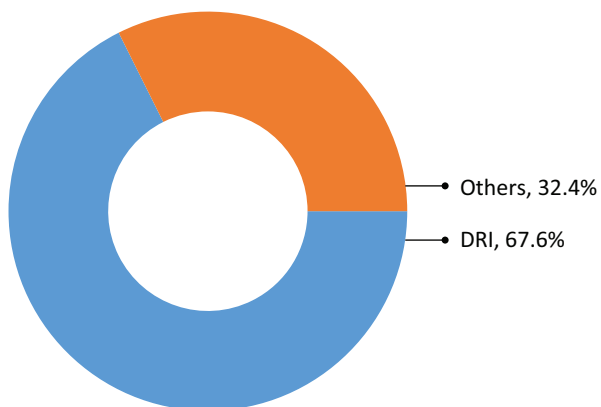


FIGURE 20: Share of emissions from DRI

Analysis of cluster level energy consumption shows that the coal/coke accounts for the major energy consumption in the cluster, estimated to be 3.34 mt (equivalent to 1.72 mtoe). The corresponding CO₂ emissions from coal/coke consumption is estimated to be 7.4 mt-CO₂, which is more than 88% of total emission from iron and steel industries in the cluster. The DRI industries are the largest consumer of energy as coal in Ballari steel cluster with a share of 78%. It also accounts for a major emission share on account of coal use (74%) (Table 4).

Table 4: Details of coal/coke consumption

Industry sub-sector	Coal/coke* consumption		Emission
	(mt/year)	(mtoe/year)	(mtCO ₂ /year)
DRI	2.61	1.31	5.49
Others	0.73	0.41	1.91
Total	3.34	1.72	7.40

* Average GCV for coal (5000 kcal/kg) and coke (7500 kcal/kg) is considered

The distribution of thermal energy uses in the Ballari cluster indicates that the share of DRI industries alone is equivalent to 76% of toe and corresponding avoided CO₂ emissions to the tune of 74% (Figure 21). The remaining shares are contributed by other industries comprising pellet, SRRM, mini blast furnace and BF-BOF in the cluster.

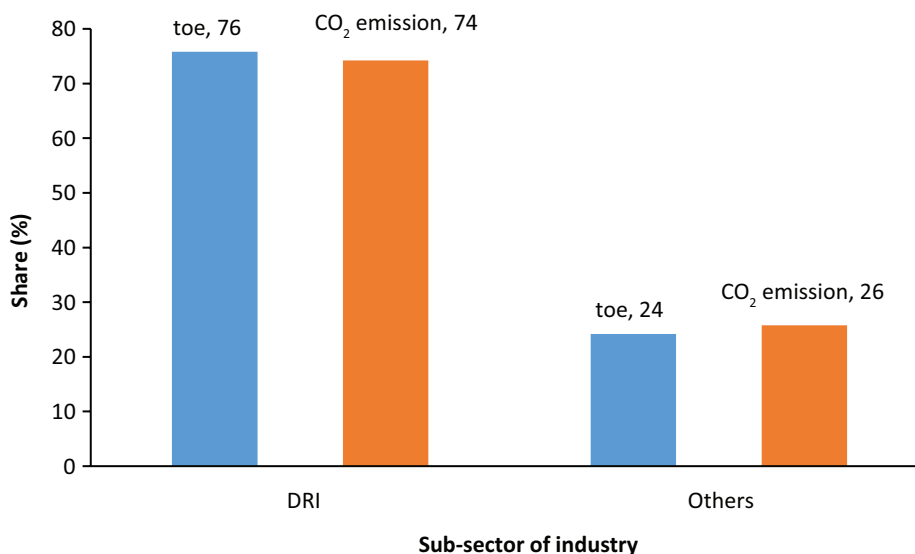


FIGURE 21: Distribution of thermal energy use in Ballari cluster

3.5 Key energy performance indicators

The SEC level of iron and steel industries is observed to vary widely across different industries within the cluster, depending on the quality of input resources, product profile, technology use, operating practices, etc. (Table 5).

Table 5: SEC levels of iron and steel industries

Industry type	Specific energy consumption (unit/tonne)		
	kWh	Coal [#] (kg)	Coke ^{\$} (kg)
Pellet	30–35	50–55	–
DRI	70–80	1000–1200	
BF	80–120		600–700
BF-BOF	80–120		600–700
EIF with CCM	850–950	–	–
Reheating furnace (in SRRM)	4–6	90–120	–
Rolling Mill	80–120	–	–
Ferro Alloy [@]	3500–4500	–	450–550

[#] Considered GCV of used thermal energy source (coal) is 5000 kcal/kg

^{\$} – GCV of fuel is 7500 kcal/kg

[@] – Mentioned specific electricity consumption for ferro manganese alloy manufacturing only

