ENERGY PROFILE

CHENNAI FORGING INDUSTRY CLUSTER

The Energy and Resources Institute

SHAKTI
SUSTAINABLE ENERGY
FOUNDATION

Promoting Energy Efficiency in SMEs
SAMEEEKSHA

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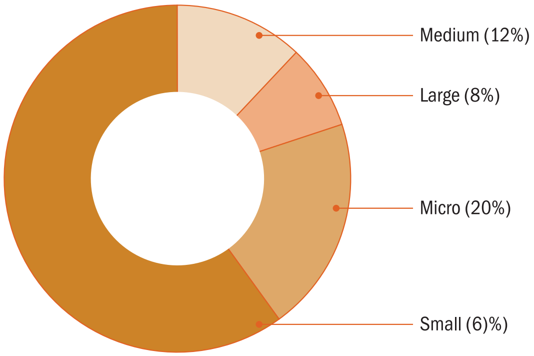
Chennai Forging Industry Cluster

Overview of cluster

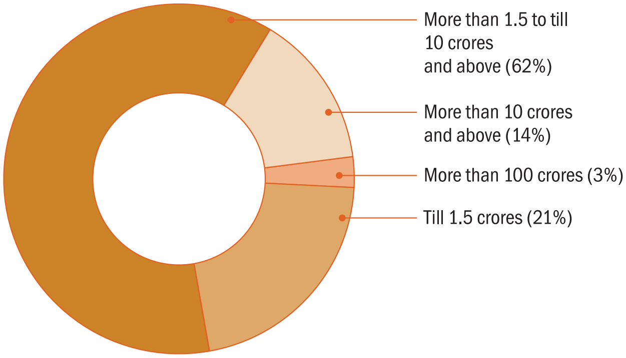
Chennai (Tamil Nadu) is a prominent cluster in southern region of about 50 forging units, located in various industrial estates such as SIDCO Industrial Estate in Thirumudivakkam, Ambatur, Thirumazhisai, Ponneri, etc. The industrial estates are located around the main city of Chennai. Forging units in Chennai cluster are principally known for their ability to make superior precision auto components and non-auto components that are supplied to a wide range of vehicle-production industries and machinery and engineering, electrical equipment production industries, and others.

The Indian forging and heat treatment industry is a major contributor to the manufacturing sector of the Indian economy. Majority of the forging units have in-house heat treatment facilities, while some units undertake heat treatment from external heat treatment units. Heat treatment is an allied process for treatment of forging and machined components. The total production from the Indian forging industry during 2015–16 was about 1,92,000 MT, with a growth of about 20% over the previous year. The major raw materials used in the Chennai forging units include carbon steel, alloy steel, and mild steel. The products, after forging, are heat treated and machined for use in various types of automobile and engineering/electrical products manufacturing.

The Chennai forging cluster mainly caters to the demands of various large original equipment manufacturers (OEMs) of all types of cars and truck manufacturers, such as Tata Motors, Ashok Leyland, Nissan Motors, Volkswagan, Mahindra & Mahindra, Bajaj Auto, etc. The Chennai forging cluster also caters to the demands of (non-auto components) electrical components, engineering components for OEM L&T, Godrej, etc. Forging industries in Chennai provides employment to about 4,500 people, directly or indirectly. The estimated total turnover of forging industries in Chennai is more than ₹14,000 million rupees.



Distribution of forging units as per category

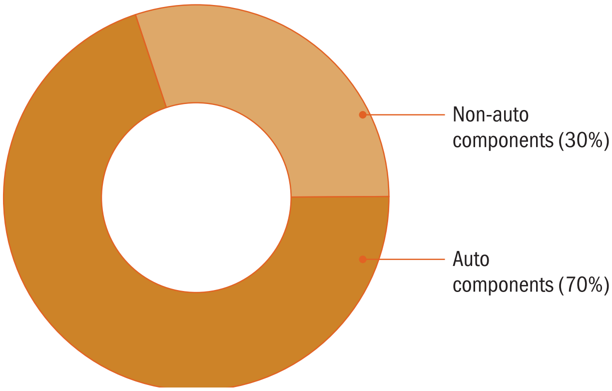


Distribution of forging industries based on annual turnover

Product, market, and production capacities

The products of forging industries in Chennai cluster are mainly used in different sectors, starting from automobile, light and heavy machine components, and electrical equipment, catering both to OEM and replacement market and general engineering.

