Energy Mapping of MSME Forging Sector

Bureau of Energy Efficiency,
(Ministry of Power, Govt. of India)

Imprints

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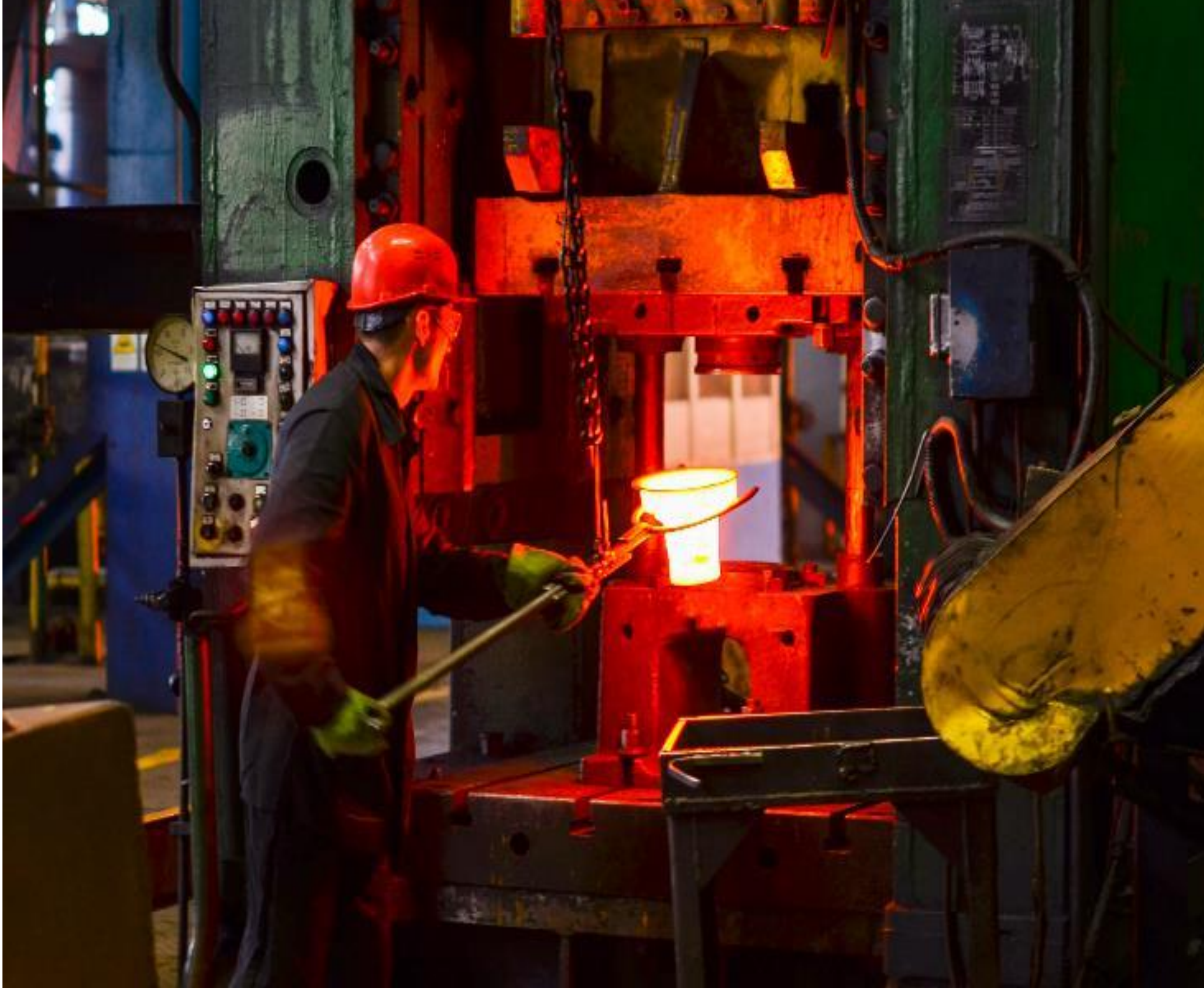
Abbreviations

AI	Artificial Intelligence
AIFI	Association of Indian Forging Industry
BEE	Bureau of Energy Efficiency
BOP	Best Operating Practices
CAD/E/M	Computer Aided Design/ Engineering/ Manufacturing
CAGR	Compound Annual Growth Rate
CEA	Central Electricity Authority
cfm	Cubic Feet per Minute
CICU	Chamber of Industrial & Commercial Undertakings (Industry Association)
CLCSS	Credit Linked Capital Subsidy Scheme
CNC	Computer Numerical Control
COC	Cycle of Concentration
DG	Diesel Generator
DHI	Department of Heavy Industries
DIC	District Industries Centre
DISCOM	Distribution Companies
DPR	Detailed Project Report
ECM	Energy Conservation Measures
EE	Energy Efficiency/ Energy Efficient
EET	Energy Efficient Technology
EnMS	Energy Management System
EnPI	Energy Performance Index
ESCO	Energy Services Company
FO	Furnace Oil
FRP	Fiber Reinforced Plastic
GCV	Gross Calorific Value
GEF	Global Environment Facility
GST	Goods and Services Tax
HSD	High Speed Diesel
HT	Heat Treatment
HVAC	Heating, Ventilation and Air Conditioning
IA	Industry Associations
IE	International Efficiency standard
IGBT	Insulated Gate Bi-polar Transistor
IoT	Internet of Things
IRR	Internal Rate of Return
ITI	Industrial Training Institute
kgoe	Kilogram of Oil Equivalent
KPI	Key Performance Indicator
kWh	Kilowatt-hour
LDO	Light Diesel Oil
LM	Lean Manufacturing
LMCS	Lean Manufacturing Competitiveness Scheme
LNG	Liquified Natural Gas
LPG	Liquified Petroleum Gas
LSHS	Low Sulphur Heavy Stock Oil

Abbreviations

LSP	Local Service Provider
ML	Machine Learning
mmWC	Millimetre of Water Column
MoMSME	Ministry of Micro, Small and Medium Enterprises
MoP	Ministry of Power
MOSPI	Ministry of Statistics and Programme Implementation
MSME	Micro, Small and Medium Enterprises
MU	Million Units
MWh	Megawatt-hour
NG	Natural Gas
NIFFT	National Institute of Foundry and Forge Technology, Ranchi
NIP	National Infrastructure Pipeline
NPV	Net Present Value
NSIC	National Small Industries Corporation
PID	Proportional Integral Differential Control
PLC	Programmable Logic Control
PLI	Performance Linked Incentive scheme
PPAC	Petroleum Planning and Analysis Cell
PRGFEE	Partial Risk Guarantee Fund for Energy Efficiency
RE	Renewable Energy
REA	Rajkot Engineering Association
SCM	Standard Cubic Meter
SCR	Silicon Controlled Rectifier
SDA	State Designated Agency
SEC	Specific Energy Consumption
SOP	Standard Operating Procedures
TEQUP	Technology and Quality Upgradation Programme
toe	Tonne of Oil Equivalent
UNIDO	United Nations Industrial Development Organization
VFD	Variable Frequency Drive
VMC	Vertical Milling Centre
VSD	Variable Speed Drive
WB	World Bank
WHR	Waste Heat Recovery
ZED	Zero Defect Zero Effect



1. Introduction

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Bureau of Energy Efficiency (BEE*), a statutory body under the Ministry of Power, Govt. of India*, has notified broad policies for promotion of Energy Efficiency (EE) in India. Industrial segment including MSME sector has remained one of the focus sectors of the BEE to enhance energy efficiency. Several initiatives have been taken by BEE from time to time to promote the competitiveness of MSME sector through sustainable use of energy, *such as BEE SME program and support for WB-GEF & UNIDO-GEF programmatic interventions*.

These and similar initiatives have contributed to improve efficiency of MSME clusters in the country. However, in quantitative terms, there is not much authentic information and data available with respect to MSME's energy consumption and energy saving opportunities. Also, prior interventions in MSME sector were limited to specific clusters, and do not comprehensively cover sector specific policy and implementation aspects.

In this context BEE has devised the "Energy and Resource Mapping Study" for 10 energy intensive MSME sectors including Forging MSME sector. The study aims to identify the present scenario of the forging sector in terms of energy consumption, applicable EE technologies, readiness of the sector in adopting EE solutions and develop a sector level EE policy roadmap for the Forging MSME sector. Following activities have been envisaged to execute this assignment:

Field Studies

Review of Energy consuming processes & technologies
Calculated Specific Energy Consumtion benchmarks at process level
Identifying EE solutions, technologies and best pratices relevant to sector

Sector level energy mapping

Calculating energy consumption at sector level and future projections
Benchmarking Energy Consumption with clusters & international benchmarks
Estimating technology penetration level and EE potential at sector level

Energy efficiency policy roadmap

Mapping needs of the forging sector stakeholders at sector /cluster level
Technical, financial and capacity building interventions required
Policy and regulatory level recommnedations for forging MSME sector

Towards that objective, BEE has appointed PwC India to establish energy consumption patterns, highlight opportunities for EE technology upgradation along with policy recommendations and implementation plan for pacing up the EE initiatives in forging clusters across India including Delhi NCR, Pune, Ludhiana, Chennai, and Bengaluru. To conduct this study, several initiatives are carried out by PwC India which directly and indirectly benefitted the forging sector stakeholders:

- Detailed Energy Studies in 50 forging units along with recommendations for energy improvement
- Analysed the Specific Energy Consumption benchmarks at sectoral/ sub-sectoral level

- Identified Energy efficient technologies relevant to the sector and developed technology roadmap
- Disseminated the learnings and created awareness on EE across forging MSME sector & clusters
- Mapped the readiness of sector in adopting EE solutions and developed EE policy roadmap

Approach and Methodology

Based on our understanding of the objectives, we adopted a structured methodology that comprised of desk research, field studies, stakeholder consultations followed by assessment and analysis. Given the limitations associated with this desk-based study, the primary surveys and field studies were primarily targeted to collect data on the sector and best practices that could assist in EE projections.

We have followed the *mixed approach of primary surveys, one-to-one consultations, workshops, energy studies & secondary research* as shown in below section to achieve the project outcomes:

1. **Primary Surveys in 160 Forging** covering 8 MSME clusters to collect information on
    - Type of products manufactured and type of metal
    - Metal reheating technology and type of forging
    - Annual production and fuel-wise energy consumption
2. **Field studies in 50 MSME Forging units** covering 5 MSME clusters to analyze the following
    - Review of energy consuming processes & operations
    - Calculate Specific energy consumption for processes
    - Identify Energy Efficiency solutions to the MSME forging unit
3. **Secondary research on energy benchmarks and relevant EE technologies**
    - Identified process specific national and international energy benchmarks
    - Identified EE technologies relevant to the sector, techno-commercial feasibility
    - Estimation of technology penetration levels and projections for EE potential
4. **10 Awareness creation workshops and 2 Stakeholder consultations**
    - 5 Inception workshops to explain about assignment objectives and project features
    - 5 Dissemination workshops to share project learnings and understand cluster needs
    - 2 Stakeholder consultations to understand sector needs & develop EE policy roadmap
5. **One-to-one consultations with industry stakeholders** to understand forging sector needs
    - Detailed discussions with AIFI regional and national chapters

- One-to-one consultations with cluster level associations - Rajkot Engineering Association; Shapar Veraval Industrial Association (SVIA) at Rajkot, Chamber of Industrial & Commercial Undertakings (CICU) at Ludhiana etc.
- Consultations with technology suppliers, and local service providers

Building on the data collected, a deep dive analysis of sectoral energy outlook and EE reduction potential was conducted. A dynamic excel model was developed to undertake the sub-sector level analysis based on *metal reheating furnace and metal forging technique* from 2021 to 2031 to estimate energy consumption in BAU scenario and energy intensity reductions in EE moderate and ambitious scenario.

Estimating sub-sector level production
- India's GDP growth from 2021 to 2031
- Historical sectoral production statistic
- Current share and projections of type of forging- Closed die, open die
- Share of induction, oil & gas fired furnaces and projections based on fuel switch

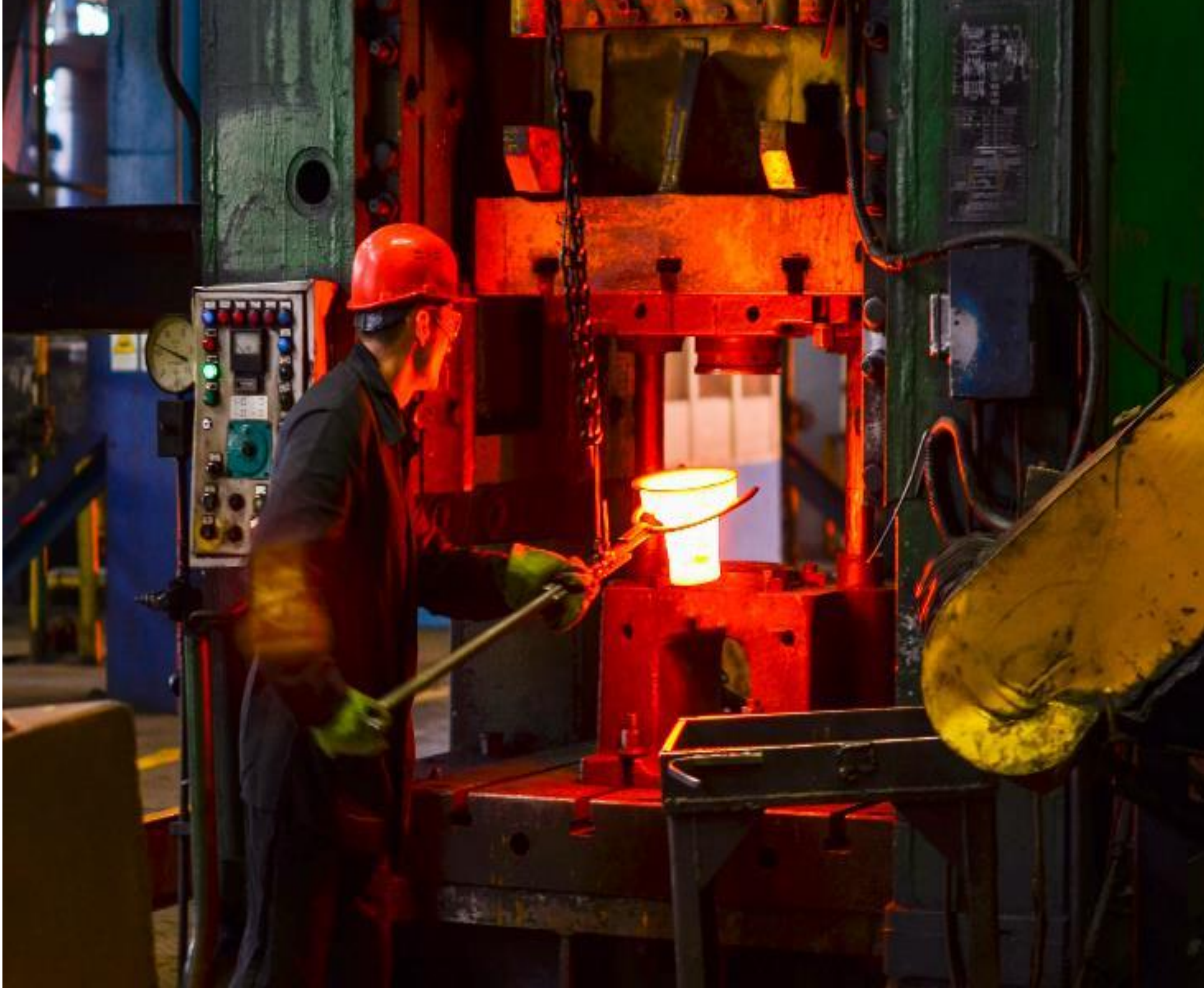
Estimating sub-sector level SECs
- Estimaitng SEC based on field studies
- Subsectoral SECs based on type of metal reheating technique
- Validation of data inputs from industry experts
- Revising SEC and other assumptionn

EE Projections in different scenarios
- Defining Business as Usual (BAU) and alternate scenarios-
  - EE scenario (moderate)
  - EE+State-of-art scenario (ambitious)
- Estimating EE penetration levels in alternate scenarios at sectoral level
- Changes in SEC in alternate scenarios

Recommendations
- Estimating emissions reduction potential at sectoral level and opportutines for EE improvement
- Mapping needs of the forging sector in achieving identified EE potential
- Technical, financial and capacity building interventions required for EE adoptions

Energy demand for the forging sector is evaluated based on various contributing factors, which includes sectoral production/service demand, specific energy consumption, energy efficiency improvement, etc.

This “BEE Energy mapping study” ultimately aims to generate a sector level energy efficiency roadmap for the forging MSME sector. Findings of this study will also help to formulate policies and prepare the implementation plan for pacing up the EE initiatives in the forging clusters across India.



2. Forging Sector Overview

2. Forging sector overview

Forging sector is considered as the backbone of manufacturing industry. Forging process can create parts that are stronger than those manufactured by any other metal forming process. It is a major input to the sectors which support economic growth of the nation such as automobile, general engineering, agriculture, aerospace, power, construction & mining equipment, and railways.

Expansion of manufacturing and infrastructure in emerging economies like India will generate demand for a wide variety of machinery and equipment, which, in turn, will create demand for forging parts. Forging market is also directly linked with the development of the overall automobile sector and with growth of the automobile industry it is expected to generate huge demand for forging producers.

Forging is a manufacturing process where metal is pressed or squeezed under great pressure into high strength parts known as forgings. The process is usually performed hot by preheating the metal to a desired temperature before it is worked. Economically, forged products are attractive because of their inherent superior reliability, improved tolerance capabilities.

The global metal forging market size was valued at USD 83.85 billion in 2019 and is expected to grow at a compound annual growth rate (CAGR) of 5.0% from FY20-25.

Closed Die forging or impression Die forging, open die forging, Ring roiling forging and precision forging are the most widely used processes globally. Products formed by impression die and ring rolling are gaining the market share, market share of the open die products has been decreasing over the last one decade[1].

