Energy Profile

# Hooghly Mixed Cluster

Promoting Energy Efficiency in SMEs

SAMEEEKSHA

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***Suggested Citation:*** TERI. Energy profile – Hooghly mixed cluster. 2023

## Published by

The Energy and Resources Institute (TERI)
Darbari Seth Block, IHC Complex, Lodhi Road,
New Delhi - 110 003

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# Acknowledgements

This work would not have been possible without support from Department of MSME & Textiles and Government of West Bengal. Their support has helped TERI to adopt a deep-dive approach to energy savings consisting of technical assistance in undertaking a large number of diagnostic studies, new efficient technology promotion, capacity building/ training programs and awareness workshops among MSMEs in West Bengal.

We would like to acknowledge the support received from Hooghly Chamber of Commerce and Industries (HCCI) and Engineering Export Promotion Council India (EEPC India) during awareness generation, data collection and diagnostic studies among MSMEs in Hooghly cluster.

TERI would especially like to thank Mr R K Chhajer, President, HCCI, Mr Swapan Kumar Ganguly, Secretary General, HCCI, Mr Aakash Shah, Vice-Chairman, EEPC India and Mr D J Basu, Director (P&A), EEPC India for their assistance and contributions in the cluster level activities.

Thanks are also due to various MSMEs in the cluster for providing inputs to the report.