The products being manufactured in Chennai Forging Cluster are about 70% auto components and 30% non-auto components. The products forged in Chennai include axle parts, gear parts, upper pin, shafts pin, clutch plates, connecting rods, forks, camshafts parts, bearing races, etc. These custom made products are mainly used in the automotive sector. Also, some of the non-auto components are valve parts, electrical switchgear/motors parts, etc.



Product category wise distribution of forging industries

The production by the MSME units in the cluster is in the range of about 50 to 2,500 tonnes/month. Product-wise distribution of forging industries in the cluster is provided in the figure on the right. The production and installed capacity of the similar industries in the cluster varies from unit to unit and even production of a unit is also not constant during the year. The nature of the cluster and the type of products manufactured is such that the production is recorded in format of the tonnes of forging manufactured of a particular type of product. Based on the interactions with entrepreneurs and industrial associates in the cluster, it is estimated that the cluster produces approximately 400 lakhs of forging jobs/products by consuming around 9,400 tonne of oil equivalent (toe) energy. The table below provides details on number of units, aggregate production, and energy consumption by a particular type of product in the cluster.

Annual production by forging industries

Product category	Number of units	Production (tonne/year)*
Micro	10	7200
Small	30	43200
Medium	6	18000
Large	4	124800

*Figures as per collective data of AIFI

Raw material usage in cluster

Chennai forging cluster uses steel rods of different sizes as raw material. The major raw materials used in the forging units of Chennai include mild steel, carbon steel, alloy steel, stainless steel, aluminium, super alloy, special steels. Carbon and stainless steel grades are ASTM/ASME SA 182 F, 304, 304L, 304H, 309H, 310H, 316, 316H, 316L, 316 LN, 317, 317L, 321, 321H, 347, 347 H (prices of stainless steel are between ₹2,40,000 per tonne to ₹2,80,000 per tonne). Most of these raw materials are available locally or are obtained from other domestic markets and are manufactured in India. Prices of various grades of carbon steel like 15C8, EN8D, SAE8620, used for forging are between ₹48,000/tonne to ₹58,000/tonne. The sources of raw materials of forging products include Jindal Steel Works Ltd and Bhushan Steel Ltd

Raw material for forging (billets)

Production process

The forging manufacturing industries in Chennai majorly produce auto and non-auto components/products. The major steps involved in forging are cutting of steel rods in the form of billets, and then heating of billets in the furnace and forging is done in presses. The forged component is trimmed and sent for heat treatment. The generic process steps followed by the unit are briefed as follows:

Raw material procurement and quality inspection: Raw material in the form of steel bars is received from major steel suppliers or procured directly. The quality of raw material steel is inspected with spectrometric and microscope testing facilities either within the plant or from outside testing facilities for proper grade and quality of steel.
Raw material cutting: 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.