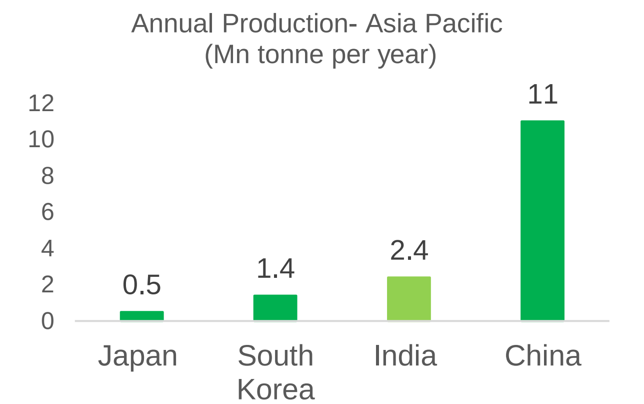


Figure 1: Comparison of Asian forging Industry

China produced around 11 Mn tonne of the forged products during 2019-2020, while India produced 2.4 Mn tonne during the same financial year. India is second largest producer of the forging components in Asia.

Automotive sector is the largest consumer of the forged products. Impression die forging is expected to grow in the Asia region on account because of presence of the numerous auto manufacturing companies located in south east Asian countries (Including India and China).

Indian forging industry has been seeing the downfall due to the shortfall of demand in auto sector in past few years. During 2019-2020, revenue of Indian forging industry was estimated at around 4.5 Billion USD[2]. thus, contributing to around 5-6% in total global forging Industry.

2.1. *Indian Forging Sector*

Forging sector in India is considered as the backbone of the manufacturing industry. Indian Forging sector caters to requirements of the automobile, machinery, agriculture, engines,

[1] https://www.forging.org/uploaded/press-releases/files/2015%20stat%20release.pdf
[2] https://auto.economictimes.indiatimes.com/news/auto-components/etauto-exclusive-lockdown-blues-forging-industry-might-decline-50-by-september/75532300, conversion of 75 INR = 1 USD is considered

aerospace, powertrains, power, construction & mining equipment, railways, and general engineering. Indian forging industry is globally recognized for its technical capabilities and has a capability to forge a wide variety of raw materials.

Indian forging industry, *with an installed capacity of around 4.7 Million (Mn) tonne*[3]*,* has produced over 2.35 Mn tonne of the forged products during the financial year (FY) 2019-20. With a total production of worth INR 35,000-45,000 crore, Indian forging industry provides direct employment to more than 300,000 people in the country along with an additional 50,000 contract laborer.

Table 1: Installed capacity and Production details forging

Year (FY)	Installed capacity (Mn tonne)	Production (Mn tonne/year)	Production (Rs Crore)
2015-16	3.8	2.3	28,289
2016-17	3.9	2.4	31,189
2017-18	4.2	2.6	34,000
2018-19	4.5	3.0	45,000
2019-20	4.7	2.4	34,000

The Indian forging industry, which mainly manufactures the automotive components, is directly impacted by cyclical market trends occurring in end-user industries. Over the past 2-3 years, the forging industry has observed a slowdown in the domestic as well as export market. As automotive sector is facing slow-down since 2018, which was further magnified due to Covid induced global recession, the Indian forging units are also feeling the impact on their revenues.

India forging industry contributed to around 5-6% in global forging Industry. Among this, forging exports from India contributed to over 24% in the total forging revenue. The present export market includes mainly USA and Europe.

Products manufactured: The forging units in Indian MSME clusters are principally known for their ability to make superior precision components. These forging units cater to wide range of secondary production industries including automotive (65%) and non-automotive industries such machinery and engineering, railways, agro machinery and tools, power, defense, mining, and oil & gas industry. The automobile sector is a major consumer of forging parts produced in the country.

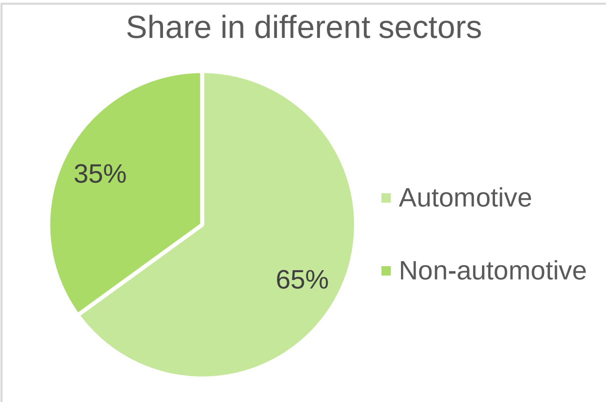


Figure 2 Share of the forging products in different sector

Majority of the forging industries manufacture the multiple automotive and engineering products, which are usually custom made These include propeller shaft, front axle, upper pin, crown wheels, gears, shafts, connecting rods, forks, camshafts, flanges, and valve body.

Scale and size of units: Indian forging industry has gradually evolved from being a labor-intensive industry to a more capital-intensive industry. Small scale units are also increasing their capital investment to keep pace with the increasing demand, especially in the global markets.

3 Source: *https://www.indianforging.org/indian-forging-industry/, Accessed on 16-Jul-2020*

Large share of the forging industry is made up of micro, small, and medium enterprises (MSMEs). According to Association of Indian Forging Industry (AIFI) data base, 83% of the forging units in India are fall under micro and small enterprise. While 9 percent are Medium Sized, the remaining being Large Scale (Figure 3).

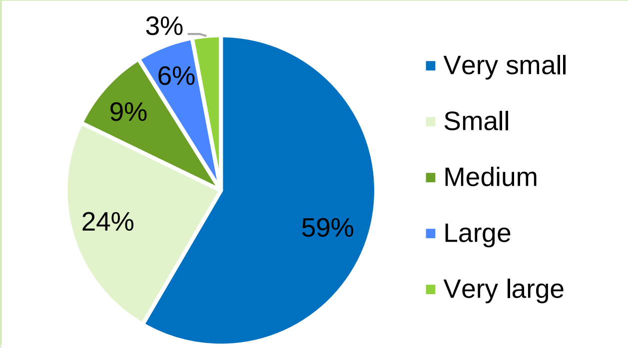


Figure 3 Distribution of forging Industries

The medium and large-scale industries account for about 70% of total forging production of India, while the remaining 30% is produced by the micro and small-scale units.

Metal Forming technique: Indian forging sector consists primarily of hot closed die forging, which constitute about 63% of the total installed capacity in the country3, followed by open die forging constituting (~17%), cold closed die and ring rolling account for 7%, 6% respectively (Figure 4). Products formed by closed die are gaining the market share, on account of increase in auto manufacturing companies in India.

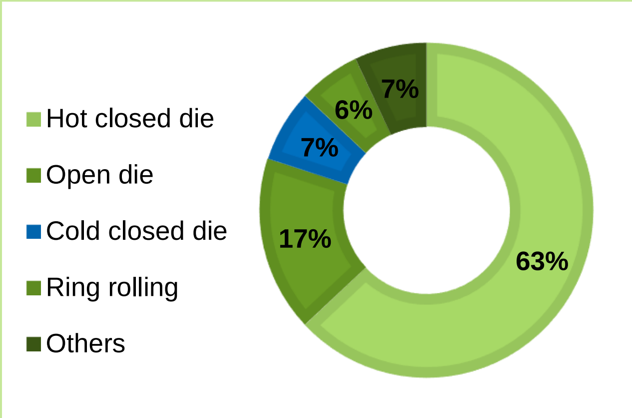


Figure 4 Forging process and % share in Industry

Heat treatment is an allied process for treatment of forging and machined components. Some forging units have in-house heat treatment facilities, while others undertake heat treatment from external heat treatment units.

Type of metal processes- The Indian MSME forging cluster produces a variety of materials. The major raw materials used in the forging units include mild steel, carbon steel, alloy steel, stainless steel, aluminum, super alloy, and special steel.

Most of these raw materials are produced locally or obtained from other domestic markets. Long bars and billets are used as raw materials in forging industries. The main sources of raw materials of forging products are steel rolling mills located in nearby regions.

2.2. *Key growth drivers of the market: - End-user segment insights:*

The Government's thrust on manufacturing sector with initiatives like 'Make in India' and 'Skill India' has created positive economic sentiments amongst the business community. The new manufacturing policy which envisages the increase in the share of manufacturing in the GDP to 25%, the role of forging industry to support manufacturing is very vital. Since all auto and engineering sectors use forging products in their manufacturing.

Export market-

Indian forging industry is now increasingly addressing opportunities arising out of the growing trend among global automotive OEM's (Original Equipment Manufacturers) to outsource components from manufacturers in low-cost countries such as India.

Many global OEMs and Tier-I players are setting up purchasing offices in India and looking at procuring high standard quality products. Hence export market presents a great opportunity for the industry to tap into, with India's current share of export in forging stood at only 1-2%.

Automotive:

Based on volume, India is currently the fourth largest automobile industry, globally. Steady growth of the automotive sector has also led to the steady development of other subsidiary industries like the auto component industry, indicating demand for forging parts.

- Demand likely to pick up with steady rate due to increase in disposable income
- Spare parts consumption could drive demand
- Demand for electric vehicles is likely to go up with more thrust for a cleaner environment

Power: Consistent power supply and availability of quality electrical equipment are necessary for the growth of the Indian economy from a global perspective. "Power for All" will generate huge demand for power transmission and distribution equipment-

- Ageing equipment will require replacement
- The forging industry is expected to benefit from such power generation installations

Construction and Heavy engineering equipment:

The construction sector in India is poised for steady growth due to substantial investments and capacity additions. Demand for forging components is expected to expand with the growth of the infrastructure market in India.

National Infrastructure Pipeline (NIP) has also set plans to help take India to USD 5 Tn economy and there is a planned budget of USD 1.4 Tn. on infra projects for next 5 years.

2.3. *Key Challenges*

Since most of the forging manufacturing units fall under small and medium enterprises (MSMEs), they cannot use advanced technological equipment or automation due to high costs, thus limiting their marketing strength. The inability to supply high quality products to large domestic and global market players, act as a huge barrier for the industry to grow further.

In addition to this, ever rising fuel prices and non-reliable availability of fossil fuels, has also become a major problem for the MSME units in the forging sector. These MSMEs also have limited knowledge capabilities to evaluate production technologies relevant to their unit, and limited capacities to access finance.

Figure 5: Key challenges for the forging industry

2.4. ***Geographical Coverage***

There are about 400-600 forging units in India, out of these, of majority (nearly 92%) of the forging units in India falls under the category of medium and small-scale industry.

A peculiarity of the MSME industry in India is its geographical clustering. The forging industries are also located in clusters across the country, there are about 10 major clusters where the forging industries are predominantly located across different states. The major forging clusters are in Pune, Rajkot, Mumbai, Delhi NCR, Jalandhar, Ludhiana, Jamshedpur, Bengaluru, Coimbatore, and Chennai, among other Indian cities.

Each of these forging clusters caters to some specific end-use market. Major forging clusters in the country are shown in below section as shown in Figure 7

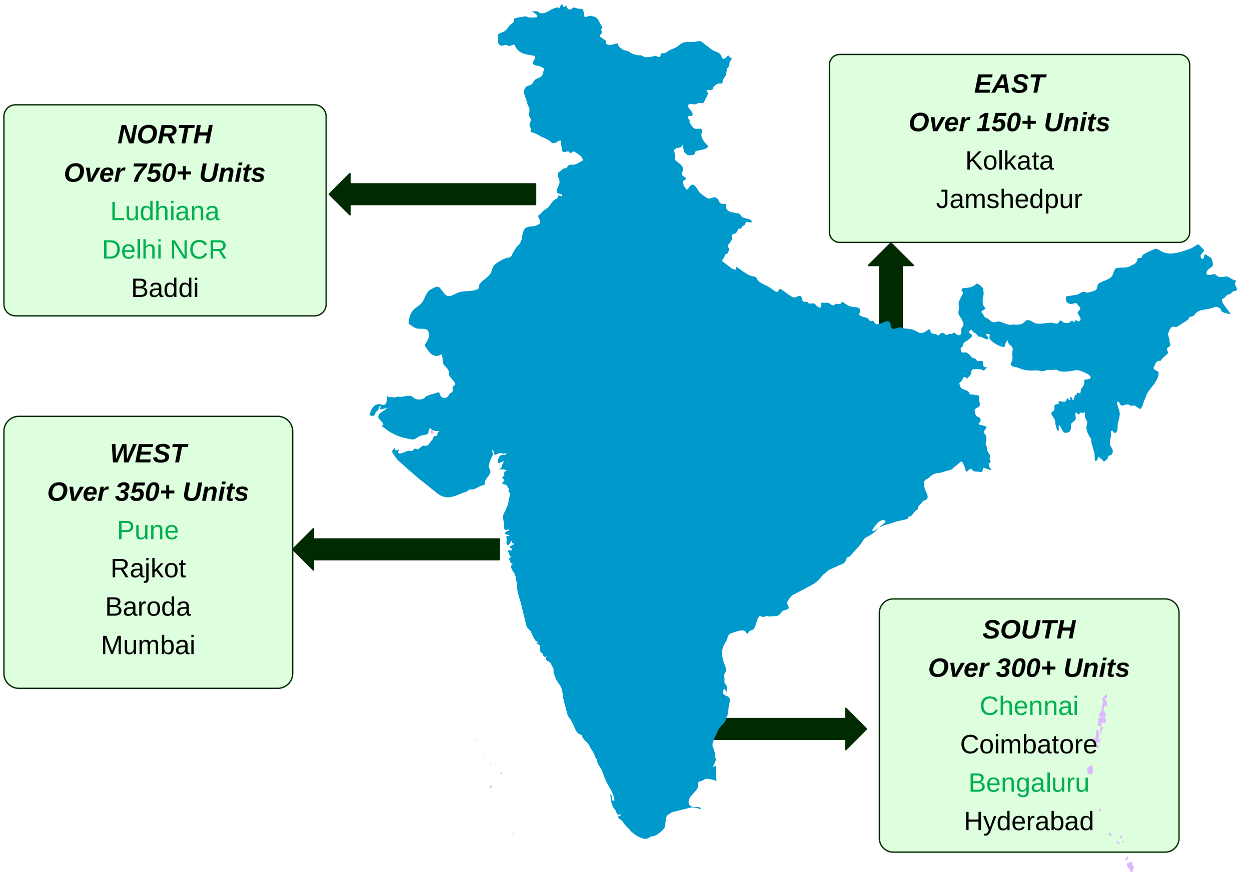


Figure 6 Forging clusters in India

2.4.1. ***Forging Industry in Northern Region***

Delhi-NCR is one of the prominent forging cluster in the Northern region, there are around 100 forging units in the cluster spread across Faridabad, Palwal, Gurugram, Rohtak, Noida, Ghaziabad, Manesar and Bhiwadi region. Forging units in the region mainly produce the components for auto sector manufacturers in NCR region. Few of the units also produce forged components for agriculture, heavy machinery, Oil & Gas, and engineering sectors.

Forging industry in the cluster majorly use three forms of the energy i.e., Electricity, Furnace Oil (mainly Low Sulphur Heavy Stock-LSHS) and Gas (Predominantly-PNG); very few units also use the other liquid fuels for the metal reheating. Major industry associations active in the cluster are

– IamSMEofIndia (Faridabad Chapter), Gurugram Industry Association (GIA), and Association of Indian Forging Industry (AIFI North Chapter).

Table 2 Details of the Delhi NCR- Forging cluster

Description	Details
Location	Delhi NCR
Number of forging units	100
Products manufactured	Automotive and Machining components
Type of fuel used in cluster	Electricity, Furnace Oil, NG, and LPG
Prominent heating Technologies	Induction Billet Heaters, Oil Fired furnace, Gas fired furnace
Prominent Industry association	IamSMEofIndia, AIFI Northern Region
Prominent Institutes	NSIC technical services centre

Ludhiana-Jalandhar is a prominent forging cluster in the northern region, there are around 300 forging units in the cluster. Forging units in the cluster supports the Auto, Agriculture, Cycle, Machinery and Engineering sectors. Forging industry in the cluster majorly use three forms of the energy - electricity, furnace oil and gas for the production.

Major industry associations active in the cluster are – Chamber of Industrial and Commerce Undertaking (CICU), Punjab forging association and Association of Indian Forging Industry (AIFI), Federation of Indian Export Organization (FIEO) in Jalandhar region. Crank shaft, connecting rods, brake drum, spanners, special tools, etc. are the main forged products forged in the cluster. Forging units in this cluster processes different grades of steel, carbon steel, alloy steel, and mild steel.

Table 3 Details of the Ludhiana Forging cluster

Description	Details
Location	Punjab
Number of forging units	200
Products manufactured	Automotive, Cycle and Agriculture
Type of fuel used in cluster	Electricity, Furnace Oil, NG, and LPG
Prominent heating Technologies	Induction Billet Heaters, Oil Fired furnace, Gas fired furnace
Prominent Industry association	Chamber of Industrial and Commerce Undertaking (CICU), Punjab forging association and Association of Indian Forging Industry (AIFI), Federation of Indian Export Organization (FIEO)
Prominent Institutes	Central Tool room Ludhiana
SDA	Punjab Energy Development Agency

Baddi[4] is emerging as one more forging cluster in Northern India, presently there are around 15 operational units. *Baddi cluster provides the various products to automotive industries - such as axles, gears, shafts, bearing race, crankshaft assembly, transmission components, yoke,*

[4] *Discussion with Baddi Association (2020 Field visit for project activities)*

spindles, few components for aerospace industries. Industry is using a mix of conventional oil-fired furnaces to modern Induction heating furnaces.

Metal Preparation

Bandsaw is predominantly used for billet cutting across the different forging clusters. However, some units in Ludhiana also use shearing machines for cutting of the billets and strips.

Billet heating

Oil fired furnaces are predominantly used for metal heating in the Ludhiana and nearby forging clusters. Gas based heating is widely adopted for metal heating in the Delhi-NCR cluster.

Forging operations

Pneumatic hammers are widely used for the open die metal forming operations in Ludhiana Phagwara forging clusters.

Hydraulic hammers are widely adopted by the forging units in Delhi-NCR forging clusters.

Forging units in the Phagwara clusters carry out this forging processes to form the metal rings ranging from a few inches to a few meter (outer diameter).

Coining is predominantly. used for the multiple forging for the auto industry. Trimming is carried out for almost all forged products for flash removal. Advanced metal forming machines are now capable of producing the flash less forged products which has almost no flash. Flash less forging is being done by fewer progressive and front runners MSMEs across the Ludhiana, Phagwara forging clusters.