4. Energy Efficient Technology Options



4.1 Energy efficiency options for DRI industries

In coal-based DRI industries, coal is used for heating the input raw material mixture as well as during the reduction process. A majority of the input energy is lost through off-gases, which can be recovered effectively by retrofitting with customized WHR systems. These include:

- » Waste heat recovery for power generation using WHRB
- » Iron ore preheating rotary kiln using WHR system

Apart from WHR, there are other energy efficiency (EE) measures applicable for rotary kiln and associated auxiliaries. The potential energy saving options for DRI industries include the following:

- » Switch over from lumps to iron ore pellets
- » Mullite-based kiln lining for thermal insulation
- » Variable frequency drives (VFDs) for motive loads like fans, compressors, pumps, etc.
- » Adoption of gas-route based DRI production

4.2 Energy efficiency options for EIF-based industries

The potential energy saving options for EIF-based industries are as follows:

- » Installation of scrap bundling system
- » Adoption of continuous casting and direct rolling in composite EIF system
- » Installation of VFDs in (i) cooling pump system of continuous casting machine and (ii) air compressor
- » Installation of multi-stage centrifugal cooling water pumps

4.3 Energy efficiency options for SRRM industries

The potential energy saving options for SRRM industries are summarized below:

- » Installation of recuperator for preheating of combustion air
- » Switch over from pulverized coal-fired furnace to coal gasification system
- » Renovation of furnace lining and surface insulation
- » Installation of VFDs in (i) cooling pump system of continuous casting machine and (ii) air compressor
- » Switch over to continuous casting and direct rolling system

5. Key Stakeholders



The industry associations are one of the key stakeholders, both at the state level and cluster level, facilitating networking and addressing pertinent issues relevant to the steel industries. A few prominent industry associations also facilitate technical support to the member industries by organizing awareness events like workshops, trainings, etc. The key stakeholders and their contact details are provided in (Table 6).

Table 6: Key stakeholders of iron and steel industries in Karnataka

Institution/Organization	Contact details
Industrial Development & Director of Industries and Commerce	Commissioner Government of Karnataka No 49 South Block, Khanija Bhavan Road, Bengaluru – 560 001 Email: commissioner@karnatakaindustry.gov.in
District Industries Centre	Joint Director Hospet Road, Ballari – 583 103 Email: jd-bellary@karnatakaindustry.gov.in
Karnataka Udyog Mitra	Managing Director 3rd floor, Khanija Bhavan (East wing) No 49, Race Course Road Bengaluru – 560 001 Email: md@kumbangalore.com
Federation of Karnataka Chambers of Commerce and Industry	Federation House, Kempe Gowda Road, Bengaluru – 560 009 Email: info@fkcci.in /president@fkcci.in
Karnataka Sponge Iron Manufacturers Association (KSIMA)	Plot No 33, 1st Floor, Opp. BPCL Petrol Bunk, Infantry Road, Sanjay Gandhi Nagar, Ballari – 583 104 Email: madeinindiaksima@rediffmail.com
State Designated Agency (SDA) Karnataka	Managing Director Karnataka Renewable Energy Development Limited (KREDL) 6/13/1, 10th Block, 2nd Stage Nagarabhavi, Bengaluru – 560 072 Email: kredlmd@gmail.com
MSME DFO	Rajaji Nagar, Industrial Estate Bengaluru – 560 044 Email: dcdi-bang@dcmsme.gov.in

6. Conclusion



Ballari is an important iron and steel cluster in Karnataka with industries representing pellets, sponge iron and crude steel production (using BF, BF-BOF and electric induction furnace) along with downstream industries such as steel re-rolling. The secondary steel industries in Ballari cluster are thermal energy intensive, using energy from several sources such as coal, coke and electricity. The total production of steel in the cluster is estimated to be 8.71 mt. The overall energy consumption of Ballari steel cluster is estimated to be 1.84 mtoe per year with the corresponding emissions of 8.34 mtCO₂.

Of all the steel industries, DRI assumes important position in terms of overall energy consumption (about 72% of total) and associated emissions of about 67%. The DRI sector accounts for the highest share of coal/coke in the cluster (about 78%).

A close look at technology use and energy consumption shows that the cluster uses old and inefficient technologies leading to higher energy and emission indicators across different types of industries. Studies of similar industries in other steel clusters indicate significant scope for improving energy and environmental performance by adopting energy efficient technologies.

Furthermore, in line with India's nationally determined contributions (NDCs), the steel industry needs to adopt various decarbonization technological solutions to achieve net-zero emissions by the year 2070. However, this would require robust technical assistance on a long-term basis along with suitable policy and financial mechanisms at cluster level.

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- ii JPC Statistic 2023-24
- iii SDA Karnataka and JPC report of 22-23 and 23-24
- iv JPC Statistic 2023-24
- v Ballari district profile, Government of Karnataka
- vi JPC Statistic 2023-24