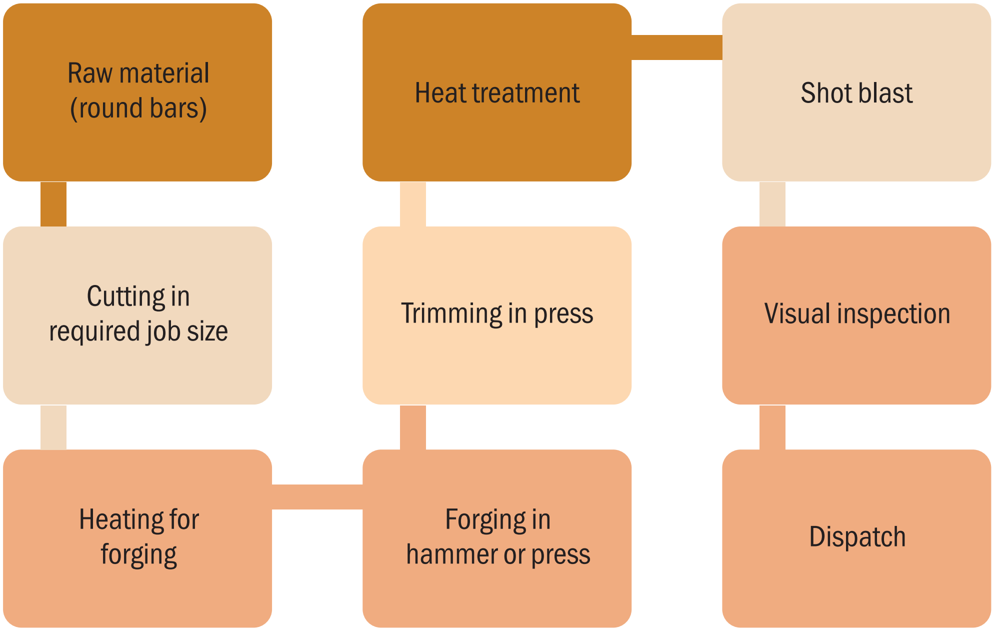
Raw material heating and forging: The billets are heated in FO-fired furnaces or in an induction billet heater up to temperature of 1,200–1,270 °C as per the forging temperature requirements of different grades of steel. The heated billets are removed one by one from the furnace and placed in hammer for forging. The heated billet is forged in desired shape in one or number of strokes in the hammer. Also, some units use presses for particular forging products.

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

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

Inspection and despatch: Final inspection of jobs are done with respect to the dimensions and quality and sent to the machining shop or despatch.

The generic production steps for forging products are shown in the figure below.



The metal is pressed between two dies (tooling) that contain a pre-cut profile, based on product specifications. A temperature of about 1,250°C is used for the forging operation. In this, metals weighing between a few kilograms to about 20 tonnes are forged. The forgings are generally produced on hammers, hydraulic presses, and mechanical presses. Using impression die forging process, products with complex shapes and closer tolerances can be produced. Metals and alloys that can be forged through the impression-die process include carbon and alloy steels, tool steels, and stainless, aluminium, and copper alloys, and certain titanium alloys.

Select forging components

The heat treatment process is performed to achieve the desired properties of forged job and the time cycle w.r.t temperature profile depends on the type of forged jobs. Shot blasting is done to achieve desired surface finish and then rough and final turning is carried out on lathe machines. Finally, visual inspection is carried out and components are sent for final dispatch.

Technologies employed

The use of outdated and outmoded technologies is a major challenge in the cluster. Presently, most of the units use belt drop hammers for forging and few units use forging presses for precision. Shearing machines for productivity improvement may replace the bandsaw used for cutting raw material. Units in Chennai forging clusters are using reciprocating compressors for air utility (air blowing); adoption of rotary screw compressors for the same may lead to operational efficiencies. Heat treatment techniques include annealing, normalizing, case hardening, precipitation strengthening, carburizing, nitrating, tempering, quenching, and induction hardening. Mostly, heat treatment units use pit type and pusher type furnaces. Some of the primary process technologies have been explained below:

Oil-fired furnaces

Furnace oil is 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 80–100 litre/tonne.

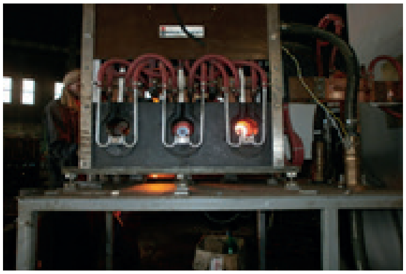
Blowers with electrical motors of 3 to 7.5 hp are used in furnaces for providing the combustion air for fuel. In Chennai forging cluster, it has been observed that some units are operating a common blower for furnaces and no automated control for air fuel, which results in unreasonable consumption of FO.

Box type forging furnace

Electric furnaces

Electrical energy is also used for heating the billets for forging and for heat treatment. The production capacities of electrical induction furnaces typically range between 100–500 kg/hr and connected power ranges between 100–1,000 kW. Specific electricity consumption for these furnaces are about 450–500 kWh/tonne. 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. The furnaces have recirculating air fans with electrical motors between 3 to 7.5 hp.