2.4.2. *Forging Industry in Western Region*

Pune second largest city in Maharashtra, has developed into a manufacturing centre for many industries like automobiles, pumps, rubber, plastics, pharma, chemicals, and allied engineering. Pune is the country's largest manufacturing hub of automotive components. With the increasing presence of many automobile companies and auto ancillary divisions in Pune, a large number of the machining, forging, and heat treatment units have become suppliers to Original Equipment Manufacturers' (OEMs) in the automobile sector.

Pune forging cluster accounts for about 20–25% of the total national production of forged components. There are around 60 forging units located in the Pune region. Pimpri- Chinchwad and Bhosari hosts the maximum number of the forging units in the region. Domestic users of forgings from the cluster are automobile companies like Tata, Mahindra, Bajaj, JCB, ordinance factories around Pune and engineering firms like Thermax, Forbes Marshall, Kirloskar and so on. The domestic market constitutes major part of the total supply from these MSME units.

Table 4 Details of the Pune Forging cluster

Description	Details
Location	Maharashtra
Number of forging units	60
Products manufactured	Automotive, Heavy Engineering
Type of fuel used in cluster	Electricity, Furnace Oil, NG, and LPG
Prominent heating Technologies	Induction Billet Heaters, Oil Fired furnace, Gas fired furnace

Prominent Industry association	AIFI Western Chapter, Pimpri-Chinchwad Association
Prominent Institutes	Maharashtra Industrial Development Corporation (MIDC), Automotive Research Association of India (ARAI) forging industry division
SDA	Maharashtra Energy Development Agency

Rajkot is one of the leading forging cluster in the west, there are around 150 forging units in cluster. *Cluster servers mainly to pump manufacturers, engineering works and automobile sector*. Cluster uses electrical energy, Furnace oil and natural gas for the heating applications. Major industry associations in the cluster are Rajkot Engineering Association, AJI GIDC, GLIA, Shapar-Veraval. Ring rolling and closed die are the major operations performed in the cluster[5]. As per collective data from the different associations annual production is over 4.34 lakh tonne annually. *Closed die production accounts for the 76% of the energy consumption and 24% is attributed by the ring rolling operations*.

Table 5 Details of the Rajkot Forging cluster

Description	Details
Location	Gujarat
Number of forging units	60
Products manufactured	Automotive, Heavy Engineering
Type of fuel used in cluster	Electricity, Furnace Oil, NG, and LPG
Prominent heating Technologies	Induction Billet Heaters, Oil Fired furnace, Gas fired furnace
Prominent Industry association	Rajkot Engineering Association, AJI GIDC, Shapar-Veraval Industry Association
Prominent Institutes	NSIC technical services centre
SDA	Gujarat Energy Development Agency

Metal Preparation

Bandsaw is predominantly used for billet cutting across the different forging clusters.

Billet heating

Induction based heating is predominately used for billet heating in the Pune, and Rajkot forging clusters.

Forging operations

Pneumatic hammers are widely used for the open die metal forming operations in Rajkot and Pune forging clusters.

A very few units carry out the ring rolling operations.

2.4.3. *Forging Industry in Southern Region*

Chennai Cluster- Chennai is a hub of engineering and automotive industries in India. All sectors of the automotive and engineering sector are represented, including two-wheelers, four-wheelers,

[5] http://sameeeksha.org/pdf/clusterprofile/Rajkot-Forging-Industries-Gujarat.pdf (2016) *Accessed on 16-Jul-2020*

cranes, earthmovers, mining, and oil drilling equipment, to pumps & valve bodies, and defence parts etc. With the increasing presence of many automobile companies and auto ancillary divisions in Chennai, a large number of the machining, forging and heat treatment units have become suppliers to Original Equipment Manufacturers' (OEMs) in the automobile sector.

Major industry associations active in the cluster are – AIFI, Ambattur Industry Association, are leading association in the region having around 40 forging member units. 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, Volkswagen, 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.

Table 6 Details of the Chennai Forging cluster

Description	Details
Location	Tamil Nadu
Number of forging units	~40
Products manufactured	Automotive, Electrical component, engineering
Type of fuel used in cluster	Electricity, Furnace Oil
Prominent heating Technologies	Induction Billet Heaters, Oil Fired furnace
Prominent Industry association	AIFI, Ambattur Industry Association
Prominent Institutes	DIC, ITI
SDA	Tamil Nadu Generation and Distribution Corporation Limited

Bengaluru is Bangalore is the hub for machine tools in India and cluster accounts for 60% of the value of production of machine tools in the country. It is also home to forging industries & heavy engineering companies and cluster is having around 40 forging units. These machine tool, engineering and forging units are mainly located in Peenya Industrial estate, Attibele Industrial estate, Bommasandra Industrial estate, and nearby regions i.e., Tumakuru, Malur Harohalli, Hoskote, Hosur etc.

Forged products in the region catering to different sectors of economy such as automobile industry, aerospace industry, and CNC Machine industry across the globe. Forging units in the region use the different production processes and equipment such as drop hammers, pneumatic hammers, hybrid hammers, machining processes etc. Major industry associations active in the cluster are – Peenya Industry Association and Association of Indian Forging Industry (AIFI) Southern Chapter.

Table 7 Details of the Bengaluru Forging cluster

Description	Details
Location	Karnataka
Number of forging units	~40
Products manufactured	Automotive, Engineering, CNC Machines
Type of fuel used in cluster	Electricity, Furnace Oil
Prominent heating Technologies	Induction Billet Heaters, Oil Fired furnace

Prominent Industry association	Peenya Industry Association and AIFI Southern Chapter
Prominent Institutes	DIC, The Karnataka German multi-skills development centres
SDA	Karnataka Renewable Energy Development Limited

Metal Preparation

Bandsaw is predominantly used for billet cutting across the different forging clusters. However, some units in Chennai and Bangalore also use shearing machines for cutting of the billets and strips.

Billet heating

Induction based heating is predominately used for billet heating in the Pune, Chennai, and Bangalore forging clusters. Oil fired furnaces are predominantly used for metal heating in the Bangalore for open die forging operations.

Forging operations

Pneumatic hammers are widely used for the open die metal forming operations in Bangalore, Pune forging clusters.

Hydraulic hammers are widely adopted by the forging units in a very few units in Bangalore and Chennai forging clusters.

Forging units in the Bangalore clusters carry out this forging processes to form the metal rings ranging from a few inches to a few meter (outer diameter).

Coining is predominantly. used for the multiple forging for the auto industry. Trimming is carried out for almost all forged products for flash removal.

Advanced metal forming machines are now capable of producing the flash less forged products which has almost no flash. Flash less forging is being done by fewer progressive and front runners MSMEs across the Bangalore forging clusters.

2.4.4. *Forging Industry in Eastern Region*

Jamshedpur -Adityapur is the having over 50 forging industries, these industries mainly cater the forged products requirement of the automotive sector. *Adityapur Auto Cluster*[6] *is home to forging units that serves to auto sector, heavy machinery, and allied engineering sector*. Adityapur Small Industries Association, Jharkhand Small Industry Association are the two prominent Industry association in the region. Most of the Industries in the region are small and Medium enterprise.

Kolkata is having forging units spread over the Kolkata, Howrah and nearby regions. Kolkata is predominantly foundry cluster but there are few forging units in operation in the region. 27 forging units from the he Jamshedpur and Kolkata region are member of AIFI Eastern region.

2.5. *Sector level stakeholders*

In context of our existing working relationships in a number of MSME clusters, the local level stakeholders show great interest and enthusiasm for energy efficiency initiatives and technical

6 http://www.findglocal.com/IN/Jamshedpur/1863309453949679/Adityapur-Auto-Cluster *Accessed on 20-Jul-2020*

cooperation activities. These stakeholders can be positioned as opinion influencers among the local industrial community during project activities in any particular cluster.

The primary stakeholders in the cluster are the industry associations, individual forging units and MSME DI. The other stakeholders include the technology suppliers, government agencies, financial institutions, and academic/training institutes.

Industry Association

Industry Associations are increasingly becoming more professionally managed with dedicated staff for day-to-day operations. These associations serve as the first avenue to understand cluster dynamics such as energy efficiency technology needs, disseminate best practices among member units and also assist in organizing various cluster level awareness programmes on EE. Leveraging these industry associations from the initial stage of the study would be quite valuable in:

- Understand the membership profile of MSMEs in the cluster
- Cluster profile of Industrial association including number of MSMEs, size of MSME units
- Present business scenario, barriers for energy efficiency
- Support in reaching out to member industries for project activities

The major industry associations in the Indian forging sector are presented next.

Table 8 List of key industry associations

Organization	Email
AIFI Secretariate – Pune	trupti@indianforging.org
CICU	sbsingh@taaranindustries.com
FIEO	ashwanikumar57@gmail.com
Punjab Forging Association	smahendru@nicksgrp.com
AIFI – Ludhiana Chapter	umeshmunjal@highwayindustries.com
Pimpri-Chinchwad Association	mypcpa@gmail.com
Peenya Industry Association	Peenya Industry Association
Hosur Industries Association	Hosur Industries Association
AIFI – Southern region Chapter	thiagarajanmf@gmail.com

Government Institutes:

There are government support bodies, such as District Industries Centre (DIC) in the cluster which also work towards the development of the cluster particularly for MSME industries.

Automotive Research Association of India (ARAI) – Pune

Automotive Research Association of India (ARAI) serves hundreds of customers in a year including Automotive OEMs; Engine, Component and Systems Suppliers; large number of SMEs etc. ARAI‟s forging division organizes training and undertakes R&D projects as well as testing and validation.

Various initiatives, such as the Auto Cluster Development Centre, which provides facilities like CAD-CAM centre and stimulation for design of tools and auto components have also been undertaken in the cluster.

Government institutes in Ludhiana Region

Institute for auto parts and hand tools technology was set up to a research & development organization for auto component and hand tools manufacturing sectors with the aim to uplift technological level of small & medium enterprises of the region (UNDP initiative). Central institute of hand tools (MSME tool room, Jalandhar) is a premier organization responsible for the development of hand tool industry in the country

Key national and regional stakeholders associated with forging are presented next-

Association of Indian Forging Industry AIFI is national association for the forging in India, representing Indian forging industries at various platforms national and international platforms. AIFI has over 300+ forging members across the country, Southern region office of AIFI is located at Chennai. AIFI has regional chapter in Bangalore, Northern region office is located in Ludhiana and AIFI - secretariat located in Pune.

The association provides support on addressing various cluster specific issues. In addition, activities of the association include seminars, workshops, technical programmes and training for shop-floor workers and dissemination of newsletters. AIFI host the Organize National and International Conferences on the forging and on new technological developments in the sector. and AIFI represents Indian forging at International Forging Congress International Forging Congress.

AIFI periodically publish the quarterly magazine (Focus) comprises macroeconomic review of the Indian forging sector, impact of economic trends, technical and knowledge articles related to forging industry, case studies and BOPs and global aspects with respect to forging industry. AIFI has strong sill development curriculums for forging industries and host regular training programs, technical seminars and workshops for the forging industries.

Chamber of Industrial and Commerce Undertakings (CICU)

Chamber of Industrial and Commerce Undertakings (CICU) is one of the most predominant Industry association in the region. CICU has strength of about 1,200 members and over 100+ forging units as well as individual forging consultants, equipment suppliers, and LSPs. Punjab forging Association (PFA) is associated with CICU and is leading forging association in the Ludhiana, Association is also associated with CICU. PFA have strength of over 50 members comprising forging units.

The association provides support for skill development and promotion of EE drive in the clusters. CICU has been institutional in the region for strengthening the MSME with *technical capacity building through workshops, B2B events, technology seminars, technology collaboration, training on 5S, Kaizen, ISO activities etc*. In addition, activities of the association include seminars, workshops, technical programmes and training for shop-floor workers and dissemination of newsletters. CICU is planning to set up regional chapter of National Institute of Foundry and Forge in Ludhiana.

Federation of Indian Exports Organization (FIEO)

Federation of Indian Exports Organization (FIEO) have over 50+ forging and hand tool units associated with them in the Jalandhar region. Association is supporting the forging and hand tool industries in the Jalandhar region, multiple projects from UNIDO, GEF on EE have been promoted by the association in the region to foster development across forging and hand tool industries. FIEO has been promoting the EE culture in the hand tool forging cluster through multiple initiatives of BEE and GEF -UNIDO, UNDP programmes.

Peenya Industry Association – Bangalore

Peenya Industry Association, located in Bangalore, is one of the oldest industrial estates in Southeast Asia. Association has strength of over 5,000 members and several forging units and individual forging consultants, equipment suppliers, and LSPs.

2.5.1. *Institutions supporting forging units*

National Institute of Foundry and Forge Technology (NIIFT) is one of the pioneer institutes for the foundry and forging is located in Ranchi and was instituted in 1966. Since inception NIIFT has been supporting the R&D, training programmes for the foundry and forging industries. Institute providers multiple education and training courses related to Forging and Foundry Technology, , Manufacturing Engineering, Materials and Metallurgical Engineering etc. Institute has world class infrastructure to promote the R&D activities, key facilities offered by NIIFT are – Mechanical laboratory, Metallography, FMS, Non-destructive and mechanical Testing Non-destructive and mechanical Testing, Ceramic lab, Spectroscopy, Environmental and Pollution Control Lab, Metrology, Electronics etc.

National Small Industry Corporation (NSIC) is one of the oldest institutes in the country, instituted in 1955. Broader objective of NSIC is to promote, aid and foster the growth of MSME enterprises in the country. NSIC have been working on multiple programmes for skill development, training etc. NSIC has multiple regional centers supporting different MSME clusters. Institute supports common facility services for MSME industries, to enhance their competitiveness and quality. NSIC provides multiple facility to the industries – material testing facilities, energy auditing, chemical testing, energy efficiency, environment management training etc. Key activities supported by NISC relevant to forging units are-

- Conduct hand-on trainings for skill enhancement of shop-floor workforce around energy efficiency and management.
- Develop curriculum for professional courses in forging and foundry technologies through consultation with stakeholders
- Establishing of facilities such as for forged component testing, Computer Aided Design for forging operations, die development etc.

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3. Energy Consumption and benchmarks

3. Energy consumption and benchmarks

3.1. Energy Benchmarking

The term benchmarking involves "comparing actual or planned practices, such as processes and operations, to those of comparable organizations to identify best practices, generate ideas for improvement"[7] which form the basis for measuring performance in an industry.

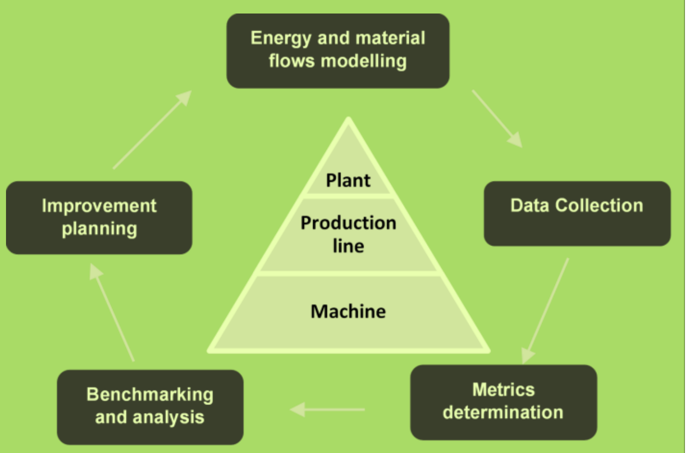
Energy efficiency benchmarking can be defined as the technique to identify the best practices and achievable energy efficiency improvement targets in companies and industries. The management in an industry can compare their baseline values with benchmark and take steps to ensure improvements in energy efficiency.

Energy efficiency benchmarking can be divided into internal and external benchmarking. Internal benchmarking is the comparisons within one company to establish the baseline and best practice. External benchmarking is to compare companies in the same or similar industry sector to establish the best-in-class performance. Additionally, general benchmarking is the comparisons of practices regardless of the industry field.

Benchmarking as defined above is process of searching for best practices that lead to excellence in performance. Baseline can be established by comparing the best practices practiced and subsequently, areas of potential improvement, and areas of focus can be identified. A variety of methods and studies have been carried across industry to come up with the best practices of energy efficiency benchmarking.

Example: A five step energy benchmarking method (E^2BM method)

E^2BM method can be applied at each individual process (e.g. machine), interrelated processes (e.g. production line), and a plant. This method relates energy consumption in manufacturing process to material flows to visualise the effectiveness and variations of energy usage. The inputs received from the prior step are used for developing strategies to improve energy efficiency. It consists of five steps and takes three levels of hierarchy into consideration i.e. plant, production line and machine.



[7] Source: Guide to the project Management body of knowledge, PMBOK, 2013.

3.2. *Energy Performance Indicators for the sector*

Key Performance Indicator (KPI) can be defined as a quantifiable/measurable value that demonstrates how effectively the industry or equipment or process is performing. KPIs can be financial and non-financial. A pictorial representation defining KPI's is shown along in the figure The four challenges in defining and maintaining KPIs are: (a) understanding industry's strategy

and key objectives, (b) measure is deemed important to area/process of the industry, (c) targets of KPI improvement must be realistic and (d) in case, accurately measuring and reporting indicators is difficult, internal process or SOP should be defined.[8]

Table 9 EnPIs related terms and definitions

Term	Definition	Notes
Energy baseline	Quantitative reference(s) providing a basis for comparison of energy performance	An energy baseline reflects a specified time period
Energy consumption	Quantity of energy consumed	-
Energy efficiency	Ratio or other quantitative relationship between an output of performance, service, goods, or energy, and an input of energy	Conversion efficiency: energy required/energy used; output/input; theoretical energy used to operate/energy used to operate
Energy performance	Measurable results related to energy efficiency, energy use and energy consumption	Results can be measured against organization's energy targets and energy performance requirements
Energy performance indicator	Quantitative value or measure of energy performance, as defined by the organization	EnPIs could be expressed as a simple metric, ratio, or a more complex model[9]

EnPIs can be a simple parameter, a simple ratio, or a complex model. Examples of EnPIs can include energy consumption per time, energy consumption per unit of production, and multi-variable models. The organization can choose EnPIs that inform the energy performance of their operation and can update the EnPIs when business activities or baselines change that affect the relevance of the EnPIs, as applicable.

Energy performance indicator of a forging industry is represented as energy consumed per tonne of forged product (kWh/tonne), the indicator can be further divided to arrive at sub-process/equipment-wise EnPI such as metal heating (kgoe/tonne), air compressor (kW/cfm). The EnPI for any equipment varies depending on end application, usage pattern and several variable parameters.