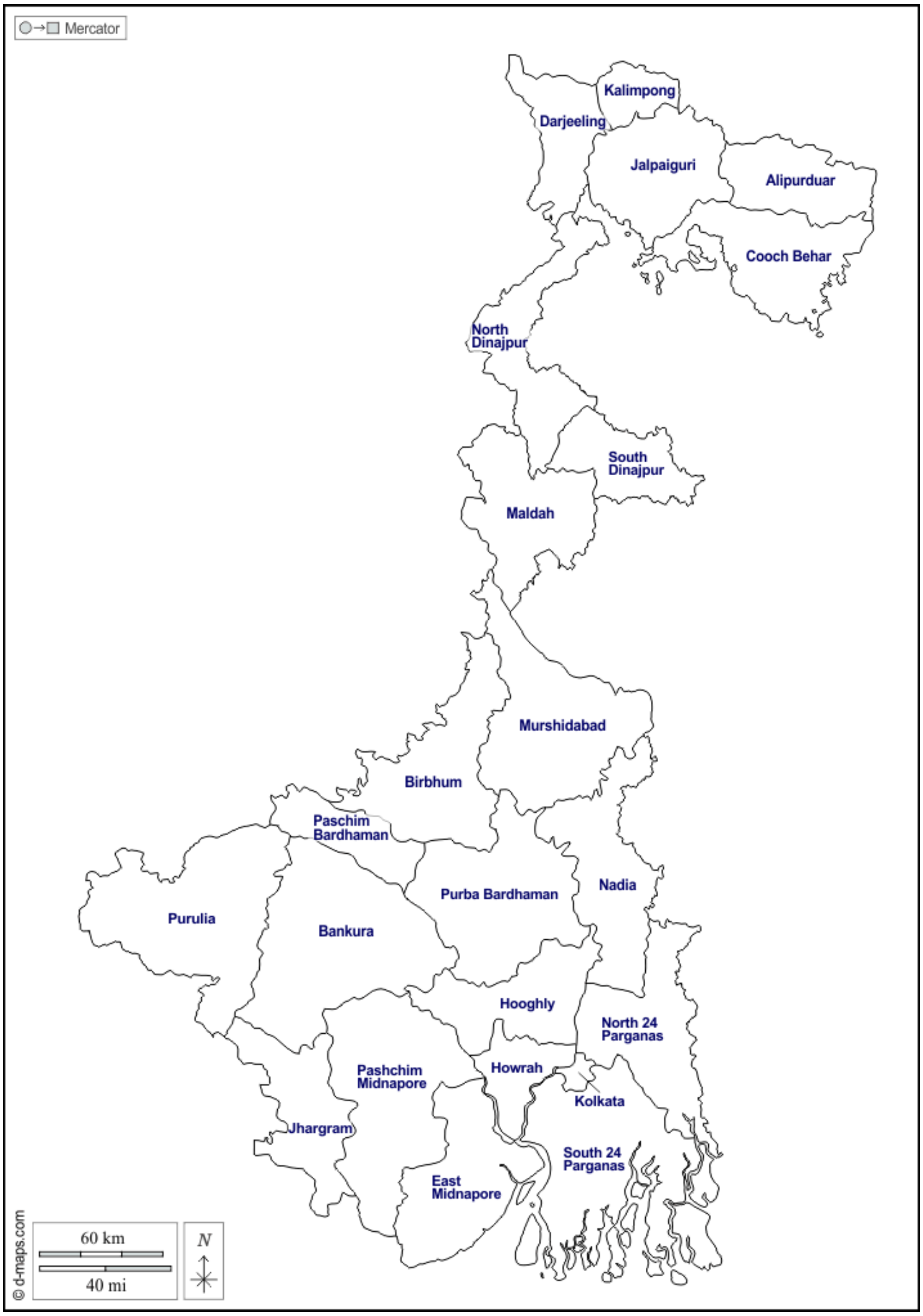
# Abbreviations

| | |
|---|---|
| CESC | Calcutta Electric Supply Corporation Limited |
| CFM | Cubic Feet Per Minute |
| CNC | Computer Numerical Control |
| FO | Furnace Oil |
| FRP | Fibre Reinforced Plastic |
| GHG | Greenhouse Gases |
| HMC | Horizontal Machining Centers |
| HT | High Tension connection |
| kL | Kilo Litre |
| kVA | kilovolt amperes |
| LDO | Light Diesel Oil |
| LPG | Liquefied Petroleum Gas |
| LSHS | Low Sulphur Heavy Stock |
| LT | Low Tension connection |
| MSME | Micro, Small And Medium Enterprises |
| PDB | Power Distribution Board |
| PMM | Permanent Magnet Motor |
| TFH | Thermic Fluid Heaters |
| tph | Tonne Per Hour |
| VFD | Variable Frequency Drive |
| VMC | Vertical Machining Centers |
| WBSEDCL | West Bengal State Electricity Distribution Company Limited |
| WHR | Waste Heat Recovery |

# Hooghly Mixed Cluster

## 1.0 Overview of cluster

The district of Hooghly lies on the bank of the Hooghly River, about 15 km away from Kolkata. The district, which has a geographical area of about 3149 sq. km. The district is surrounded by Nadia and North 24 Parganas in the east, Purba Burdhaman in the north, Bankura in the west and Paschim Midnapore in the south.




**Location Map of Hooghly District in West Bengal**

Hooghly has about 1000 registered industries, majority of which are in the MSME sector. A number of energy intensive MSMEs including engineering, metals and alloys, chemicals, plastic products, food products and so on are located in the district. Most of the industrial units are located are located near the key state/national highways like Grand Trunk Road, Delhi Road and Durgapur Expressway in sub-urban towns like Konnagar, Nanagram, Serampore, Dankuni, Baidyabati, Bhadreswar, Chandannagar and Sankarbati. The prominent industries in cluster are few large companies of Aditya Birla Group like Jayashree Textiles, Rayon plant, Steel plant and Insulator plant and JSW Steel BPSL and a number of leading MSMEs like ArcVac ForgeCast, Nezone Strips, Vikrant Forge, Century Industrial Products, Nipha India, Fibro Plastichem and Waldies.

## 2.0 Product, market, and production capacities

A variety of raw materials are used in this mixed cluster due to the presence of various types of units. The raw materials for foundry include pig iron, metal scrap, coke, borings etc. For rolling units angles, flats, squares or strips are the main raw materials which are procured from outside. The major raw materials of the chemical industries are resin, lead bars, caustic soda, ethanol etc. The major raw materials of the engineering units are mainly castings and engineering components. Castings are sourced from foundries and other raw materials are procured from allied component manufacturers.

**Storage area in a chemical unit**

**Black coils**

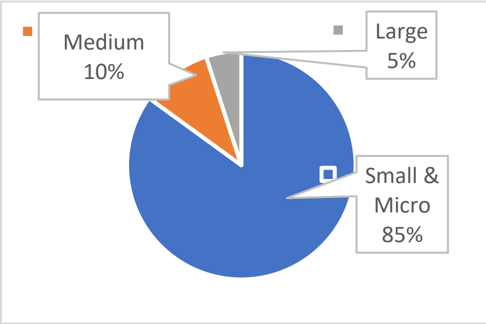
**Engineering components**

The products manufactured here traditionally cater the requirements of the different sector. The foundry products are mainly used in engineering units, railway, and automobile sectors. The products of the rolling units are mainly billets/ingots or pipes/tubes. The engineering units are manufacturing tractor/auto parts, agricultural machinery, industrial machinery and jewelry. Chemical units have a wide range of production like rubber, resin, FRP, antioxidant, etc.

There are over 1000 units in this cluster. Based on the contract demand categorization of the units is given in the table below.