Induction billet heater



Bell type Electrical heat treatment furnace

Belt drop type die hammers

These hammers are used for forging of hot billets into various shapes for shafts, flanges, gear blanks, pipe fittings, rollers, hubs, and so on. The capacity of the forging hammers typically range between 0.5 to 3 tonnes. Electric motors in the range of 30 to 100 hp are used for driving the hammers. Forging capacity, depending on the number of hammers and their capacities, varies from 300 tpa to 3,500 tpa.

Closed-die hammer forging

Screw press

The capacity of screw presses is in the range of 100 to 1,500 tonnes. Electric motors used for driving these presses range between 30 hp to 150 hp. Screw presses with electrical motors of 5 to 30 hp are used for trimming and coining operations. These presses are operated by the pneumatic clutch and brake and screw is used for adjusting the height of stroke length. It is used mostly with shaft end heating jobs.

Energy scenario in the cluster

Electricity, furnace oil, and LPG provide the main source of energy for most of the forging units in the Chennai cluster. Almost all the units are depended on electricity from grid to meet their energy needs. The average connected loads per unit are dependent on the kind of products and installed capacity of the plant. Majority of the units have HT connection. The other forms of energy use in the cluster include furnace oil (FO). FO is used for heating for forging as well as for heat treatment. The power situation is not that good, hence, the units are dependent on DG set (which is operated during the power interruptions only) but its use is not that significant in terms of fuel consumption, compared to electrical energy from connected grid supply. The primary energy usage areas in the forging units in the cluster are shown in the table below.

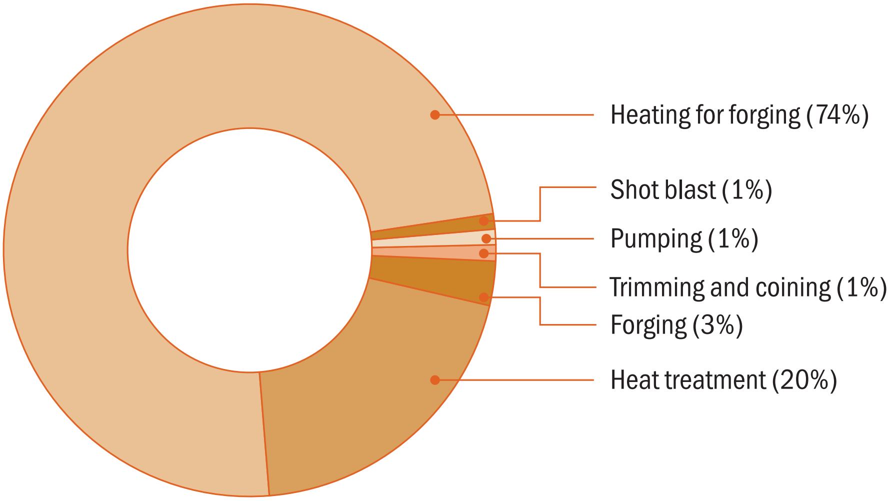
Screw press

Details of energy supplies with unit rate in Chennai for forging industries

Type	Unit	Average Rate	Sources
Electricity	₹per kWh	7	TNGDCL
FO	₹per litre	22	BPCL
Diesel	₹per litre	56	BPCL, HPCL

Unit-level consumption

The units primarily use FO for heating process in their furnaces and have LT electricity connections. Some of the units who use induction billet heaters have HT connection at 11 kV stepped down to 433 V which is fed to the respective power distribution board (PDB). DG sets are used only during unscheduled power outage. The major energy consuming process in a forging unit is heating of forging job components which accounts for about 74% of total energy consumption followed by heat treatment (20%) as shown in the pie chart below.