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[8] Source: The Basics of Key Performance Indicators, https://www.thebalancecareers.com/key-performance-indicators-2275156

[9] Source: International Standard, ISO 50001 - Energy Management Systems - Requirements with guidance for use, 1st edition 2011-06-15

EnPIs can further be classified as direct or indirect. Direct EnPIs are the internal factors for comparison within an industry to come up with best practices and establish baselines. Indirect

3.3. *Energy consumption benchmarks for forging sector*

Forging industry is energy intensive and energy cost accounts for about 15–20 per cent of total production cost. The primary process steps in forging method are metal heating, forging and HT operations, machining, and finishing. Induction furnace and oil/gas fired furnaces are the two main metal heating furnaces used by forging. Metal heating accounts for 47-64% of the energy of the total energy consumed in the forging units. Forging and heat treatment operations consume 27-30% of the energy used by the forging industries. The remaining balance is used in auxiliary operations. Energy consumption of different processes across the different forging clusters is presented in figure below.

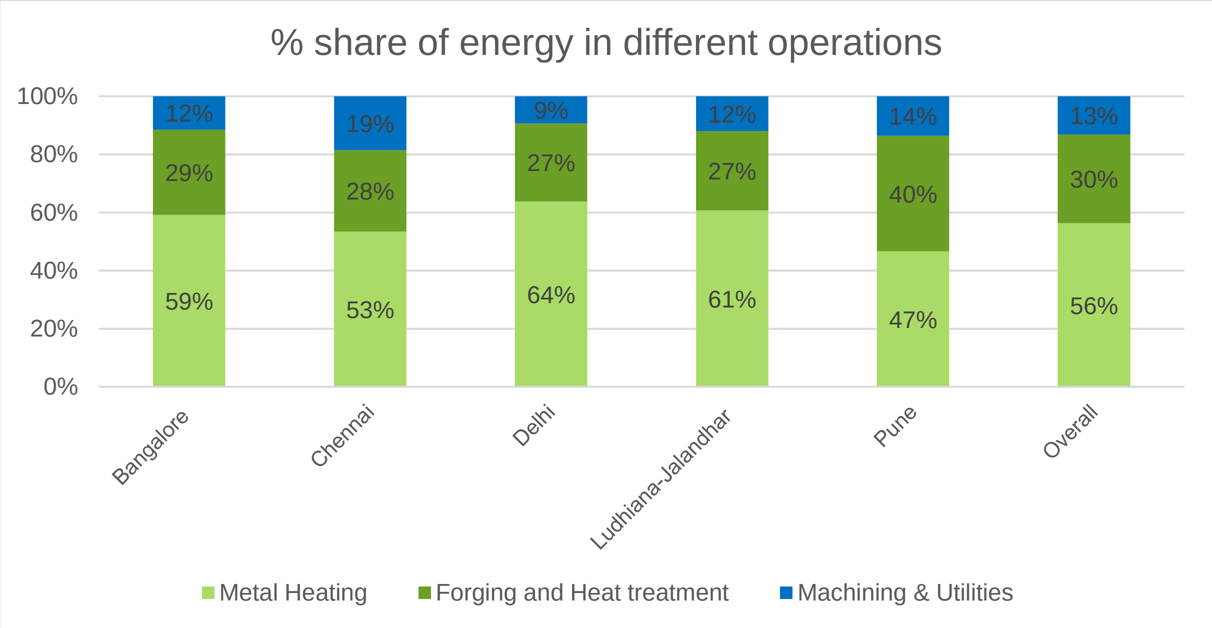


Figure 7: Share of energy uses in different forging processes

Furnaces and auxiliaries have a huge potential for energy conservation, around 10-35% of the energy can be saved - by selecting right type and size of equipment, maintaining the air fuel ratio, complete combustion, waste heat recovery, automation of processes, periodical maintenance, and by adopting best operational practices. In Indian forging context, some clusters are doing better than others. Within the clusters some forgings are doing better than others. They have identified and implemented energy efficient technologies and practices. Thus, there is need for benchmarking and energy mapping. This shall further improve the efficient and competitiveness of the Indian forging industry. SEC (kgoe/tonne of final product).

3.4. *SEC comparison across various clusters across India*

The specific energy consumption (SEC) of any forging varies considerably depending on the type of metal heating and allied forging operations and the degree of mechanization used.

Average SECs of forging in some of the prominent clusters are represented in the bar graph below.

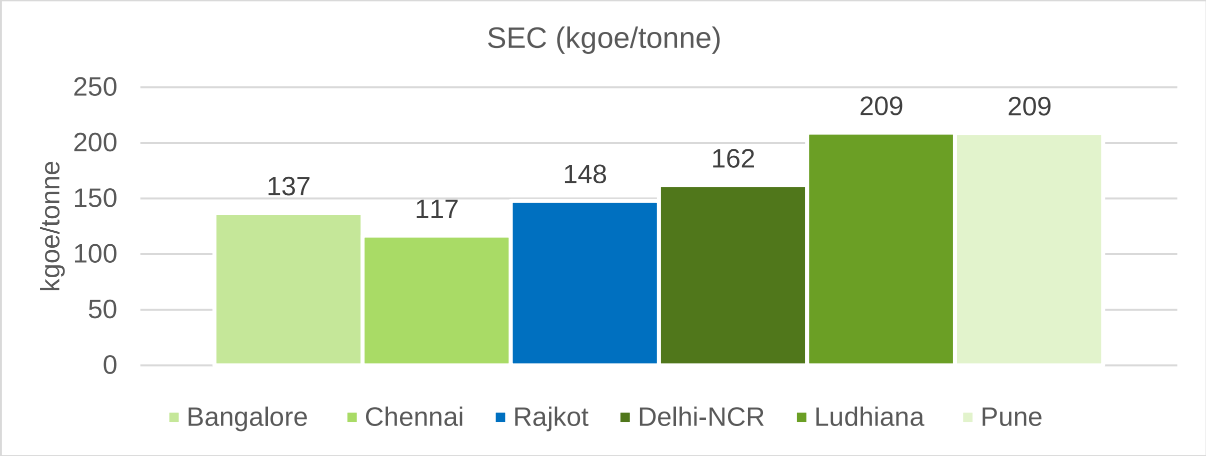


Figure 8: SEC benchmarks for different forging clusters across the country

SEC variation across the different clusters[10] based on the metal heating technologies is presented in Figure 9 and Figure 10

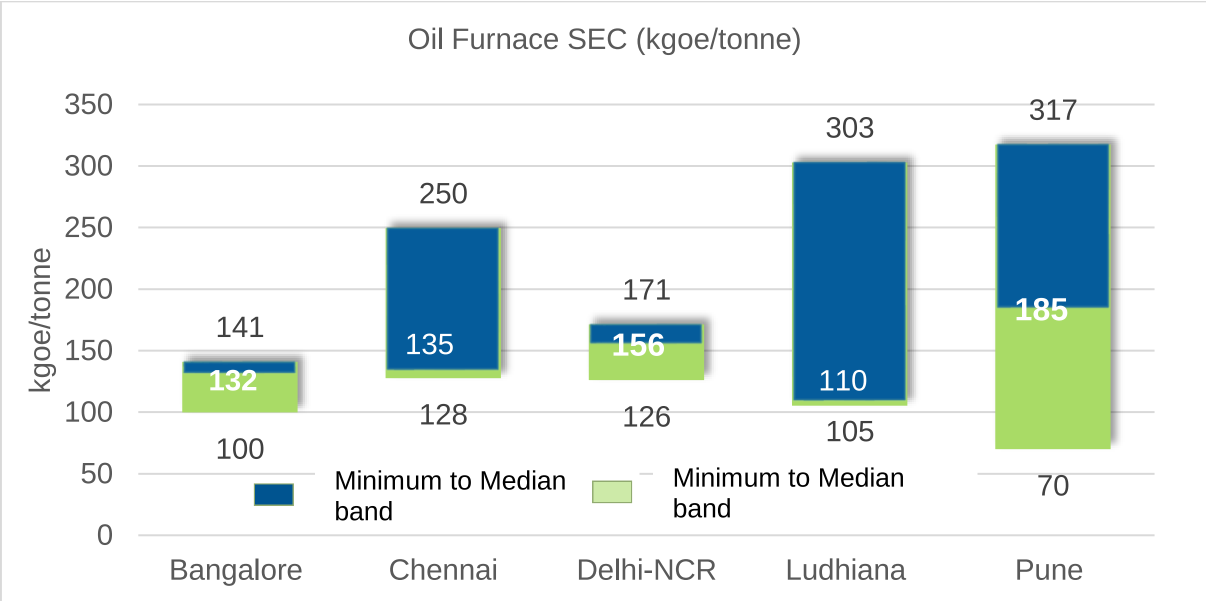
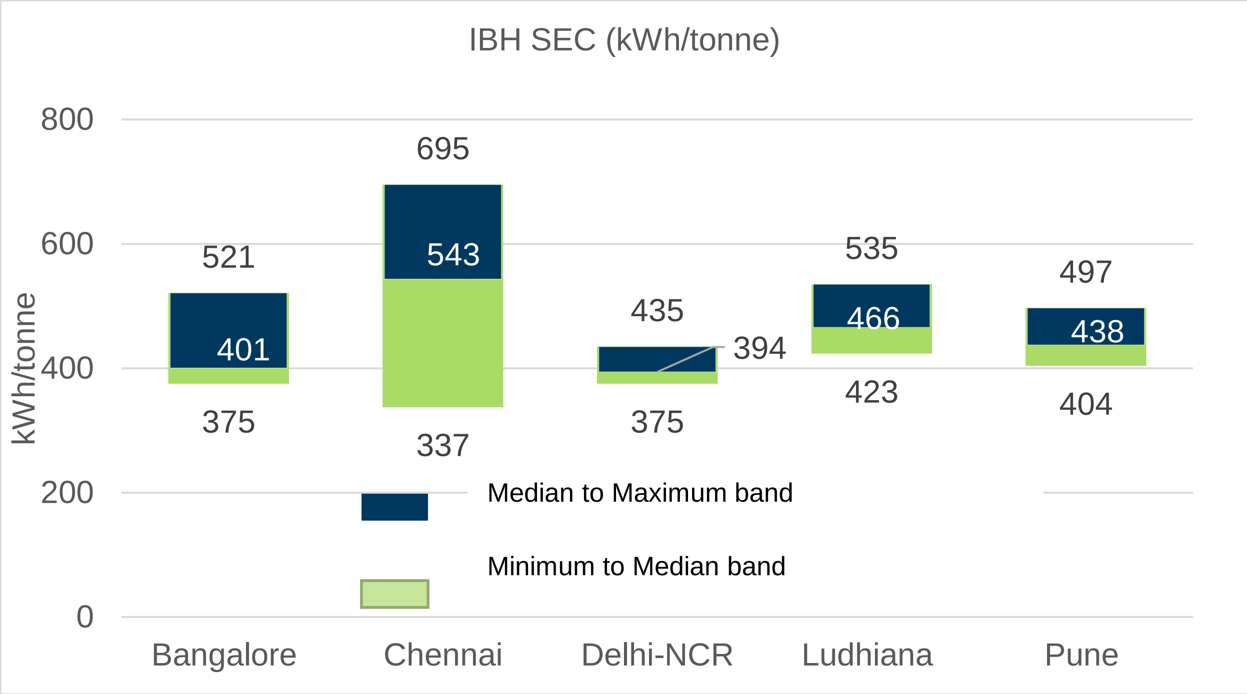


Figure 9: SEC for different forging units using oil /gas fired furnaces for metal heating

[10] Details are based on the energy audit and filed studies carried out under BEE energy and resources mapping assignment across different forging clusters



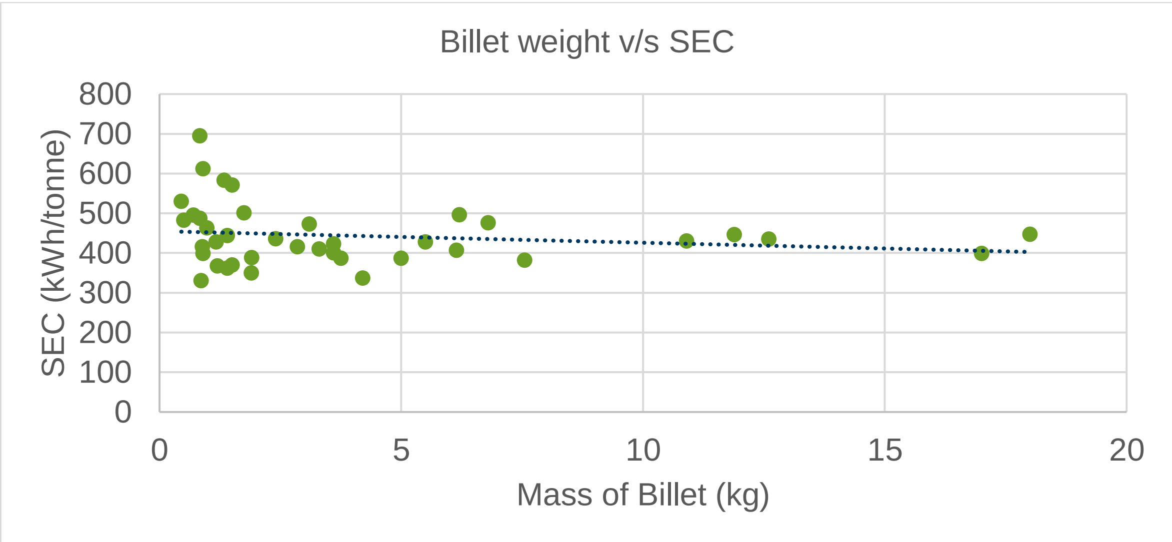


Figure 10: SEC for different forging units using the Induction billet haters technology

During the study correlation between the size of the billets and SEC was observed and the same is presented in the Figure 10. Forging units using the higher size coil to heat the billets are having the high SEC level. Most of the units processing the heavier billets using the adequate coil size have lower SECs. Thus, it is very crucial to follow the SOPs while using the IBH to have the optimized SECs levels. SEC of the induction billet heater marginally decreases with increase in the mass of the billet provided the unit had adopted the best operating practices.

To carry out the better comparison the SEC should be monitored on the basis on different type of the forging operations. Variation of the SEC for different forging operations is presented next.

Variation of the SEC for different forging processes by use of the different metal forming applications are presented in Figure 11.

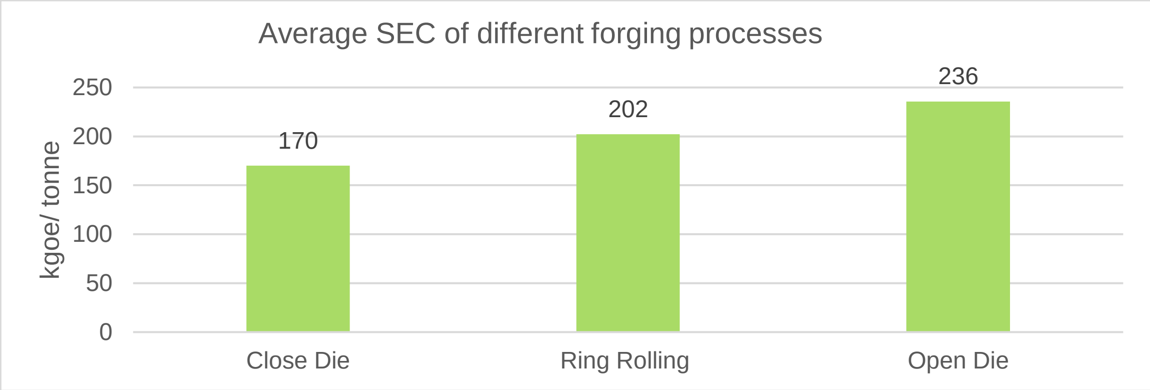


Figure 11: SEC of forging units based on different operations

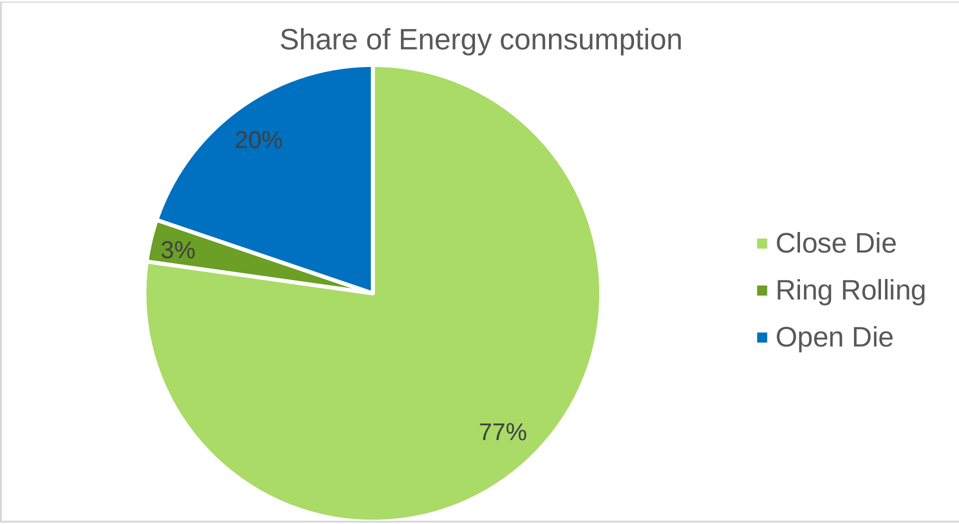


Figure 12: Share of the energy based upon the metal forming operations[11]

Variation in the SEC can be broadly classified in the four main parameters –

- ***Type of metal -reheating furnaces***
- ***Type of the forging operations***
- ***BOPs***

Details of each category mentioned above is presented in detail next-

- ***Type of metal re-heating furnaces***
- *Metal re-heating furnaces can be broadly categorized into two categories – Induction billet heaters (IBH) and oil/gas fired furnaces*
    - *Induction billet heaters* – metal is heated using the electrical energy in the IBH, use of this heating technology provides better control of the billet temperature and higher level of the automation is possible. Scale losses are lower in this technology as compared with other heating technologies
    - *Oil/Gas fired heating furnaces* – metal is heated using the oil/gas in the box type furnaces, use of this heating technology can be used to heat the large (less volume) / irregular size pieces (strips and specially cut work piece generally used in hand tool industry). Scale losses are slightly higher due to contact of the flame with metal, precise controlling of the metal temperature is very difficult, metal is generally over heated (10-30 degree) - leading to higher SEC.