**Categorization of the industries**

| Category | Contract demand (kVA) | Number of units |
|---|---|---|
| Small & Micro | Below 300 | 850 |
| Medium | 300-1500 | 100 |
| Large | Above 1500 | 50 |




## 3.0 Production process

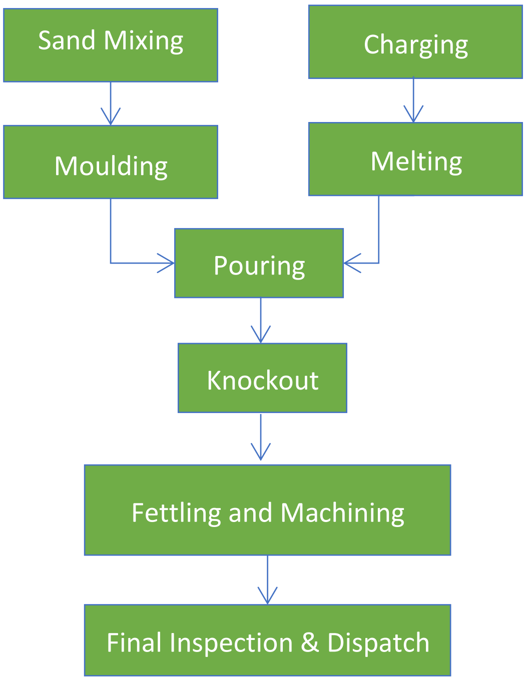
A large variety of products are manufactured in the cluster. The process for each category of units is discussed below.

### 3.1 Foundry units

The major steps of process are mould sand preparation, charge preparation followed by melting, pouring, knockout and finishing. The steps are explained below.

**Sand preparation**: The major equipment used is sand mixer. Electricity is used to run the sand mixer. Fresh sand is mixed with adhesives like bentonite in sand mixer then it is pressed in moulds. Some amount of fresh sand is added.

**Core preparation and moulding**: For core preparation, fresh sand is used. Cores are baked in coal or LPG fired ovens. Few units have installed electric core drying ovens. After hardening of core, it is mounted in mould. In mould preparation sand is pressed in mould casing. Upper and lower half of mould is assembled together and then it gets ready for pouring.




**Process flow diagram of foundry**

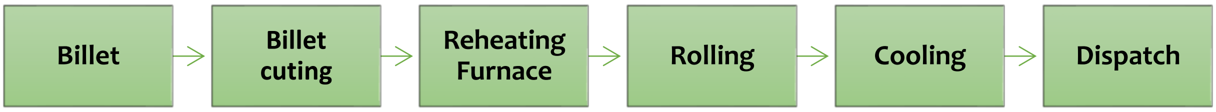
**Melting:** Melting of charge is done with help of induction furnace. Induction furnaces run on electrical supply. Once melt attained required temperature and metallurgy, the liquid melt is poured into the sand moulds using ladles.

**Knockout and finishing:** Moulds are left to cool for certain time before knocks-out of the casting from the sand. Subsequently the casting is sent for finishing, which involves shot blasting and machining. A generic process flow diagram of a typical foundry is given.

## 3.2 Rolling units

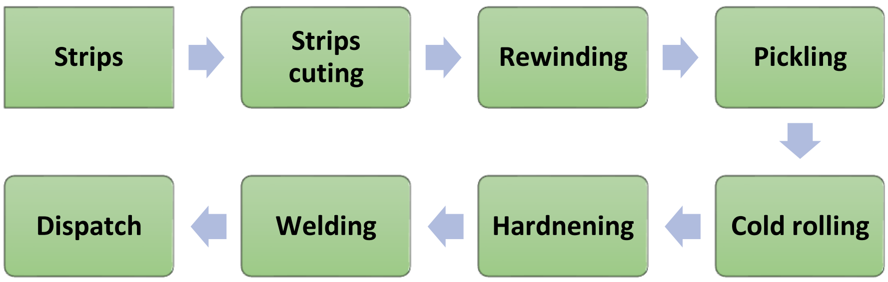
Most steel products from casting operations are further processed to produce finished steel products in a series of rolling and finishing operations. There are two common shaping processes, namely (i) rerolling of billets/ ingots and (ii) hot or cold rolling of coils. In general, rolling process includes application of mechanical forces to metal surfaces through a series of rolls to produce specific shapes and sizes by reducing widths and thicknesses.

Hot rolling involves reheating of metal slabs/ingots/billets close to soaking temperature and rolling them into thinner and longer products through successive rolling mill stands. The steel slabs/billets are heated to about 1,150°C–1,250°C depending on type of raw material in reheating furnaces. Mainly pusher hearth furnaces are used in the cluster with coal or LDO as primary fuel.