Unit-level typical energy consumption share

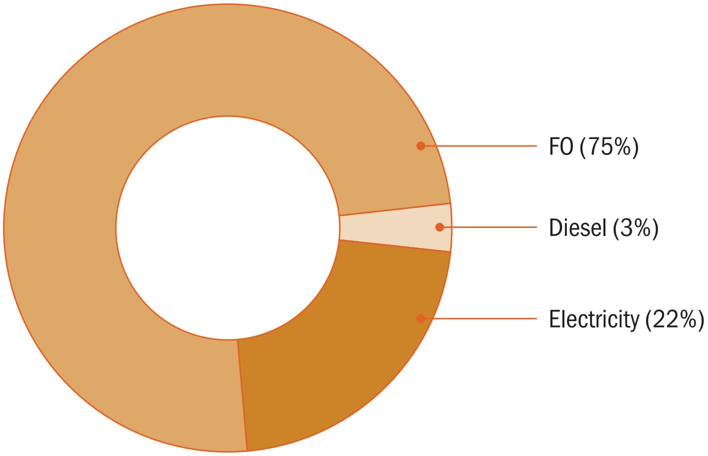
Cluster-level consumption

The overall energy consumption of the cluster is estimated 9,440 tonnes of oil equivalent per annum leading to carbon emissions of 45,107 tonnes of CO_2. The overall energy bill of cluster is estimated to be ₹358 million, which is about 3% of cluster turnover.

Energy consumption of the Chennai Forging cluster (2014–15)

Energy type	Annual consumption	Equivalent energy (toe)	Equivalent emissions (t CO_2)	Annual energy bill (million ₹)
Electricity	24 million kWh	2,077	23,669	181
Thermal (FO)	7,140 kL	7,047	20,563	157
Diesel Generator	340 kL	316	875	20
	Total	**9,440**	**45,107**	**358**

The breakup of estimated energy consumption of different types within the cluster has shown the following table.



Energy consumption mix

Potential energy-efficient technologies

Some of the major energy saving opportunities in the forging units in the cluster have been discussed below.

Induction billet heater

Induction billet heater, in forging, is a new age technology with a potential of 30%–70% energy saving as compared to oil-fired heating for forging (monetary savings range from 10%–15% based). Induction technology is flexible in operation with reduction in scale losses, which leads to material savings. It also avoids other hassles of storage of oil, piping arrangements, etc. Due to extremely low heat loss, surrounding temperature near induction furnace is very less which creates better working conditions for the labour as compared to fuel-fired furnaces. Specific energy consumption for FO-fired furnace can be brought down from 120–150 litres/tonne (0.15 toe/tonne) to 400 kWh/tonne (0.04 toe/tonne), using the induction billet heater. Investment for induction billet heater ranges from ₹15 lakh to 50 lakh, depending on size, with simple payback period of one to three years.

Reheating furnaces

Box-type furnaces are mainly used for heating the forging job. Cut billets are heated in these furnaces and then transferred through gravity tray channel to hammer for forging operation. These furnaces are prone to surface heat loss and heat loss through flue gases. Normally furnace oil is the fuel used in box-type forging furnaces. Also for the heat treatment process, some units are operating the electrical heat treatment furnaces.

Waste heat recovery for air preheating

Many of the forging units use oil fired forging and heat treatment furnaces. The exit flue gas temperatures of FO-fired furnaces, used in these units, are in the range of 450°C–700°C. These furnaces have not been equipped with any heat recovery systems but in Chennai forging cluster, the blower air pipe is passed through/over the exhaust channel. The waste heat available in high temperature flue gases can be recovered in a metallic recuperator system for preheating combustion air resulting in significant improvement in furnace efficiency (over 10%) and substantial reduction in fuel consumption. Energy savings of 8%–15% can be achieved, depending on the type of process, process cycle time, and flue gas temperature. Investment for recuperator varies from ₹1.0–4.0 lakh with a simple payback period of eight months to two years, depending on type of process and temperature.

Improved insulation of reheating furnaces

Forging and heat treatment furnaces used are mostly built with a refractory brick lining which are prone to heat loss after a continuous usage over the period and results in fuel loss. There is a huge potential in using ceramic insulations in the box-type furnaces, which enables less fuel consumption in cold start in the furnace along with less heat up time. Energy savings of 4% to 6% can be achieved by improving insulation of the furnace depending on the previous surface heat loss and type of refractory used and size of the furnace. Relining or repairing of the heat treatment furnace can be done with an investment of ₹0.30 lakh to 2 lakh, depending on the size of the furnace with simple payback periods ranging from five months to 1.5 years.

Thyristor control for electrical heat treatment furnaces

The electrical heat treatment furnaces in use are of resistance heating type. Normally on-off control is used for controlling the heating cycle. In on–off control due to continuous switching, life of heating coil reduces due to thermal shocks and frequent failure occurs. Thyristor control can be used instead of on–off control, which can give around 7%–15% energy savings and can increase the coil life due to smooth switching with the precise temperature. Investment for thyristor control varies from ₹0.20-1.5 lakh depending on total electrical rating of heating coils with simple payback period of three months to one year.