[11] Based on the study carried out in the five forging clusters under BEE energy and Resource mapping assignment.

Most of the units in the Bangalore, Delhi -NCR produce the larger volumes of the high-end forging products – generally use the IBH for the close die forging applications. These clusters use the oil / gas fired heating technologies for the open die and ring forging applications.

- ***Type of forging operations***
  - ***Close die forging*** *is most widely adopted technology for metal forming across the different forging clusters.*
  - ***Open die forging*** *is most widely adopted for larger size forged products, mainly applicable for forming the forged parts for heavy machinery and oil& gas industry.*

Open die forging is mainly located in the Delhi-NCR, Bangalore clusters, fewer units are operational in other clusters.

  - ***Ring rolling*** *is most widely adopted to prepare the seamless rings for the oil & gas applications and valve industries.*

Ring rolling units are predominantly operational across the Bangalore forging cluster, fewer units are operational across the Phagwara forging cluster.

- ***Best operating practices and EE technologies*** *for the different processes used in forging units play is vital role in optimization of the energy consumption in the units. Summary of key BOP's and technologies is presented in Table 10*

Table 10: Summary of BoPs and EE technologies for different forging processes [12]

Particulars	Best	Major Area of Improvement Required to meet the Benchmark values	Best operating practices
Induction billet heater (kWh/tonne)	330	• Use of an IGBT based induction furnace. • Use temperature control for the controlling the hot billet temperature	• Use appropriate coil size for the job • Maintain the furnace surface temperature 70-90 ºC
Oil fired furnaces (kgoe / tonne) **Heat treatment furnaces**	70	• Maintaining proper air – fuel ratio to maintain the uniform temperature in furnace • Improving operating practices, Proper sizing of the blower (pressure and volume) • Installing waste heat recovery recuperator)	• Maintain the appropriate air fuel ratio • Liquid fuel – 1.15-1.20 • Gaseous fuel – 1.12-1.15 • Maintain the appropriate surface temperature • Ceiling – 110-120 ºC • Side wall – 85-100 ºC

[12] Elaborative details of ah technology and BOP is presented in technology compendium section

Particulars	Best	Major Area of Improvement Required to meet the Benchmark values	Best operating practices
			• Flue gas exit temperature – 250-300 ºC
Metal forming presses	NA	• Use of the VFD based presses for optimization power • Use of modern hydraulic hammers instead of pneumatic hammers	• Use of the adequate metal temperature required for metal de-forming operations and avoiding re-heating
Screw Air compressors (Pressure 7 bar)	0.15	• Use of IPM screw compressors • Technology shift to screw compressors with integrated control systems	• Optimizing the pressure drop in pipeline and arresting air leakages
Reciprocating Air compressors (Pressure 7 bar)	0.2		
Pump set (efficiency) up to 10 kW	80%	• Selection of adequate pump with appropriate flow and head, Proper maintenance	• Monitoring the water quality and operating parament's periodically
Motors and Drives	96%	• IE4/ Permanent Magnet, Replacement of rewound motor	• Avoid multiple time re-winding • Avoid installing higher capacity (rated than required) motors
Lighting	135	• Use of higher efficient Star rated LEDs, use of adequate lux level in different areas	• Use of the motion sensors and automatic switching of lights

4. Energy efficiency potential in forging sector

4. Energy Efficiency Potential in forging sector

Forging is one of the most energy intensive sectors, the majority of the energy is consumed in metal heating and allied operations depending upon the type of the forging operations. Metal re-heating contributes considerable share in the energy pie for the forging units, followed by the forging and heat treatment processes.

Energy saving potential is a function of the present efficiency levels, type of fuel used, energy efficiency measures applicable for different forging clusters, and readiness of the forging clusters in adopting the new state of art technologies. Details of the present fuel mix, penetration level of different technologies, EE potential for the different forging clusters and national level projections is presented in this section.

The Forging sector mainly uses oil and electricity for meeting the energy requirements. Gas is used as fuel in limited operations in limited clusters, oil/gas is used for HT in some clusters and used as fuel in DG for back power. Major application of the different fuels is presented next.

Electricity
- Metal heating - Induction billet heaters
- Forging hammers and presses
- Machining, shot blasting, air compressor, cooling towers

Oil
- Metal heating furances
- Heat treatment furacnes
- DG back up power

Gas
- Metal heating furnacs
- LPG is mainly used in heat treatment furnaces

During the BEE- *"Energy and resource mapping assignment"* detailed primary survey (EoI forms 200+) and secondary stakeholder consultations (250+), field visits (65+), energy audits (50), review of the past reports and interventions carried out across forging clusters, discussion with IA (12+) and technology providers - were carried out to evaluate the penetration level of different technologies and shar of the different fuels etc.

Summary of the cluster level and sector level findings based on the elaborative and extensive study is presented in section next.

4.1. *Energy consumption at cluster level*

Different forging industries use the mix of the conventional and modern metal heating technologies. Based on the different technologies and operations predominantly three forms of the energy are used by the sector i.e., electricity, coke, and gas. Share of the energy varies for the different forging clusters based upon the type of the technology and different operations catered during the formation of the final product.

During the BEE energy and resource mapping study, the share of the fuel mix for five forging clusters ***(Bangalore, Pune, Delhi-NCR, Chennai, Ludhiana)*** is calculated based on the energy audits and stakeholder consultations with industries and multiple industries associations in these clusters (physical meetings, workshops, webinars).

Findings for these clusters have been thoroughly discussed with prominent industry associations and industries through workshops / physical meetings and one-one interactions with multiple industries.

Five cluster level workshops were conducted across – Bangalore, Pune, Delhi-NCR, Chennai, Ludhiana forging clusters to validate the findings. Regional consultations across the prominent forging clusters (western region, northern region) were also conducted to validate the findings.

Summary of the different forms of energy used in different forging clusters is presented in Table 11 and share of the energy (toe) for different clusters is presented in Table 12.

Table 11: Fuel mix for the different forging clusters (five clusters)

Energy type	Unit	Bangalore	Pune	Delhi-NCR	Chennai	Ludhiana	Overall
Electricity	million kWh	40	155	172	98	645	1798
Gas	tonnes	715	6527	22586		6	29834
Oil	tonnes	10904	12813	3334	2619	51912	81582

*Table 12: Energy share of different fuels in five forging clusters (Units - **toe**)*[13]

Energy type	Bangalore	Pune	Delhi-NCR	Chennai	Ludhiana	Overall
Electricity	3,465	13,344	14,761	8,403	55,445	95,419
Gas	822	14,695	25,943	-	7,232	48,692
Oil	11,740	13,495	3,500	2,777	55,127	86,639
Total	16,027	41,534	44,205	11,180	117,804	230,750

[13] Appropriate GCV values of the different fuel based upon the discussion with Industries review of the GCV reports at different audited units, across different clusters have been used to convert the different form of fuel to oil equivalent units.

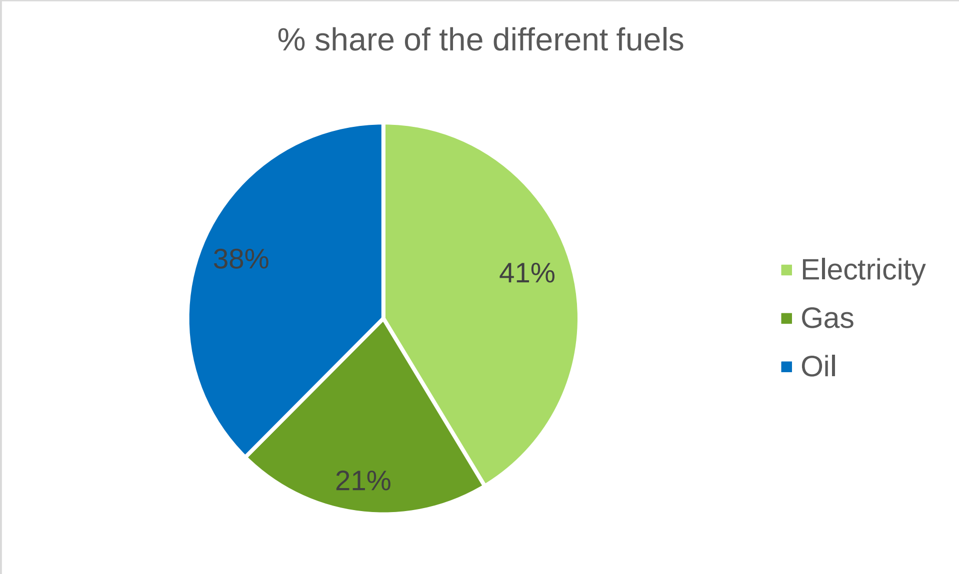


Figure 13: Energy share of different fuels across five clusters

Electricity is the prominent fuel in the five forging clusters (*Bangalore, Ludhiana, Delhi, Pune, Chennai)* accounts for around 35% of total energy demand in these clusters. Oil is the second largest used fuel in these clusters and contributes 38% to energy pie. Gas contributes to around 21% share in these clusters. *However, the gas is predominantly used in Delhi forging clusters for metal re-heating and mainly for heat treatment applications in Pune, Bangalore clusters. Units in Ludhiana – Jalandhar cluster and fewer units in Hosur use LPG cylinders for the HT processes.*

4.1.1. *Prominent metal heating technologies adopted in forging*

Different technologies are used in different forging clusters. *Summary of the technology level penetrations is carried out on the basis of the primary survey, field visits, energy studies and stakeholder consultations across different forging clusters.*

Summary of the predominant metal heating technologies (Induction heating furnace and Oil/Gas fired furnaces) adopted among the different forging clusters is presented Figure 14..

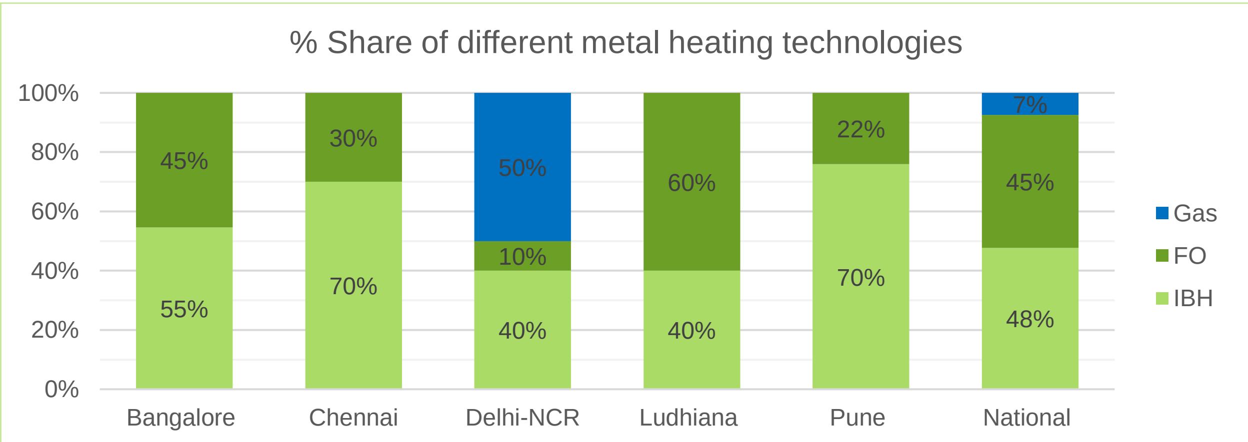


Figure 14: Share of the prominent metal heating technologies during FY 21-22

Oil fired metal heating furnaces is predominately used to heat the metal for the forging operations. Conventional box type furnaces are predominantly used across different clusters (*Ludhiana Jalandhar Bangalore)* which use higher energy per tonne of molten metal. Bangalore forging units carrying out open die operations (larger work pieces use the oil firs heating furnaces). Units in Delhi use the special low Sulphur oil for the metal heating.

Gas fired furnaces are predominately used to heat the metal for the forging operations in Delhi NCR region. Other clusters use the gas for the heat treatment furnaces. There is limited adoption of these furnaces due to lack of the proper gas pipeline across different forging clusters.

Induction billet heater (IBH) is predominantly used for billet heating from (30-300 mm). IBH is modern technology that help the forging units to heat the metal with precise temperature control and lower loss of the metal in the form of scale. *IBH is predominantly used in across the Pune Delhi, Bangalore, Chennai clusters.*

4.1.2. *Sector level production details and SEC*

Production data for the different grade of metal taken from the national level forging association (AIFI). Based upon the historical production data CAGR is calculated and CAGR growth is used to project the future production levels. SEC data for the forging is calculated from the multiple energy audits carried out under the BEE energy and resource mapping assignment, SEC data has been validated thought multiple consultations carried out different forging cluster. Details of the present level production, SEC are presented in Figure 15.

Table 13: Production data for the FY 22

Metal heating technology	Mn tonnes	SEC (toe/tonne)
Induction heating	1.90	0.165
Gas fired furnaces	0.22	0.183
Oil fired furnaces	0.59	0.185
	2.71	

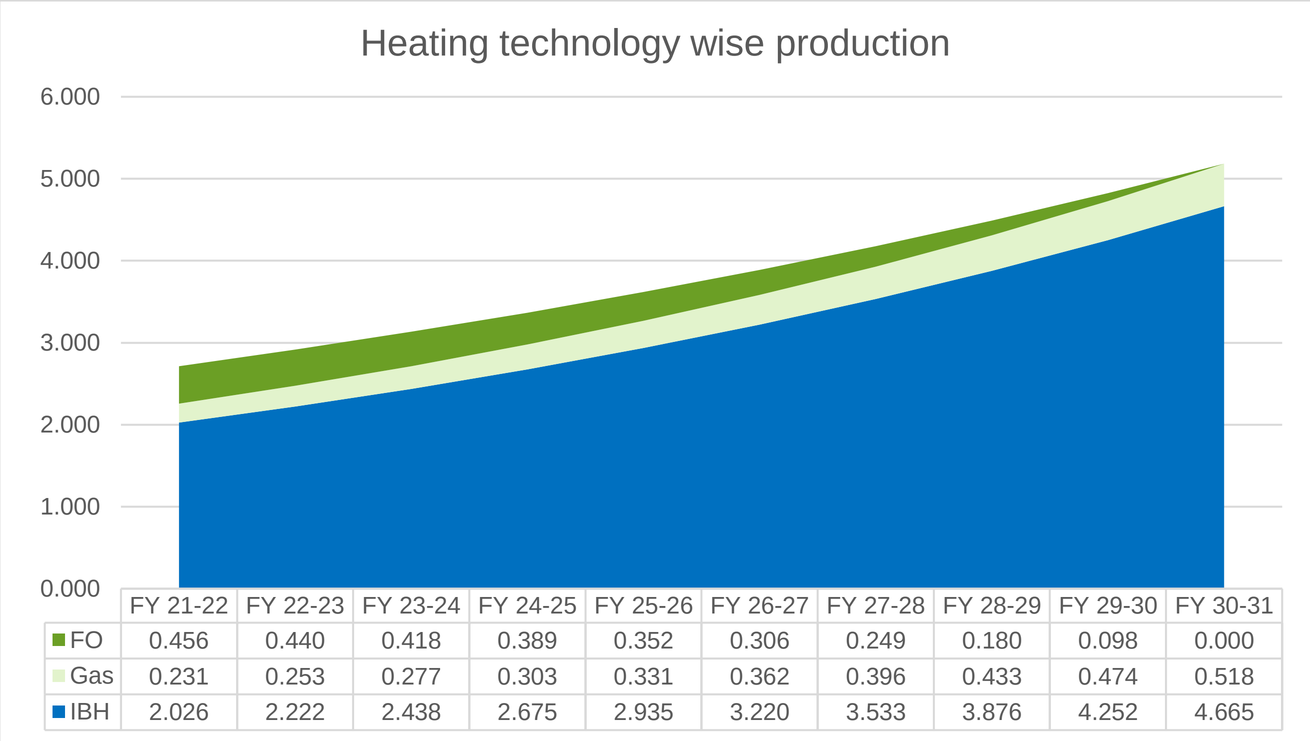


Figure 15: Share of production of based on heating technologies

4.1.3. *Sector level energy consumption*

Benchmark SEC data for the different metal and type of operations in forging validated through multiple consultations is used for calculating the sector level energy consumption data. Energy consumption for different types of metal heating technologies is calculated by product of the SEC data and production volumes. Summary of the sector level energy consumption for different metals is presented in Table 14.

Table 14: Sector level energy consumption of the different metal and metal heating technology (FY 22)

Metal heating technology	Mn toe
Induction heating	0.31
Gas fired furnaces	0.04
Oil fired furnaces	0.11
Total	***0.46***

4.2. *Projections of energy saving potential and electrical energy requirement*

In order to evaluate the energy saving potential at the sector level, mapping of energy efficiency technologies, state of art technologies, EE technologies for utilities is required along with energy saving potential.

Mapping of the technologies for the different forging clusters were done through field studies, primarily survey, discussion with IA and technology vendors. Long list of the technologies was mapped during multiple tasks and activities under BEE energy and resource mapping study.

Replication potential for different technologies in short term and long term is evaluated in closed consultations with multiple stakeholders across different *leading forging clusters* – **Rajkot-Shapar Veraval forging** cluster, **Jalandhar-Phagwara forging** cluster, **Ludhiana** forging cluster, **Bangalore forging** cluster, **Chennai** forging cluster, **Pune forging** cluster, **Delhi -NCR** and **nearby forging clusters**.

***Over 280+ forging units[14] and 12+ industry association**s (including regional chapters of AIFI regional cluster level associations) were consulted to fine tune the recommendations of different technologies and repletion potential.* Summary of different energy efficient and state of art technologies is presented in Table 15 and Table 16..