**Production process of steel (billet/ ingot) rerolling**

Hot or cold rolling involves a few steps starting with strips cutting, rewinding and pickling. Then it is rolled into either cold rolling mills or hot rolling mills where it gets thinner and longer. However, in second case, reheating is required using reheating furnace. After hardening through annealing furnace welding is done at tube mills.

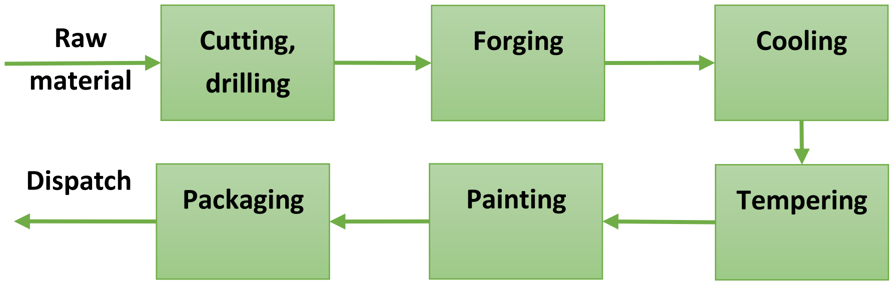



**Production process of cold rolling of steel (coil)**

## 3.3 Engineering units

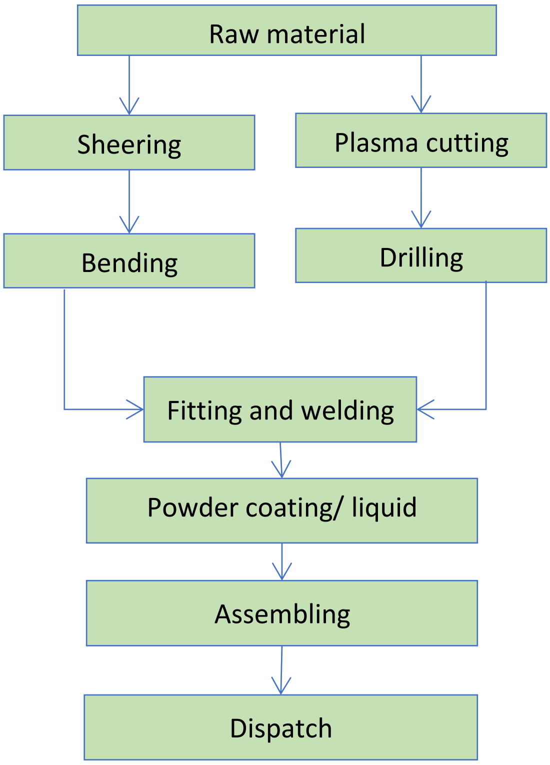
Various variety of products are manufactured in these engineering units. The processes according to the products are discussed here.

- **Industrial equipment and mechanical gear boxes**: The raw material is cut and drilled first in the sheering section. If the material has rust on its surface, then it goes for shot blasting where air and small iron particles are forced on material to clean the surface. Then forging is done in the FO fired furnaces. After that cooling and hardening is done. Then it goes to electric furnaces for tempering followed by painting in colouring furnaces and then dispatch.




**Process flow chart for industrial equipment and mechanical gear boxes**

- **Agricultural machinery, angles and channels:** The raw material is cut, drilled or bended according to the size. Then it goes to fitting and welding followed by powder coating or liquid painting, assembling and finally dispatching.




**Process flow chart for agricultural machinery, angles and channels**

- **Jwellery and ornaments:** Production process starts with designing the structure of the jwellery virtually and convert it to solid. A rubber mould is made according to the solid structure and then liquid wax is put into it. After solidification of the wax, stone setting is done and then a plaster structure of the main product is made. This structure is put into the furnace at a temperature of around 750ºC where the wax part is melted. Then the structure is transferred to the melting pot where the metal is poured where the metal got the shape according to the plaster structure. After knockout of the plaster the final product goes to checking and finishing section and after finalization it is dispatched.

## 3.4 Chemical units

The manufacturing process of the chemical industries varies widely depending on the type of products. The generic production of chemicals involves dissolving of raw materials in the reactor, heating or curing or drying and classification. After all these products are checked and ready for dispatch.

Mixing of raw material → Chemical reaction → Heating/ curing/ drying → Final inspection and dispatch

## 4.0 Technologies employed

Some major process equipments used in this cluster are described below.

### 4.1 Induction furnace

Majority of foundry units have induction furnaces of 500 kg to 5 tonne crucible size. These furnaces are operated in batch mode, and the typical cycle time and SEC vary considerably depending upon the type of metal melted (carbon steel, stainless steel, non-ferrous, etc.) and the size of castings. The SEC varies in the range of 600–770 kWh per tonne and batch duration varies between 40 and 150 minutes.