Application of variable speed drives

Motor-driven systems are often oversized and inefficiently controlled. Variable speed drives (VSDs) can provide a more cost-effective method for reducing flow or pressure at the source by varying the speed of the connected load to match the process requirements. Energy savings in VSD applications usually range from 8%–20 %. Some of the potential applications of VSDs in the forging industry have been mentioned below. The investment required for VSD is around ₹0.20 lakh to 3 lakh, depending on the electrical rating of the motor with simple payback period of eight months to two years.

Press motors

Mechanical and hydraulic presses are generally used in forging industries. Presses go under variable load depending on job size and operation to be performed. Jerk load operations are frequent in presses and this can be improved by using VSDs. VSD can reduce overall power consumption along with soft starting of the motors which will improve life of motors.

Compressed air

Savings of more than 40% can be realized by improving the supply and reducing the demand in compressed air systems. Opportunities can be found in the supply side by installing new or optimizing existing equipment and reducing the system pressure. Demand can be reduced through improving end uses and repairing leaks. Blow-off nozzles can be upgraded to high-efficiency engineered nozzles or replaced with a low-pressure electric blower. Some of the potential areas of compressor system with specific option are mentioned below.

Replacement of air compressor with variable frequency drive air compressor

During normal operation, screw air compressor operated on unloading position for more than half the time. Installation of new variable frequency drive (VFD) air compressor instead of load/unload control air compressors minimizes the unload power consumption, resulting in energy savings of 20 to 35%. Investment for VFD type air compressor ranges between ₹3 lakh and 10 lakh, depending on the size of the compressor with payback period of one to two years.

Plugging compressed air leakages

Compressed air is an expensive utility in a plant. However, in most cases, air leakages in the piping system are quite high (more than 20%) and go unnoticed. The compressed air leakage can be reduced to about 5% with better operating practices. The plant can reduce significant energy consumption by controlling compressed air leakages with no or minimum investment.

Reduced pressure setting of air compressors

The pressure setting of air compressors is often much higher than the actual air pressure requirement at the point of use in the plant. The typical unload and load pressure settings are 8.5 and 7.5 bar, respectively. Reducing the compressed air pressure as per end-use requirements results in high-energy savings. Reduction of generation pressure by one bar can lead to energy saving of 6%.

Replacement of rewound motors with energy efficient motors

Rewinding of motors results in drop in efficiency by 3–5%. It is better to replace all old motors, which have undergone rewinding two times or more. The old rewound motors may be replaced with EE motors (IE3 efficiency class). This would result in energy savings of 3% to 7% with simple payback period of 1.5 to three years on the investments done.

Energy-efficient lighting

Presently, mercury vapor lamps (MVL) and halogen lamps of 150W, 250W, and 400 W are generally used on the shop floor. This lighting system has low lux levels with less life. Magnetic induction lamps of 100W, 150W, and 200W can be installed in place of MVLs, which will give better illumination along with bright light with up to one lakh burning hours life. T-12 tube lights (of 52W including choke) and halogen lamps (150W and 250W) are generally used by forging units in the cluster. These inefficient lightings can be replaced with energy efficient LED lighting (LED tube lights of 10W and 20W) and flood lamps and high bay lamps (20W, 40W, and 80 W) which would provide better illumination and energy savings. Since a large number of lamps are used in the units, the existing lighting may be replaced with EE lighting in a phased manner. Payback period for lighting is generally two to 3.5 years.