[14] Including the post audit workshop and cross cluster consultations

Potential of technology penetration levels across

Table 15: Process specific replication potential of ECM across forging clusters

Sr. No.	Technologies	Energy savings potential	Replication Potential in short-term (till 2025)			Replication Potential in long-term (till 2030)		
			Micro	**Small**	**Medium**	**Micro**	**Small**	**Medium**
1.	New generation IBH with IGBT control along with IoT based alerts and automation	10-30%	High	Medium	Saturation	Saturation	Saturation	Saturation
2.	Use of modern pneumatic clutch all electric presses with VFD for forging	5%	Low	Medium	Medium	High	High	Saturation
3.	Fuel switch in Oil- NG	5-10%	Low	High	High	Saturation	Saturation	Saturation
4.	Relining of furnaces / Insulation	5-10%	High	High	Saturation	Saturation	Saturation	Saturation
5.	Electrically operated Heat treatment / Annealing / Normalization furnaces	20-30%	Low	High	Saturation	High	Saturation	Saturation
6.	Automatic continuous lines	10-20%			Low		Low	Low
7.	Multi axis Machining centre (5 / 6 Axis with automatic tool changer)	5-10%	Low	Medium	High	Medium	Saturation	Saturation
8.	IoT based EMS	2-5%	Low	Medium	Medium	Medium	Saturation	Saturation
State of Art [15]								
9.	Flash less forging	5-10%		Low	High	Low	High	Saturation
10.	Installation of robotic automation in forging lines (Hammers and Presses)	3-5%		Low	Low	Low	High	Saturation
11.	Automatic continuous lines	10-20%			Low		Low	Low

[15] Productivity grain due to state of art technologies is not presented in this table

Utility specific Energy conservation measures

Table 16: Utility specific replication potential of ECM across forging clusters

S. No	Technologies	Energy savings potential	Replication Potential in short-term (till 2025)			Replication Potential in long-term (till 2030)		
			Micro	Small	Medium	Micro	Small	Medium
1	IE3/IE4 motors	5-15%	Low	Low	Medium	High	High	Saturation
2	EE FRP Cooling towers with temperature control and VFD / Fan less Natural draft FRP based cooling tower	5-10%	Low	Medium	Medium	High	High	Saturation
3	Appropriate size of air compressor / Arresting air leakage and pressure optimization	10-30%	Medium	Medium	Low	High	High	Saturation
4	PM Screw Compressor with waste heat recovery	20-30%		Medium	High	High	Saturation	Saturation
5	Heat Pump	10-30%			Low			High
6	Use of EE Hydraulic power pack (with Servo drive) for Clamping application	20-40%	Low	Low	High	Medium	Saturation	Saturation
7	EE retrofit of low friction metallic pipe for compressed air system	10-30%	Low	Medium	Saturation	High	Saturation	Saturation
8	Energy Efficient Transformers	20-50%	High	Medium	Saturation	Saturation	Saturation	Saturation
9	EE Air conditioner / Chillers	10-25%	Low	Saturation	Saturation	Saturation	Saturation	Saturation
10	Automatic Power factor Controller	5-10%	Medium	Medium	Saturation	Saturation	Saturation	Saturation
11	Energy Efficient Blower	20-30%	Medium	Low		High		
12	Energy Efficient Pumps	20-30%	Medium	Saturation	Saturation	High	Saturation	Saturation
13	LED lights	10-50%	Saturation	Saturation	Saturation	Saturation	Saturation	Saturation

Implementation of the energy saving, and state of art technologies will help in reduction of the energy intensity in the long run. This will help the forging units to become more efficient and competitive globally Summary of the energy saving potential for the different metal heating technologies is presented in Table 17

Table 17: Summary of the energy saving potential for different metal

Metal	Energy Saving potential (%)	Energy consumption ('000 toe) FY 21-22	Energy consumption BAU ('000 toe) FY 30-31	Estimated energy saving (Mn toe) FY 30-31
IBH*	-*	314	599	-*
Gas	2%	39	76	1
FO	100%	100	192	192
Total	***22%***	**455**	**867**	**193**

**Projected that in long run All FO will be converted to Gas / IBH cleaner technology, thus saving of IBH is balanced off with additional power requirement for the new IBH, Net saving of 190 thousand toe will occur for FO*

Projections of the different scenarios on account of the multiple interventions proposed for the sector are presented in Figure 16. Proposed sector level SEC after implementation of EE and state of art technologies in the long run till FY-2031 is presented in Table 18.

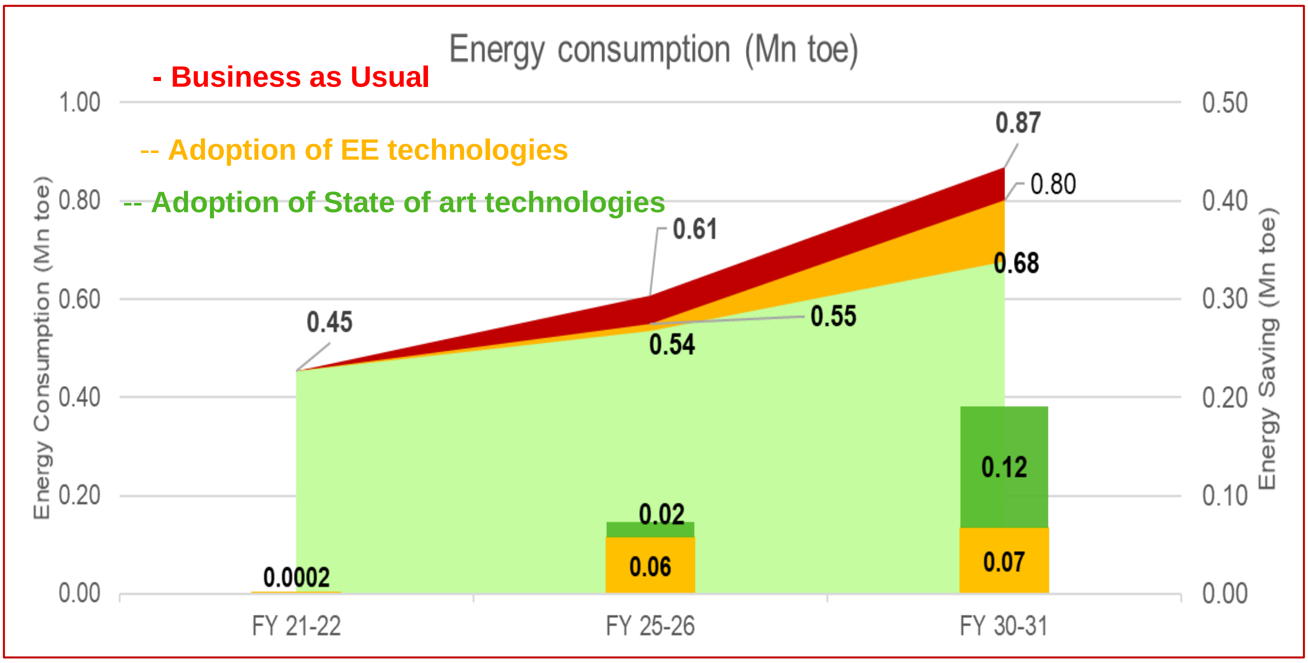


Figure 16: Projections of energy consumption and savings

Table 18: Proposed long term Sector level SEC (kgoe/tonne)

Overall sector level SEC	FY 21-22	FY 25-26	FY 30-31
Due implementation of EE measures	171	153	153
Due implementation of State of art and EE measures	171	149	130

Proposed recommendations will help units in the forging sector to transit from conventional technologies to newer cleaner technologies for the production. Based on the consultations and penetration level of the EE, state of technologies and other cross cutting technologies will lead to change in the fuel mix for the sector. Projected fuel mix for the forging sector is presented in Figure 17.

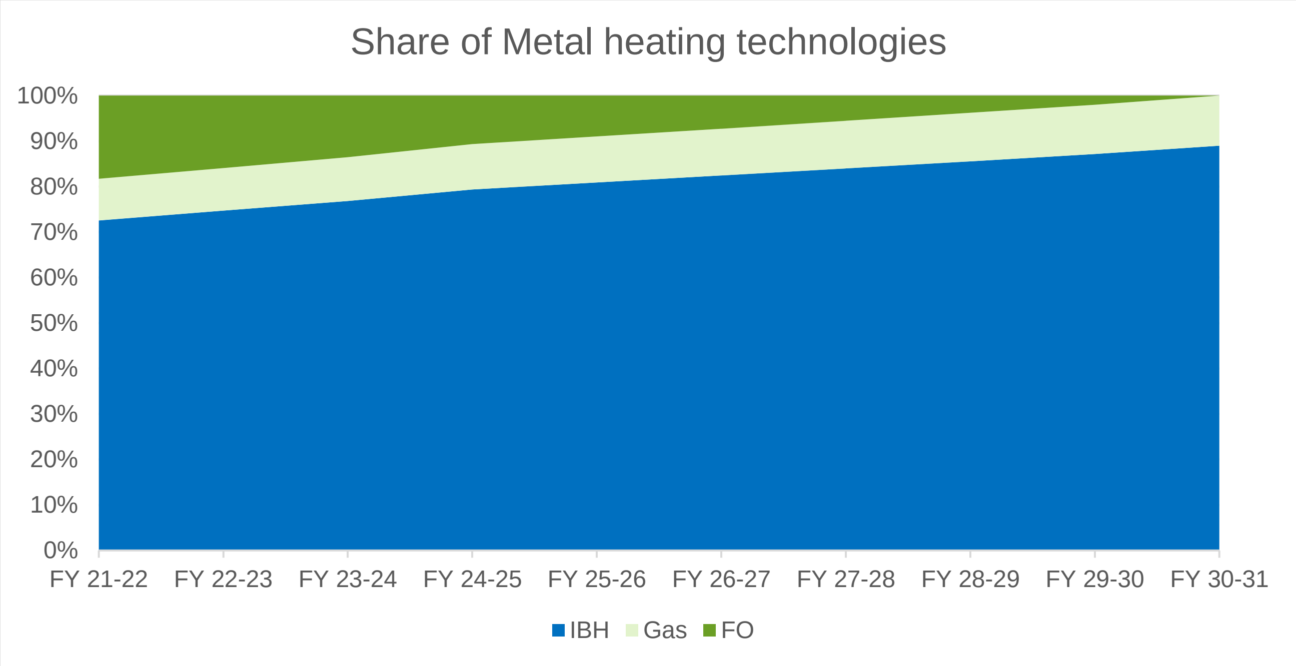


Figure 17: Projected share of metal heating technologies

Wider adoption of the IBH technology for the billet hating will eliminate the use of the inefficient FO fired box furnaces. Use of the energy conservation measures will support the forging sector to lower the SEC level and reduce the carbon intensity of the sector.

Adoption of the new technologies will help the forging sector, during the transition to cleaner energy usage in the long run. Projections carried out on the basis of adoption of new state of art technologies, advanced energy efficient technologies will help the forging sector to reduce the carbon intensity in long run.

The share of electricity (cleaner fuel technology) is expected to grow up to 89% during 2030-31 from 72.6% during FY 22. Share of the fossil fuels (Oil) is expected to drop to almost 0% during 2030-31 from 19% during FY 22.

4.2.1. *Emission reduction and additional power requirement*

Adoption of the new technologies such as IBH and other state of art technologies will help the sector to reduce the carbon emissions and dependance on the oil in the long run. With use of the IBH for the billet heating and gas and electrical furnaces will help the complete elimination of the use of the furnace oil in the sector. With the change of the technology and adoption of the energy conservation and state of art technologies the sector will help in lowing the carbon emission. Details of the emission reduction with respect to the base year (2021) with BAU scenario is presented in Table 19.

Table 19: Fuel consumption and Emissions proposed and BAU

Year		2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Fuel Consumption and Emissions – BAU											
Electricity	Mn toe	0.32	0.34	0.37	0.40	0.43	0.46	0.49	0.52	0.56	0.60
Gas	Mn toe	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.08
Furnace oil	Mn toe	0.10	0.11	0.12	0.12	0.13	0.14	0.15	0.16	0.18	0.19

Total	Mn toe	0.46	0.50	0.53	0.57	0.61	0.66	0.70	0.75	0.81	0.87
Emissions	Mn tonne of CO_2	3.40	3.56	3.72	3.89	4.06	4.24	4.42	4.60	4.79	5.13
Proposed Fuel Consumption and Emissions											
Electricity	Mn toe	0.31	0.34	0.38	0.41	0.41	0.45	0.49	0.53	0.57	0.62
Gas	Mn toe	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.07
Furnace oil	Mn toe	0.09	0.08	0.07	0.06	0.05	0.04	0.04	0.03	0.01	0.00
Total	Mn toe	0.43	0.46	0.50	0.52	0.51	0.54	0.58	0.62	0.66	0.69
Emissions	Mn tonne of CO_2	3.22	3.44	3.70	3.81	3.69	3.88	4.07	4.25	4.42	4.72

Adoption of the new technologies will help in the reduction of the 0.18 Mtoe during the FY 31. Change in the fuel mix will help in the reduction of the emission level from 5.13 Mn tonne of CO_2 (BAU FY2031) to 4.72 Mn tonne of CO_2 ; these interventions will help the sector to reduce over 0.47 Mn tonne of CO_2 emission during FY 2031. These transformations and adoption of new technologies will also help the forging sector to reduce the SEC level by over 20%.

During the transformation phase additional power will be required to support the technology transform from conventional furnace to the modern IBH. During the course adoption of the technologies as described in the section above will help the sector to reduce the energy requirement; also due to the transition from oil fired to gas fired and electrical technologies will increase the electrical energy requirement to meet the transition toward low carbon economy.

Forging sector will require additional[16] **30 MW** of power (over and above the BAU scenario) during FY 2031 to support the technology transition phase. Considering the technology penetration levels of 60% and 80% the additional power required by the sector during FY2031 will be 18-24 MW. Details of the cluster level additional electricity requirement is presented next.

Delhi forging cluster uses the mix of the modern IBH, Gas fired furnaces and oil-fired furnaces for heating applications. The forging cluster has a largest gas pipeline network; gas is used by units for heating applications, where the gas pipe is available. Share of the cleaner fuels in the cluster (gas and electricity) is around 92% for the forging units in this cluster. Fewer units still use the conventional oil-fired furnaces (open die forging); gradually these units will switch to cleaner fuels like gas or electricity. Units will adopt the gas fired furnaces which are producing larger forgings (open die / ring rolling) and other units which carry out the smaller forging (close die forging) will adopt IBH in the long run. Considering the scenario and discussion with multiple stakeholders during the BEE energy mapping study, it is projected that additional electricity requirement for the cluster till 2031 over and above BAU scenario (after adopting EE measures) will be in range of 1-2 MW.

Ludhiana forging cluster uses the mix of the modern IBH, Gas fired furnaces and inefficient conventional oil-fired furnaces for heating applications. Share of the cleaner fuels in the cluster (Gas and electricity) is around 53% for the forging units in this cluster. Conventional oil-fired furnaces are still predominantly used for heating applications (metal heating and heat treatment) in several units; gradually these units will switch to cleaner fuels like gas or electricity. Units are willing to opt for the gas fired heat treatment applications eventually once gas is available in the cluster (Gas pipeline work is under progress in the cluster). Considering the projected scenario and discussion with multiple stakeholders during the BEE energy mapping study, it is projected

[16] Power required is calculated based on the additional power required by the sector considering the present production CAGR levels and average annual operation of 5400 hours by the forging units across different scales.

that additional electricity requirement for the cluster till 2031 over and above BAU scenario (after adopting EE measures) will be in range of 10-15 MW.

Bangalore forging cluster uses modern IBH and Conventional oil-fired furnaces for heating applications, very fewer units use the gas fired furnaces for heat treatment. Share of the cleaner fuels (Gas and electricity) is around 27% for the forging units in this cluster. Most of the units in the cluster are doing open die / ring rolling operations and preparing the heavy and larger forging products. These units will eventually shift to the gas fired operations in the long run. Units in the cluster which are carrying out the smaller forging and close die forging have already been using the modern IBH with best operating practices. Hence considering the viability of the gas fired is higher as compared with IBH for the open die and ring rolling operations, larger units will adopt the electrical heat treatment furnaces in the long run. It is projected that additional electricity requirement for the cluster till 2031 over and above BAU scenario (after adopting EE measures) will be in range of 1-2 MW.

Chennai forging cluster uses modern IBH (small and medium scale units) and old conventional oil-fired furnaces (micro and small-scale units) for heating applications. Share of the cleaner fuels (electricity) is around 76% for the forging units, which is predominantly used by medium scale forging units. Most of the units in the cluster are performing close die operations and very few units are carrying out open die for preparing the heavy and larger forging products. Oil is also used across units of different scale for heat treatment applications. Smaller units in the cluster will eventually shift to the IBH / gas fired furnaces operations in the long run. Considering the projected scenario and discussion with multiple stakeholders during the BEE energy mapping study, it is projected that additional electricity requirement for the cluster till 2031 over and above BAU scenario (after adopting EE measures) will be in range of 1-2 MW.

Pune forging cluster uses the mix of the modern IBH, Gas fired furnaces and Conventional oil-fired furnaces for heating applications. Share of the cleaner fuels (Gas and electricity) is around 67% for the forging units in this cluster. Conventional oil-fired furnaces are still used for heating applications (metal heating and heat treatment) by the smaller units and units performing open die operations; gradually these units will switch to cleaner fuels like gas or electricity. Units are willing to opt for the gas fired heat treatment applications eventually once gas is available in the cluster, hence gas pipeline strengthening is required across different parts of the industrial estate. Considering the projected scenario and discussion with multiple stakeholders during the BEE energy mapping study, it is projected that additional electricity requirement for the cluster till 2031 over and above BAU scenario (after adopting EE measures) will be in range of 2-3 MW.

Cluster level summary for additional electricity requirement over and above BAU scenario during 2031 is presented next.

Table 20: Additional electricity for technology transition (over and above BAU scenario)

Cluster Name	No. of FO Furnaces	No. of Induction Billet Heater	Penetration of IBH (%) (present)	Electricity consumption (Million units)	~ Additional Electricity requirement (MW)*		
					60%	80%	100%
Ludhiana	110-120	130-150	40%	645	9	12	15
Bangalore	15-20	30-35	55%	40	1.2	1.6	2
Pune	25-30	90-105	70%	155	1.8	2.4	3
Chennai	10-15	30-35	70%	98	1.2	1.6	2
Delhi	60-65	40-45	40%	172	1.2	1.6	2

**Proposed values represent the additional electricity requirement in the cluster over and above BAU scenario during 2031. Also, the units in the cluster have adopted the proposed EE & State of art* *recommendations. Units in different clusters will also adopt cleaner heating though NG and Hydrogen for metal heating and HT in long run.*

Additionally, technical and financial barriers along with regulatory support required for the transition, and a detailed road map along with recommendations required to achieve the projections are presented in the next section.

5. Recommendations and Implementation Plan

5. Recommendations and Implementation Plan

Indian MSME forging units need to become more energy efficient to increase their competitiveness and maintain profits, however forging units face following challenges in adoption of EE technologies.