**Induction furnace**

### 4.2 Reheating furnace

The reheating furnaces installed in the cluster are continuous-type pusher hearth furnaces having capacities 3.5–12 tph. The charge or stock is introduced at one end ('feeding or charging'), which moves through the furnace and is discharged at the other end ('discharge doors'). The primary fuel used in the furnaces is pulverized coal and LDO, which is charged using the combustion air (primary air). The furnace combustion system (fuel charging mechanism) takes the temperature of soaking zone as reference for increasing or decreasing the charging rate of fuel. However, this system is by-passed in majority of the units.

**Reheating furnace**

The temperature of soaking zone is observed in the range of 1,100°C–1,200°C. However, this temperature is not maintained constantly throughout the operation and may be attributed mainly to lack of automation of combustion control system. The heat losses from surfaces and preheated air pipelines were observed to be high, mainly due to poor or no insulation.

## 4.3 Oil fired furnace

Box type forging furnace

Furnace oil and LDO are commonly used as fuel in the furnaces. The forging furnaces are used for heating of raw material (billets of various grades of steel) to 1150°C–1250°C. The capacities of these furnaces are in the range of 50 kg/ hr to 600 kg/hr. Different designs of furnaces are box and pusher types. Billets are heated either in batches or continuously. Heat treatment furnaces are used for normalizing, annealing, hardening, tempering, and carburizing of forged and machined components as per requirements of the specific jobs. The temperatures in the furnaces vary widely depending on the treatment and ranges between 250°C to 930°C. The oil consumption in the forging furnaces typically ranges between 100–180 litre/tonne, and for heat treatment furnaces, the consumption is about 100–150 litre/tonne. Blowers with electrical motors of 3 to 7.5 hp are used in furnaces for providing the combustion air for fuel. The heat losses from surfaces were observed to be high, mainly due to poor or no insulation also there is no automated control for air fuel, which results in unreasonable consumption of FO. Recently some of the units are using Low Sulphur Heavy Stock (LSHS) as the fuel.

## 4.4 Electric furnaces

Electrical energy is also used for heating the billets for forging and for heat treatment. The connected power ranges between 50–700 kW. The electrical resistive heating furnaces used for heat treatment operations typically range in capacities from 200 to 600 kg/ batch. The furnaces may be batch (pit type) or continuous (pusher type). The rating of these furnaces varies from 15 kW to 120 kW.

Electrical bucket furnace

Electric colouring furnace

## 4.5 Steam boiler

**Steam boiler**

Boilers are used in chemical units to supply steam for drying. The boilers are manually fired and generally do not have any control systems. The most common capacity of the boiler in the cluster is 2-4 tonne per hour (tph). Coal, wood and rice husk is used as a fuel for the boilers. The boilers are pressure controlled for their operation. The approximate temperature of steam produced is about 130$^{O}$C. The present efficiency of the boilers is generally low at about 55%. A majority of the boilers do not have economizers (feedwater preheaters) or other waste heat recovery (WHR) systems to recover heat from flue gases and enhance their thermal efficiency levels. The sensible heat in condensate from process areas is not generally recovered.

## 4.6 Thermic fluid heater

Some of the chemical units use thermic fluid heaters (TFH) in place of boilers for drying purposes. TFHs are closed loop systems wherein heat from combustion of fuel is transferred to thermic fluids that have the capacity to carry a large quantum of heat. The hot thermic fluid exchanges heat in dryers, thereby losing heat and flows back to the heating section. They are provided with constant speed thermic fluid circulation pump. Thermic fluid heaters generally have a manual fuel charging system and use wood wastes generated in process sections as fuel.

## 4.7 Rection vessels/ kettles

The chemical units have reaction vessels/ kettles commonly known as reactors. The chemical reaction takes place here. This is primarily made of stainless steel or rubber lined ceramic material. The units have different capacities of reaction vessels varying in the range of 1-20 kilo litre (kL). Blending motor is present with each reactor having capacity of 5.5-18.5 kW. The capacities and number of vessels in a chemical unit are dependent on type of manufacturing process, production capacity and batch size.

## 4.8 Machining

The small and micro units use conventional manual machining units. Conventional machining includes machine tools such as lathes, drill presses and milling machines that are used with a shearing tool to cut materials to desired shape and dimensions. The large and medium units use CNC, HMC, and VMC machines. The CNC machines can reduce time, enhance productivity, reduce tooling and hence decrease overall costs. CNC machines are more expensive compared to manually operated machines, although costs are slowly coming down. CNC machines come in different orientation—horizontal and vertical—and the units choose the type based on applications.