Summary of energy savings potential/ measures

S.No.	Energy saving measure	Energy savings	Monetary savings	Payback period (year)
1	Induction billet heater	30–70%	10–15%	1–3 years
2	Waste heat recovery for air preheating	7–10%	8–15%	0.5–1
3	Improved insulation of reheating furnaces	4–7%	7–10%	0.5–1
4	Thyristor control for electrical heat treatment furnaces	7–15%	10–15%	0.5–1
5	Application of variable speed drives	8–20%	8–15%	0.6–2
6	Replacement of air compressor with variable frequency drive air compressor	20–35%	20–30%	1–2
7	Plugging compressed air leakages	15–20%	15–20%	Immediate
8	Reduced pressure setting of air compressors	4–12%	5–10%	Immediate
9	Replacement of rewound motors with energy efficient motors	3–5%	3–7%	1.5–3
10	Energy efficient lighting	30–80%	25–75%	2–3

Major cluster actors and cluster development activities

The primary stakeholders in the cluster are the manufacturing units based in Chennai and the leading industry association of the region, the Association of Indian Forging Industry (AIFI). The other key stakeholders include SIDCO Industrial Estate, District Industries Centre, Chennai (DIC), MSME-DI Chennai, SIDBI, machinery suppliers, various government agencies, regulatory bodies, research and academic institutions, testing and training institutes, and (Business Development Service) BDS providers. These cluster actors provide various services to the cluster units, such as training of workers, testing facilities, financial services, technical know-how, regulatory and advisory services, raw materials supply, supply of technologies, etc.

Amongst these stakeholders, AIFI is the most proactive in the region. The members of AIFI comprise members of forging units located in Chennai. The association addresses issues related to the welfare and grievance redressal of their member industries.

Cluster development activities

Some of the medium- and large-scale industries are associated with Association of Indian Forging Industries (AIFI) while other units have not yet been associated with AIFI Chennai.

Abbreviations

Abbreviation	Full form
AIFI	Association of Indian Forging Industries
DG	Diesel Generator
DI	Development Institute
DIC	District Industries Centre
FO	Furnace Oil
HT	High Tension
kL	Kilolitre
kWh	kilowatt-hour
LED	Light Emitting Diode
Lit	Litre
LPG	Liquefied Petroleum Gas
LT	Low Tension
MD	Managing Director
MSME	Micro Small and Medium Enterprises
MT	Metric Tonne
MVL	Mercury Vapour Lamp
NPSH	Net Pressure Suction Head
OEM	Original Equipment Supplier/Manufacturer
PDB	Power Distribution Board
SEC	Specific Energy Consumption
SIDCO	Small Industries Development Corporation
toe	tonne of oil equivalent
VFD	Variable Frequency Drive
VSD	Variable Speed Drive

Note

About TERI

A dynamic and flexible not-for-profit organization with a global vision and a local focus, TERI (The Energy and Resources Institute) is deeply committed to every aspect of sustainable development. From providing environment-friendly solutions to rural energy problems to tackling issues of global climate change across many continents and advancing solutions to growing urban transport and air pollution problems, TERI's activities range from formulating local-and-national level strategies to suggesting global solutions to critical energy and environmental issues.

The Industrial Energy Efficiency Division of TERI works closely with both large industries and energy-intensive micro, small, and medium enterprises (MSMEs) to improve their energy and environmental performance.

About SSEF

Shakti Sustainable Energy Foundation (SSEF), established in 2009, is a Section-25 not-for-profit company, which aids design and implementation of clean energy policies that support promotion of air quality, energy efficiency, energy access, renewable energy, and sustainable transportation solutions. The energy choices that India makes in the coming years will be of profound importance. Meaningful policy action on India's energy challenges will strengthen national security, stimulate economic and social development, and keep the environment clean.

Apart from this, SSEF actively partners with industry and key industry associations on sub-sector-specific interventions towards energy conservation and improvements in industrial energy efficiency.

About SAMEEEKSHA

SAMEEEKSHA (Small and Medium Enterprises: Energy Efficiency Knowledge Sharing) is a collaborative platform set up with the aim of pooling knowledge and synergizing the efforts of various organizations and institutions — Indian and international, public and private — that are working towards the development of the MSME sector in India through promotion and adoption of clean, energy-efficient technologies and practices. The key partners of SAMEEEKSHA platform are: (i) Swiss Agency for Development and Cooperation; (ii) Bureau of Energy Efficiency; (iii) Ministry of MSME, Government of India, and; (iv) The Energy and Resources Institute.

As part of its activities, SAMEEEKSHA collates energy consumption and related information from various energy intensive MSME sub-sectors in India. For further details about SAMEEEKSHA, visit **http://www.sameeeksha.org**

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