We have segregated those challenges and barriers mainly in 3 categories viz. **a) technical** (covers mainly lack of awareness and capacity building), **b) financial** (covers lack of financial capacities such as weaker balance sheets of MSMEs), and **c) regulatory** (covers mainly lack of support infrastructure and skills). In addition to this, we have highlighted barriers which are pertinent to MSMEs due to their small scale, unpredictability in demand, and their dispersion across clusters.

5.1.1. *Technical barriers*

The use of outdated and outmoded technologies is a major challenge in the MSME forging sector. Limited availability and weak linkages with suppliers, and low levels of knowledge on modern technologies are the main reasons for lack of technology up gradation in the sector. Indian forging MSME units need to become more energy efficient to increase their competitiveness and maintain profits, however forging units face following technical barriers in adoption of EE technologies.

- Lack of consistent data on energy consumption and energy savings due to limited scope for energy monitoring
- Inability to understand the complexities of the EE project i.e., baseline, adjustments to baseline, energy performance contracting, M&V procedures, realization of savings etc.
- Fear of underperformance as well as disruption of routine manufacturing cycle due to troubleshooting and change in plant load factors
- Lack of awareness on available EE technologies & limited capacities to evaluate cost-benefit of EE technologies
- Limited access to energy auditors with sound technical knowledge and non-availability testing facilities
- Lack of confidence in modern state-of-art technologies due to higher investment cost
- Force of habits resist any change in routine operating practices and lack of training on importance and necessity of energy conservation
- Limited outreach to technology suppliers of EE technologies and ESCOs

5.1.2. *Financial barriers*

Implementation of potential energy conservation measures requires investments, either marginal or substantial in order to realize energy savings. Energy efficiency generally perceived as a secondary aspect when compared to the core business activity or is only considered when it directly links to increase in production/output. This perception is also brought on by lack of awareness about EE.

5.1.2.1. *MSME specific barriers in EE financing:*

- High upfront cost of EE technologies. Host entity (MSME) usually doesn't use internal funds for EE project financing

- Rigid lending policies of banks; there are limited FI's (banks, NBFCs) extending credit to pure EE projects and on merits of project cash flow
- Limited access to capital due to weak balance sheets of MSMEs and requirement for collateral
- The process of availing benefits and subsidy from EE schemes is complex and it takes considerable time to receive the subsidy
- Reluctance to undertake energy study in their unit and bear the energy auditing cost

5.1.2.2. *Financial institutes (Banks, NBFCs) specific barriers:*

Energy efficiency investments usually do not generate additional tangible revenues, but rather contribute to the earnings through a reduction in energy expenditures. This can make it difficult for banks to identify and capture cash flows from such projects and treat energy savings as assets of sufficient market value to justify a loan, despite the overall benefits which will accrue if implemented.

- Concept of EE is still very complex to FIs due to lack of standard project assessment tool, and most FIs show reluctance to develop technical capacities to evaluate projects
- EE projects are considered high risk projects with associated risks like technical risk, performance risk, hence FIs have low confidence in the estimated energy savings
- Relatively small ticket size & high transaction cost of EE projects and FIs instead prefer large investing into large capacity expansion projects
- Limited investment potential for EE at cluster/ sector level as compared to overall MSME portfolio; FIs cater already very large portfolio for MSMEs through WC and business loans
- Lower resale value of assets in energy efficiency project

5.1.3. *Regulatory and infrastructure related barriers:*

In addition to technical and financial barriers lack of supporting infrastructure and regulatory interventions also limit the uptake of EE interventions in MSME clusters.

- Though MSMEs fall under the priority lending category, EE does not fall under priority sector lending unlike to RE as per RBI guidelines; hence benefits of low interest rates cannot be transferred due to high-risk factor associated with EE technology and performance risks
- Lack of supporting infrastructure for EE upgradation such as difficulties in getting clearances for HT connection (implementing induction billet heating)
- Lack of incentives to adopt cleaner fuels such as non-availability of Natural gas pipelines in some clusters and stringent policies for net metering
- Change in government regulation/policy related to pollution, and taxes and duties can affect the viability of the unit
- Non-existence of skilling infrastructure to meet the ever-changing technology & processes

5.1.4. *Miscellaneous*

The above challenges have beleaguered the energy efficiency sector and limited its uptake. Now further when we look specifically at the MSME sector we see that it has its own challenges which has immensely restricted energy efficiency improvement in MSMEs even though there is a high potential.

- Unpredictability of future business due to global economic downturn, which may adversely affect manufacturing activities in end user sectors of forged products
- MSMEs are spread across in small clusters hence catering to them is itself a difficult task for both technology and capacity building activities
- Low awareness on various schemes of Govt. of India related to energy conservation
- High cost of production due to increase in fuel prices and non-reliable supply of fuels
- Lack of transparency in financial reporting, and unconventional business practices of MSMEs also hinder their capacities to avail benefits of EE schemes
- It is a low priority segment services than large industrial plant due to perceived notion about expected lower scale of business.
- Low priority segment for EE technology suppliers and financial institutes due to smaller ticket size of EE loans and high transaction costs

5.1.5. *SWOT Analysis*

Lower productivity, ever rising fuel prices and rising cost of statutory compliances have become major hurdles for the MSMEs. A SWOT (Strength, Weakness, Opportunity, and Threat) analysis of Indian forging sector is provided below.

Strengths	**Weaknesses**
• Steady domestic demands in the sector • Key role played by active industry association i.e., AIFI, CICU in technology adoption • Availability of technology suppliers of EETs • Forward looking outlook of entrepreneurs	• Lack of information on international customers' expectations • Lower productivity & high manufacturing costs • Use of outmoded and conventional technology • Limited funds for technology upgradations
Opportunities	**Threats**
• Potential for adoption of EE technologies automation and state-of-art technologies • Govt. thrust on auto & manufacturing sector • Increase in domestic and export demand in near-by future post-covid situation	• Severely impacted by cyclical market trends • Non-availability of skilled manpower • Increase in global competition such as China • Increase in energy costs and rising cost of statuary compliances

5.2. *Proposed Interventions:*

Forging sector in India offers immense potential for energy savings through technology upgradation, EE retrofits and adoption of operating practices. However, given the current levels of EE technology penetration and the overall health of the MSME sector, there is a need of innovative measures and policy interventions to increase the adoption of EE solutions in forging MSMEs.

We have organized multiples stakeholder consultations with an aim of building consensus on the outcomes and to seek inputs from a diverse set of stakeholders for drafting the recommendations. This study provides a very useful service by putting together the experiences from the diverse set of stakeholders and discussing identified interventions and their appropriateness & relevance.

This policy roadmap takes into consideration the current situation when the forging industry is still grappling with challenges due to the ongoing pandemic and challenging global competition. This is a time when incentives can play a more significant role; a time when policymakers have the opportunity to place conditions on grants and funding, which could include implementation of EE technologies, achieving benchmarks for EE while supporting technology and process improvements, and so on.

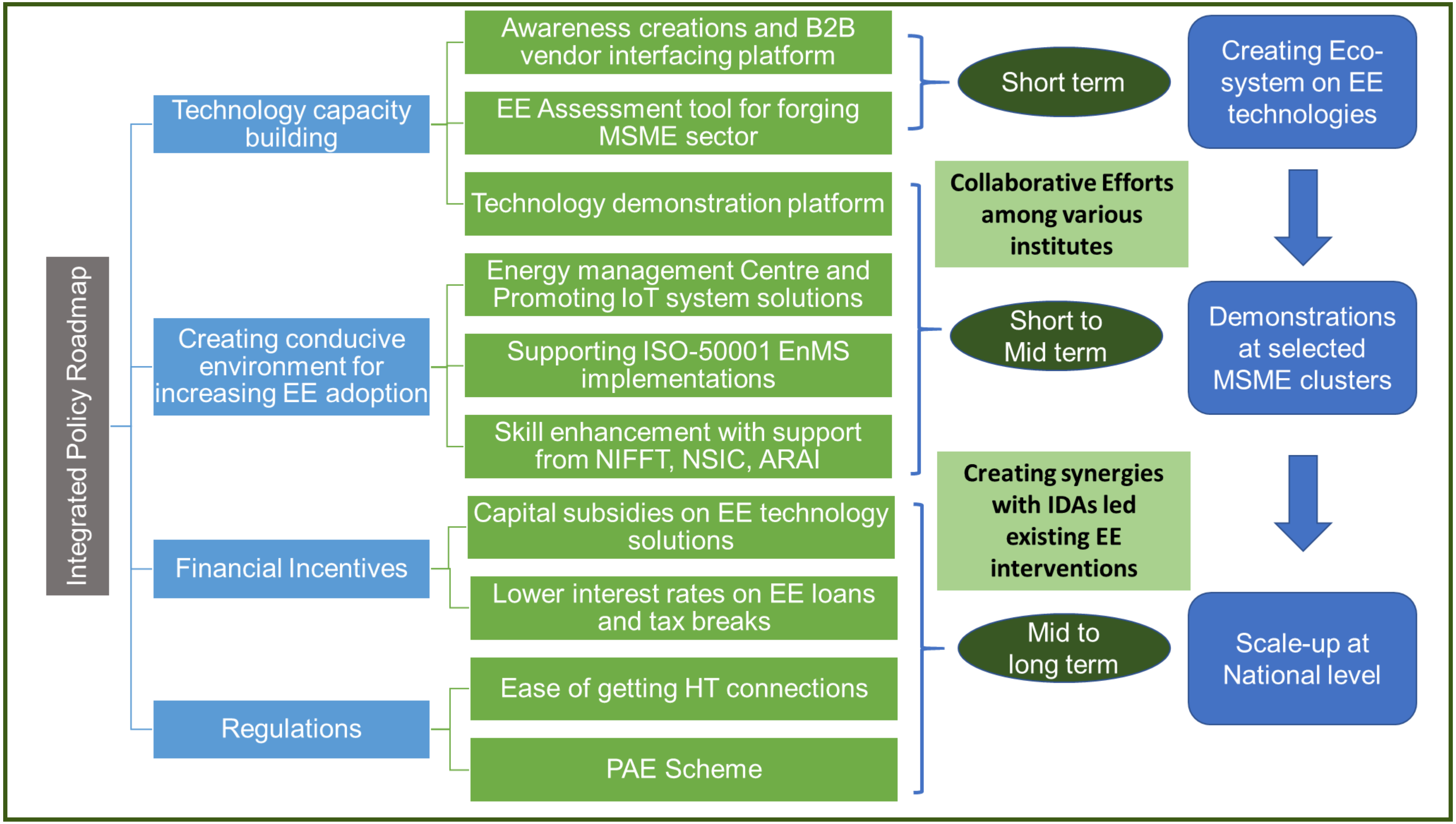
A long list of recommendations, prepared with in-depth consultations with MSME forging units, Industry Associations, industry specific institutes and other decision makers in various forging MSME clusters, is provided below. The actionable elements of the policy roadmap are integrated along four broad and parallel tracks (figure 7):

a) Technology capacity building
   - Awareness creations & B2B vendor interfacing platform
   - EE Assessment tool for forging MSME sector
   - Technology demonstration platform

b) Creating conducive environment for increasing EE adoption
   - Energy management Centre
   - Supporting ISO-50001 EnMS implementations and Promoting IoT Solutions
   - Skill enhancement support from NIFFT, ARAI, NSIC, NSDC

c) Financial Incentives
   - Capital subsidies on EE technology solutions
   - Lower interest rates on EE loans and tax breaks

d) Regulations
   - Ease of getting HT connections
   - PAE Scheme


Integrated Policy Roadmap
Technology capacity building
Awareness creations and B2B vendor interfacing platform
EE Assessment tool for forging MSME sector
Technology demonstration platform
Creating conducive environment for increasing EE adoption
Energy management Centre and Promoting IoT system solutions
Supporting ISO-50001 EnMS implementations
Skill enhancement with support from NIFFT, NSIC, ARAI
Financial Incentives
Capital subsidies on EE technology solutions
Lower interest rates on EE loans and tax breaks
Regulations
Ease of getting HT connections
PAE Scheme
Short term
Collaborative Efforts among various institutes
Short to Mid term
Creating synergies with IDAs led existing EE interventions
Mid to long term
Creating Eco-system on EE technologies
Demonstrations at selected MSME clusters
Scale-up at National level

Implementation Roadmap:

Proposed Interventions	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Technology capacity building										
Awareness creations & B2B vendor interfacing platform	X	X								
EE Assessment tool for forging MSME sector	X	X								
Technology demonstration platform			X	X						
Creating conducive environment for increasing EE adoption										
Energy management Centre			X	X	X	X				
Supporting ISO-50001 EnMS implementations and Promoting IoT Solutions			X	X	X	X				
Skill enhancement support from NIFFT, NSIC, ARAI				X	X	X				
Financial Incentives										
Capital subsidies on EE technology solutions							X	X	X	X
Lower interest rates on EE loans and tax breaks							X	X	X	X
Regulations										
Ease of getting HT connections					X	X	X	X	X	
PAE Scheme					X	X	X	X	X	
Scale-up at National level									X	X

5.2.1. ***Technology capacity building***

Need Assessment:

MSMEs usually have limited technical abilities to evaluate EE technologies and limited outreach to technology suppliers and service providers of EE technologies.

1. Limited technical capacities and weak linkages with suppliers are among the main reasons for lack of technology up gradation in the cluster.

This could be addressed by increasing the frequency of awareness workshops on EE technologies in presence of technology suppliers

2. EE investments are usually considered risky because of the uncertainties associated with the performance of technological interventions and the difficulty in demonstrating savings.

MSME's confidence can be enhanced by establishing replicable contracts for identified EE technologies and building the capacities of local FIs in evaluating EE proposals

3. Many forging units in this cluster fall under the micro/ small category, hence they have lower confidence on high investment state-of-art technologies

Technology demonstrations with a focus on hands-on training to enhance confidence of MSMEs and provide touch-and-feel experience for state-of-art technologies

5.2.1.1. Awareness creations & B2B interfacing platform

We are proposing following interventions for creating awareness on techno-commercial feasibility of EE solutions:

Proposed interventions:

a. Increasing MSMEs' awareness through workshops on energy efficiency solutions, by including a generous dose of positive case studies from other successful implementations

b. Provide the simplified case studies with calculations for the most relevant EE technologies based on typical estimation of energy cost savings, payback period & IRR

c. Match making between potential vendors and MSMEs from clusters will help in adoption of new and advanced EE technologies

d. Building the capacities of vendors and local service providers to strengthen the implementation of EE measures and post implementation services and spares

Implementation roadmap:

1. Organizing the B2B workshops and focused technical seminars with the AIFI, CICU regional chapters and technology providers. Technical workshops are to be designed to meet as per the cluster process technology upgradation requirements.
   a) Conducting workshop on state of art technologies (Flash-less forging, Hydraulic hammers, continuous forging lines etc.) in progressive MSME clusters of Ludhiana, Bangalore, Delhi and Rajkot.
   b) Conducting workshops on IGBT induction furnaces, Gas based metal heating and HT and furnaces in Delhi, Bangalore, Ludhiana, Pune forging MSME clusters

c) 4 National level workshops on decarbonization solutions in forging sector with solutions such electric heat treatment furnace, and applicability of hydrogen as a fuel for heat treatment and metal heating.

2. BEE shall also deploy consultant for these awareness and capacity building activities. The consultant will also assist in developing the case studies with support from AIFI regional chapters and local industry associations for the new technology implementation
3. Technology workshops should be conducted on regular intervals (Each quarter- one workshop in each cluster, one national workshop) to address the changing needs of the cluster and development of new energy and resource efficient technologies.
4. These workshops shall include minimum 50 forging MSMEs and will also invite local institutes/ MSME departments. These workshops shall also include the case studies presentations from technology vendors, with minimum 3-4 vendors for each workshop
5. Consultant will also provide support for the capacity development of ESCOs and LSPs in executing EE projects and implementing the ESCO/ RESCO based projects. Consultant will assist in developing the capacities for minimum 2 vendors/ OEMs/ ESCOs in each forging cluster
6. Post workshop, Consultant will also provide support for dissemination of case studies and these case studies to be circulated to forging clusters through national/ regional level associations.

5.2.1.2. ***Developing EE assessment tool for financial institutes- Short term***

Energy efficiency financing is inherently risky because of the uncertainties associated with the technology risk, performance risk, and re-payment risk based on demonstrated savings. EE assessment tool along with capacity building of local Financial institutions (FIs) can play a crucial role in building the confidence of both MSMEs and FIs in EE technologies.

The tool will provide reliable information about estimate potential energy savings compared to similar MSMEs, sector-wise Energy Efficiency measures implemented by similar MSMEs understand equipment's / utilities' performance, identifying the potential energy savings measures, and associated Investment and payback period.

a) Standard online tool which houses the technology compendium with typical use cases and payback, IRR, NPV analysis.

b) Establishing standard contracts for Energy Efficiency project appraisal through sector specific EE assessment tool

c) Developing the capacities of FIs (Banks and NBFCs) in evaluating EE proposals and sharing standard EE project appraisal documents for faster loan disbursement

Implementation roadmap:

1. BEE may hire the consultant to develop this Energy Efficiency assessment tool for forging sector.

2. This will activity start with by carrying out an analysis of sector with respect to key sub-sectors, energy consuming processes. BEE will leverage the detailed analysis carried out during the mapping study
3. It will also involve Integration of sector/ sub-sector benchmarks SEC benchmarks data for from this energy mapping study will be integrated into this EE assessment tool.
4. It will also involve identification of unit level parameters affecting SEC as an input variable for such as sub-sector, annual production, type of fuel and fuel consumption
5. BEE will also leverage the list of EE technology solutions relevant to sector for suggesting EE measures through assessment tool. BEE jointly with AIFI and other regional industry associations (CICU) will shortlist the EE technologies based on their techno commercial feasibility and financial viability.
6. The tool will perform the cost payback analysis – NPV, IRR, payback period. Banks / FIs can know about potential EE Measures in MSMEs, attractiveness of the EE investments and the cost savings and payback period,
7. BEE can also leverage the existing tools / or improvising existing tool prepared by SIDBI-ISTCL other tools prepared under SAMEEEKSHA/ other ongoing IDA led interventions
8. BEE will develop the technical capacities of FIs (banks/ NBFCs) through this interactive EE assessment and assisting in evaluating the techno-economics of EE technologies from the tool.