Lathe machine

CNC machine

## 4.9 Air compressor

Compressed air is used in pneumatic grinders, casting cleaning, and packing and for other miscellaneous uses in almost every unit. The connected load of an air compressor size may range from a few kW (single air compressor) for a small and micro scale unit to 45 kW for a medium or large scale units. The pressure requirement for majority of applications is below 6 kg/cm$^2$ (bar).


Reciprocating compressor


Screw compressor

# 5.0 Energy scenario in the cluster

Electricity, coal, furnace oil, LDO and LSHS provide the main source of energy for most of the units. Electricity is supplied by West Bengal State Electricity Distribution Company Limited (WBSEDCL) and Calcutta Electric Supply Corporation Limited (CESC). The power outage is very minimal in the cluster, and hence diesel consumption is negligible. The details of the major energy sources and tariffs are given in the table below.

**Prices of major energy sources**

| Source | Remarks | Price |
|---|---|---|
| Electricity | High Tension connection (HT) | INR 8.75 per kWh (inclusive of energy, demand charges, other penalty/ rebate and electricity duty) |
| | Low Tension connection (LT) | INR 9 per kWh (inclusive of energy, demand charges, other penalty/ rebate and electricity duty) |

| Source | Remarks | Price |
|---|---|---|
| Coal | From local market | INR 12 per kg (price subjected to market fluctuations) |
| Furnace Oil (FO) | From local market | INR 47 per kg (price subjected to market fluctuations) |
| Light Diesel Oil (LDO) | From local market | INR 60 per litre (price subjected to market fluctuations) |
| Low Sulphur Heavy Stock (LSHS) | From local market | INR 54.8 per kg (price subjected to market fluctuations) |

# 6.0 Energy consumption

## 6.1 Unit level consumption

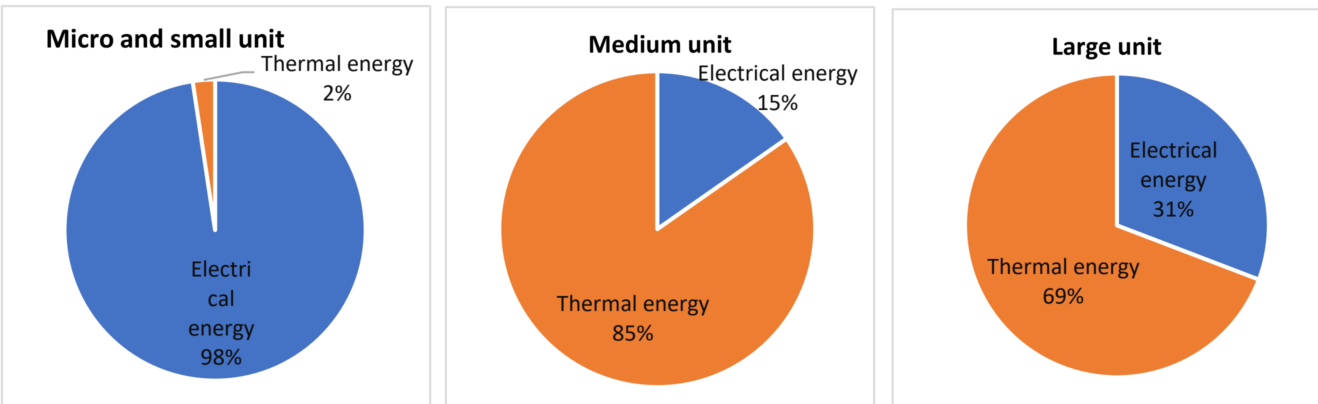
A very few small and micro units have Low tension (LT) electricity connections whereas all the medium and large units have HT electricity connections. The power supplied at 11 or 33 kV is stepped down to 433 V using transformer and is fed to the respective power distribution board (PDB) via LT switchgear located at main distribution.

The major energy in the unit level is consumed from the fuel sources (Coal, furnace oil, LDO, LSHS, Diesel) i.e., thermal energy. Electrical energy is mainly consumed to run the auxiliaries. The typical energy consumption of different capacities of units are shown in the table below.

**Typical energy consumption of the units**

| Typical unit level | Electricity (kWh/year) | Fuel (tonne/year) | Total energy (toe/year) | Total $CO_2$ emissions (tonne $CO_2$/year) | Annual energy bill (million INR) |
|---|---|---|---|---|---|
| Micro & Small | 302,529 | 0.6 | 26.7 | 241 | 6.5 |
| Medium | 1,552,078 | 1,471 | 873.5 | 4,062 | 42.8 |
| Large | 8,822,432 | 1,637 | 2,462.7 | 12,042 | 181.5 |

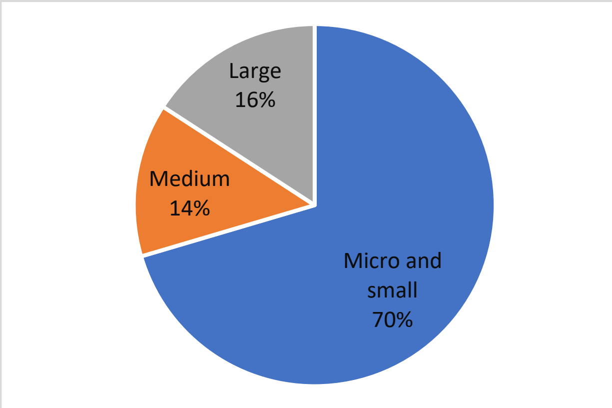
The average share of thermal and electrical energy consumption at cluster level is estimated to be 87% and 13%, respectively. The thermal and electrical energy consumption of different types of units is shown in the pie chart given below.




**Share of thermal and electrical energy consumption by various types of units**

## 6.2 Cluster level consumption

The annual electricity and fuel consumption of the Hooghly mixed cluster is estimated to be 853 million kWh and 46,300 tonne respectively, which is equivalent to 105,779 tonne of oil equivalent (toe) per annum. The total estimated 'greenhouse gas' (GHG) emissions in the cluster level is about 783,303 tonne of $CO_2$. The overall energy bill of cluster is estimated to be INR 13,065 million.




**Share of energy consumption among the types of units**

**Typical energy consumption of the Hooghly mixed cluster (2022-2023)**

| Energy type | Annual consumption | Equivalent energy (toe) | Equivalent $CO_2$ emissions (tonne) | Annual energy bill (million INR) |
|---|---|---|---|---|
| **Electricity** | 853 million kWh | 73,399 | 674,248 | 11,549 |
| **Fuel** | 46,300 tonne | 32,380 | 109,055 | 1,516 |
| | **Total** | **105,779** | **783,303** | **13,065** |

# 7.0 Potential energy efficient technologies

Some of the major energy efficient technologies relevant for the units in the cluster are discussed below.

## 7.1 Energy Efficient IE3 standard motors

Most of the units in the cluster are using lathe machines, hydraulic press machines, drilling machines, blowers etc. which use electrical motors. The ratings of these motors vary from 0.5 HP to 10 HP depending on the capacity of machine and operations to be performed. The power factor of these motors was observed to be generally lower than 0.85.

Due to presence of significant variable and jerk loading pattern observed in motors used in machines, failure rates are also observed to be high. Further no-load losses of these motors are high which increases the overall energy consumption. There is a lack of awareness about efficiency standards of motors. It was observed that most of the units use low efficiency standard motors. There is a significant potential for energy savings by replacing low efficiency motors with energy efficient IE3 standard motors. Depending on the operation period of the machines, payback period for EE motors can vary between 1 to 4 years. Energy saving of 3% can be achieved on replacement of old IE2 motor with IE3 motor and savings upto 7% can be achieved on replacement of old IE1 standard motor with IE3 motor.

IE1 & IE2 motors used in the cluster

IE3 motor

**Cost benefit analysis for IE3 motors**

| Parameter | Unit | 5 HP motor | 7.5 HP motor |
|---|---|---|---|
| Power consumption of existing lathe motor | kW | 2.5 | 3.1 |
| Efficiency of existing motor | % | 81.5 | 84.7 |
| Efficiency of IE3 standard motor | % | 87.7 | 89.6 |
| Estimated power consumption of IE3 motor | kW | 2.32 | 2.93 |
| Annual energy cost savings | Rs /yr | 7,076 | 6,683 |
| Investment required | Rs | 18,500 | 27,500 |
| Simple Payback Period | yr | 2.6 | 4.1 |

## 7.2 Retrofitting of lid mechanism for furnace crucible

All induction furnaces use crucibles for melting with crucible size varying between 150 and 2,000 kg. In all induction furnace-based units in this cluster, the mouth of crucible is kept open during operation resulting in substantial radiation losses (4-6% of total energy input).

Lid cover

Retrofitting induction furnace crucible with lid mechanism will lead to an energy saving of upto 3%. The saving would depend on size of crucible and operating practices. The investment for lid mechanism is expected to pay back within few months. The cost benefit of lid mechanism is given in table.

**Cost-benefit analysis of lid mechanism**

| Particular | Unit | Value |
|---|---|---|
| Investments in lid mechanism | Rs | 50,000 |
| Radiation loss without lid mechanism | kWh/t | 38 |
| Saving potential with lid mechanism | kWh/t | 1.7 |
| Total annual monetary saving (@ 616 t/m) | Rs/year | 116,000 |
| Simple payback period | year | 0.4 |

## 7.3 FRP blades for cooling tower

Most of the units are having cooling towers with metallic blades attach to its fan motor. Conventional metallic type blades of cooling tower fans consume more energy as compared to modern aerodynamic FRP (Fibre Reinforced Plastic) blades. Compared to fan with metallic blades, power consumption of FRP bladed fans have a better aerodynamic design and are light weight. These lightweight blades reduce the load on the motor and as a consequence energy consumption is also reduced to 15-18%. Also, FRP blades results increased life of a mechanical drives of the fan and improved corrosion erosion resistance. So, there is a potential of energy saving by installing FRP blades in place of metallic blades and downsize the fan motor.

**FRP blades for cooling tower**

**Cost benefit analysis for FRP blades in cooling tower**

| Parameter | Unit | Value |
|---|---|---|
| Existing motor input power | kW | 1.1 |
| After FRP blades installation motor input power | kW | 0.9 |
| Annual energy cost savings | Rs/yr | 11,000 |
| Investment required | Rs | 30,000 |
| Simple payback period | yr | 2.7 |

## 7.4 Energy efficient pumps

Most of the units in the cluster are having water pumping system to maintain process water requirements. These pumps varying from 3 HP to 10 HP. Most of the pumps are operating in low efficiency (30%–45%). There is a huge potential for energy saving by adopting energy efficient pumps which operates at an efficiency of 60%. The cost benefit of energy efficient pumps is given below.

**Cost benefit analysis for energy efficient pumps**

| Parameter | Unit | Value |
|---|---|---|
| Existing motor input power | kW | 5.9 |
| Existing pump efficiency | % | 37 |
| After energy efficient pump installation motor input power | kW | 3.7 |
| After energy efficient pump installation pump efficiency | % | 60 |
| Annual energy cost savings | Rs/yr | 172,123 |
| Investment required | Rs | 53,280 |
| Simple payback period | yr | 0.3 |

## 7.5 Air compressor

Most of the units in the cluster use compressed air for various pneumatic utilities and cleaning purpose. Electrical rating of these compressors ranges from 5.5 kW to 75 kW. Larger units use screw compressors whereas smaller units use reciprocating compressors. There are various potentials for energy saving. Some of the options that can be followed in air compressor system are summarized below.

### Arresting the compressed air leakage

Compressed air is an expensive utility in a plant. However, significant air leakages in compressed air piping system were observed (more than 20%), which go unnoticed and result in substantial energy and monetary losses. The compressed air leakage can be brought down to about 5% by plugging leakages mainly observed in joints and valves. By controlling compressed air leakages, these units can save a considerable amount of energy with no investment.

### Adopting VFD based screw compressor

Screw compressors are designed to operate on more than 80% load for efficient performance. There is a huge potential for energy saving by adopting VFD based screw air compressors and Permanent Magnet Motor (PMM) based air compressors having higher CFM to power ratio. Energy savings can range from 15 to 40% compared with the existing system.


**Reciprocating compressor**


**Screw compressor with VFD**

**Cost benefit of VFD screw air compressor**

| Parameter | Unit | Value |
|---|---|---|
| Annual power consumption of existing screw compressor (22 kW) | kW/CFM | 0.23 |
| Estimated power consumption with PMM and VFD based screw air compressors | kW/CFM | 0.15 |
| Annual energy cost savings | Rs/yr | 2,96,000 |
| Investment required | Rs | 5,00,000 |
| Simple payback period | yr | 1.7 |

## 7.6 Heat treatment furnace

Some of the units in the cluster outsource heat treatment operation of components. The heat treatment furnaces use FO as the fuel. The exit flue gas temperatures of furnaces used in these units are in the range of 300-750 $^{o}$C. These furnaces have not been equipped with any heat recovery systems. The waste heat available with high temperature flue gases can be recovered in a metallic recuperator system to preheat combustion air that can result in significant improvement in furnace efficiency (over 10%) substantial reduction in fuel consumption.

**Cost benefit of heat recovery in heat treatment furnace**

| Particular | Unit | Value |
|---|---|---|
| Flue gas exit temperature from furnace | $^{o}$C | 550 |
| Present temperature of combustion air at burner inlet | $^{o}$C | 38 |
| Temperature of preheated combustion air | $^{o}$C | 200 |
| Annual energy cost savings | Rs/yr | 1,60,000 |
| Investment required | Rs | 3,00,000 |
| Simple payback period | yr | 1.9 |