Role of Industry Associations and local MSME DC/ DIC centers:

Industry associations can be positioned as opinion influencers among the local industrial community, and ensuring ownership of association in all cluster events, workshops, B2B exhibitions etc. and sharing of knowledge material like Case Studies.

National Institute of MSMEs: NIMSME, which mainly works in the areas of capacity building, research, and job enrichment training, shall be leveraged for conducting workshops on creating awareness on energy efficient and state-of-art technologies

Technology Suppliers: Support for B2B interactions and sharing of knowledge material like technology brochures, and Case Studies

Project consultants and Financial Institutes: Developing the standard contracts for project appraisal of EE technologies, developing EE assessment tool with NPV, IRR calculations for faster loan appraisal process

5.2.1.3. *Technology demonstration platform*

One of the key findings of cluster level discussions was MSMEs were more likely to invest in EE Technologies specifically in state-of-art technologies on the basis of recommendations from peers. Hence, it has proposed that more demonstrations should be conducted in a front runners and opinion leaders in the MSME clusters to enhance confidence of MSMEs and provide touch-and-feel experience:

a. Technology demonstrations for state-of-art and advanced energy efficient solutions
b. Cross-cluster visit to near-by clusters for building confidence of MSMEs in advanced EETs

Implementation Roadmap:

1. BEE will carry out such pilot demonstrations in coordination with cluster stakeholders such as industry associations, technology suppliers
2. Industry associations to ensure participation from forging MSMEs, this will help in addressing the perceived risks of investing in such EETs
3. BEE shall carry out 3-5 demonstrations in each MSME cluster group and invite participants from near-by clusters for creating outreach and availing the benefits of cross learning.

   For example- forging participants from Pune can be invited to Bangalore forging cluster; also, Pune and Ludhiana cluster to Delhi / Rajkot forging cluster etc.
4. BEE will identify the demo projects based on clusters needs and product mix, progressive of the cluster, available suppliers in the cluster etc. Below are the list some state-of-art EE technologies relevant to respective MSME clusters:

EE Technology / solutions for demonstration	Relevance to forging clusters
IGBT based Induction billet heating furnaces	Ludhiana, Pune
Flash less forging	All forging clusters
NG based billet heating and HT furnaces	Ludhiana, Chennai, Bangalore, Pune
Installation of automated robotic forging lines	All forging clusters
AI based enhancements for technologies and IoT integration	All Clusters
Hydrogen as a fuel for heat treatment and other operations	Chennai, Bangalore, Delhi-NCR

5. BEE shall identify the other industry decarbonizations such as Solar PV roof-top, community solar, biomass, hydrogen as a fuel and various possibilities of electrification in forging sector for demo projects.
6. BEE will invite local bankers for these technology demonstrations to apprise them about state-of-art technologies. These demo's will help reassure FIs of performance of EETs, which in turn lead to technical capacity building within FIs, enabling them to better appraise such interventions.

5.2.2. *Creating conducive environment for increasing the adoption of EE*

MSME forging units need to become more energy efficient to increase their competitiveness and maintain profits, however due to lack of supporting infrastructure in MSME clusters, forging owners face various challenges in adoption of EE technologies:

1. Poor practices on energy management, lack of consistent data on energy consumption limits the scope for realizing the benefits of energy efficiency

This could be addressed by promoting ISO 50001 EnMS and IoT technologies, this will help MSME units to adopt the energy monitoring practices

2. Lack of supporting infrastructure such as limited access to energy auditors, non-availability of testing facilities limits the uptake of EE technologies

A permanent Energy Management Centre at cluster level with energy auditing facilities, testing instruments and common utility solutions

3. Non-existence of skilling infrastructure to meet the ever-changing technology needs and lack of standard curriculum on energy conservation

A range of skills with a focus on hands-on training are required to operate new technologies, to adopt best operating practices and comply with minimum EE efficiency standards

5.2.2.1. Developing the ecosystem for the energy monitoring by supporting ISO 50001 EnMS implementations in MSMEs

Need Assessment:

Energy Efficiency efforts are often plagued by lack of consistent data on energy and operations; therefore, push is required to promote energy monitoring practices and technologies. Energy monitoring will also ease out the M&V process where EE implementations are taking place.

During our study in Bangalore and Ludhiana cluster, it was emerged that submetering of Gas fired heat treatment furnaces could help to enhance their energy efficiency improvement attempts.

In typical forging it is very essential to select proper type & size of metal heating furnaces, operate the equipment scientifically with proper measurements by giving due focus to the energy monitoring and by regular energy audits which can highlight the potential areas for energy conservation.

Proposed interventions:

ISO 50001 EnMS will help the MSME units to develop the EE culture, adopt the energy monitoring practices and sustain the benefits of energy conservation measures. It will also ease out the Monitoring & Verification process where EE implementations are taking place.

a) Technical consulting services for ISO-50001 certification in selected MSME clusters (10 MSME units in each forging cluster)

b) Workshops on creating awareness on ISO-50001 and training on ISO-50001 protocols - The frequency of workshops on energy management system must be increased, with a focus on including a generous dose of positive case studies from other successful implementations.

Implementation roadmap (1 Year timeline):

a) Market assessment: Identifying progressive MSME clusters and early adopters in each cluster for implementation of EnMS (1-2 Months)
c) Launch Workshop- National level launch workshop in support with AIFI and 3-4 cluster level workshops with local industry associations- (3-4 months)
d) Technical consulting services in 5-10 MSMEs in each of identified MSME clusters (3-6 Months)

   a. Energy Review of Facilities, Equipment, Systems, Processes and Personnel.

   b. Energy Baseline Setting, Derivation of EnPIs and Performance Process.

c. Development of energy policy, implementation, and development of Internal Auditors

e) Support for EnMS certification through accredited bodies and organizations (6-12 Months)
f) Building capacities of local service providers and local consultants for sustenance of EnMS culture at local level and building markets for ISO-50001 (11-12 Months)
g) Dissemination workshop at cluster level for sharing the learnings and felicitations of adopters on EnMS (Month 12)

Major stakeholders and their responsibilities

Industry Associations	Project consultants	Bureau of Energy Efficiency	National Institute of MSMEs

- **Industry Associations:** Industry associations can be positioned as opinion influencers among the local industrial community and ensuring ownership of inviting member MSMEs to cluster events, workshops etc. and sharing of knowledge material like Case Studies.
- **Project consultants:**
  - Identification of interested MSME units for ISO 50001 certification
  - Consulting services for EnMS implementations and certifications
  - Carry out awareness workshops on importance of ISO 50001- EnMS
- **National Institute of MSMEs:** NIMSME, which mainly works in the areas of capacity building, research, and job enrichment training, shall be leveraged for conducting workshops on creating awareness on ISO-50001 and training on ISO-50001 protocol
- **Bureau of Energy Efficiency:** BEE can provide services for technical consulting services for ISO-50001 certification in selected MSME clusters. BEE can engage project consultants to provide these consulting services.

Benefits to sector stakeholders

- Energy management system will build a culture of sub-process level energy benchmarking
- Ease out the M&V process where EE implementations are taking place.
- Help in strengthening the ESCO based projects, establishing the baselines and also help in better evaluation of the savings.

5.2.2.2. *Promoting Internet of thing (IoT) systems & energy monitoring technologies – Short Term*

These IoT systems provide access to real-time equipment performance, energy consumption, and building I data to support a smarter, data-driven maintenance strategy. Hence, push is required to promote IoT systems and energy monitoring technologies.

a) Linking IoT technologies with ISO-50001 for realizing the energy savings of installed EETs

b) 2-3 demo projects in few progressive MSME clusters on IoT technologies for hands-on-training

c) Providing incentives and subsidies on IoT and energy monitoring solutions

d) B2B matchmaking between MSMEs &vendors and building capacities of LSPs

Implementation roadmap (2 Year timeline):

1. BEE will link this activity with ISO-50001 EnMS implementation, BEE will leverage the MSME premises where ISO-50001 implemented for carrying out demo projects on IoT systems
2. BEE will make these IoT systems and energy monitoring equipment mandatory as a pre-requisite for ISO-50001 implementation, however, BEE will provide upfront subsidies on installation of these energy monitoring technologies
3. BEE will carry out these demo projects in 2-3 units in prominent MSME clusters.
4. The timeline for this activity would be 2 year, where first 3 months would be installation and certification of EnMS. Next 9 months would be for monitoring and assessing the benefits of EnMS implementations and IoT installations.
5. Second year onwards, MSME units will be invited for demonstrations. BEE in association with industry associations will invite MSME units for hands-on-training
6. BEE will support in inviting technology vendors of energy monitoring solutions on common platform and creating awareness by sharing case studies on successful implementations
7. BEE will assist in building capacities of local service providers in forging clusters to implement energy monitoring solutions in MSME forging units

Relevant stakeholders:

Industry Associations	Technology vendors	India Smart Grid Forum

Role of various actors/ stakeholders

Technology vendors: Support for B2B interactions and sharing of knowledge material like technology brochures, and Case Studies

Industry Associations: Ensuring ownership of forging units in all cluster events, workshops, B2B exhibitions etc.

India Smart grid forum: It can help in creating awareness on state-of-art IoT systems and assist in organizing B2B vendor exhibitions for promoting of these technologies. Smart grid forum can also help in identifying IoT technologies eligible for subsidies and incentives.

Benefits to sector stakeholders

- Increase awareness on energy monitoring solution and explaining direct and in-direct benefits of IoT system
- Help in strengthening the ESCO based projects and establishing the baselines faster.
- Energy monitoring systems will also help in better evaluation of the savings.

5.2.2.3. *Energy Management Centre (EMC) at cluster level- Mid term*

Need Assessment:

During energy studies it was identified that limited access to energy auditors and lack of handholding support to MSMEs limits the EE implementations in MSME clusters. Many forging units in the sector fall under micro category with limited financial capacities, hence they have limited funds to invest into energy auditing activities and high-cost investments solutions.

Proposed interventions:

We propose to have permanent Energy Management Centre at each major forging cluster. We propose to establish a common facility, may at Industry Associations premises, to provide services for energy auding, testing facilities and common utility solutions. We are proposing following interventions for creating the ecosystem for EE interventions in MSME clusters through this EMC:

- Demonstrate the direct, in-direct benefits of EE technologies through energy auditing services
- Access to energy auditors and building the capacities of local consultants on carrying out energy auditing activities
- Providing common testing and utility solutions for forging MSMEs in the cluster.

Implementation roadmap (2 Year timeline):

1. BEE will provide its support to local associations for developing Energy management Centre at cluster level.
2. Establishment of EMC will be done in 1 year and for the next year BEE will provide handholding for supporting various activities of EMC
3. BEE will support in identifying local auditors, provide them hands-on training followed by sample energy audits through experts with forging specific energy audit experience
4. BEE will also support in encouraging plant heads and production managers of forging units to enroll for energy auditor and energy manager examinations
5. BEE will support in reskilling of certified energy auditors for forging focused audit in each forging cluster
6. BEE will provide support for establishing standard energy audit template for Energy Efficiency project evaluation
7. BEE will also carry out awareness workshops through energy auditors to be led by EMC in cluster and inviting testimonials from plant managers of forging units

Functions of Energy Management Centre:

a. Energy Auditing facilities:

- Conduct energy audits at subsidized rates for forging MSMEs. BEE may consider linking these energy auditing activities with PAE scheme for additional benefits
- Provided end-to-end hand holding support to MSMEs for installation of the EE projects
- Developing capacity of local consultants in conducting energy audits, walk-through audits

b. Common testing facilities:

- Establishing of a common center for providing services related to Computer Aided Design (CAD), CAM for die development
- Establishing of a common testing facility to provide services for testing facilities such as forged component strength testing, Coordinate Measuring Machines (CMM) and

radiography which will help in reducing rejection rates and increasing production hence increase in SEC.

- Liaison with NSIC, MoMSME, IAs, to hold such facilities at their premises

Relevant stakeholders:

Industry Associations	Technology vendors	DI-MSME & MSME-DIC

Role of Industry Associations and local MSME DC/ DIC centers:

Industry associations can be positioned as opinion influencers among the local industrial community, and ensuring ownership of association in all cluster events, workshops, B2B exhibitions etc. and can also host the common facility center at their premises

DI-MSME/ MSME-DIC: Establishment of a common facility center at MSME DIC premises to carry out demonstration/ pilots in coordination with cluster stakeholders.

NSIC Technical Services Center (NTSC): NTSC can assist in developing common testing facilities at their center along with services for stimulation and CAD/ CAM for prototype development

Technology Suppliers: Support for B2B interactions and sharing of knowledge material like technology brochures, and Case Studies

5.2.2.4. Skill Development in forging MSME sector

Need Assessment:

Non-existence of skilling infrastructure is the major hurdle in adopting the ever-changing technology & processes. A range of skills are required to operate new technologies, to adopt best operating practices and comply with minimum EE efficiency standards.

Proposed interventions:

We are proposing to leverage and expand existing center of excellence institutes such as NIFFT Ranchi, ARAI forging division - Pune and NSIC Technical Services Centre in Rajkot, Pune, New Delhi etc.

- Leveraging National Institute of Foundry and Forge Technology for hands-on-training and holding diploma courses on forging technologies
- Leveraging ARAI forging center located in Pune for promoting soft interventions such as 5S, Kaizen etc.
- Leveraging NSIC Technical Services Centre and National Skill Development Centre for developing curriculum on skill development on forging specific technologies

Implementation roadmap (2 Year timeline):

A. **Leveraging National Institute of Foundry and Forge Technology- (Month 1- Month 12)**

National Institute of Foundry and Forge Technology (NIFFT), Ranchi is a public engineering and research institution in Ranchi. *During consultations, there was a need felt across the AIFI and CICU (Ludhiana) to leverage this premium institution for preparing the new skillset for the work* *force in the forging sector. This institution can play the leading role in developing the new age of the skillset required by the industry to meet next generation of technological advancement.*

1. NIFFT to set up a series of training and diploma courses for the operating level staff on best operating practices in forging units. These courses can be developed jointly with industry stakeholders, NSDC and BEE, being the nodal agency on EE in India.

2. NIFFT possibly with support from BEE and/or MoMSME can support in conducting hand-on trainings for skill enhancement of shop-floor workforce around energy efficiency technologies.

   Some such technologies include

   a. AI/ ML based enhancements for process technologies and IoT integration
   b. Hydrogen as a fuel for heat treatment and oxyfuel burner operations

3. NIFFT to consider developing various local chapters at key Foundry and Forging clusters across India in consultation / collaboration with prominent industry associations.

B. Leveraging Automotive Research Association of India (ARAI) Forging division Pune

Automotive Research Association of India (ARAI) serves hundreds of customers in a year including Automotive OEMs; Engine, Component and Systems Suppliers; large number of SMEs etc. ARAI‟s forging division organizes training and undertakes R&D projects as well as testing and validation

1. Conducting programs on forging technology and subjects which indirectly aid efforts to reduce cost / increase productivity e.g., 5S, TPM

2. Conducting customized corporate skill enhancement training program covering various areas of forging operations, quality, and management

3. Guiding in layouts for smoother material / process flow and efficient operations

C. Leveraging NSIC Technical Services Centre and National Skill Development Centre

NSIC through 'NSIC Technical Services Centers' (NTSCs) provides technical support to MSMEs include skill development in Hi-Tech as well as conventional trades, product testing at testing laboratories accredited by NABL, energy audit, environment management etc. NTSC Rajkot is a most credible organization in the field of Energy Audit, testing facilities authorized by Govt. of Gujarat.

During consultations, NTSC has shown interest in collaborating with BEE for creating knowledge base and ecosystem for scaling up the implementation of EE technologies. We envisage that NSIC, through its extensive experience, to perform the duties and support BEE in:

1. NSIC in support with NSDC to develop professional training courses and curriculum for the operating level staff on EETs and best operating practices in MSME forging units.

   These courses can be developed jointly with BEE, being the nodal agency of the Govt. of India on energy efficiency matters in the country.

   The National Skills Qualification Framework (NSQF) theoretically makes it possible to drive competency-based training for every job role in industry. Framework from NSDC on National Occupational Standards (NOS) will be followed for creating course curriculum.

NOS specify the standard of performance an individual must achieve when carrying out a function in the workplace, together with the knowledge and understanding they need to meet a standard consistently.

- Each NOS defines one key function in a job role.
- Each NOS must be a concise and readable document,
- Each NOS usually consisting of no more than five or six pages (some are only 1 or 2)
- NOS describe functions, standards of performance and knowledge / understanding.

It is possible for all current vocational courses, like, ITI Courses, or similar vocational courses in polytechnics, to be aligned to job roles (including forging sector) at specific NSQF Levels. For Example- An ITI Course in Plumbing would say they are training for plumbers at NSQF Level 3. Similarly, a polytechnic, training in fashion design, may say it is training for NSQF Level 5 for Garment Cutters.

2. NSIC possibly with support from BEE can support in creating the ecosystem for scaling up the implementation of some of the state-of-the-art technologies through live demonstrations

- Some such technologies include Automated forging lines, flash less forging, Hydraulic hammers, VFD based forging clutch presses, Gas fired heat treatment furnaces etc.

3. Establishing of facilities such as for Computer Aided Design for dies for flash less forging

D. Leveraging local universities, ITIs and other institutes for developing EE curriculum

Leveraging local institutes, universities, and centers for developing courses on Energy management- in Rajkot NSIC-NTSC, NIIST Mandi Gobindgarh , Karnataka German Multi Skill Development - Bangalore, Central tool room in Ludhiana etc.

1. Inclusion of the technical courses on energy management and conservations and inclusion of Advanced Diploma courses in local ITIs

2. Develop curriculum for professional courses in forging processes and technologies through consultation with stakeholders

Benefits to sector stakeholders

a. This will prepare the workforce ready to implement best practices and energy efficient technologies in the sectors
b. Different forging clusters will have easier access to the centers of excellence
c. Skilled labor will empower the units to adopt the new technologies.

Relevant stakeholders:

BEE	National Skill development Corporation	National Institute of MSMEs

Role of various actors/ stakeholders

BEE: Assist in providing finance for procuring state-of-art technologies for hands-on-training at NSIC center and local skill development institute

Industry associations shall ensure inviting member MSMEs to trainings and workshops for capacity development

National Institute of MSMEs: NIMSME, which mainly works in the areas of capacity building, research, and job enrichment training, shall be leveraged for developing the technical courses on energy management and conservations

National Skill development Corporation: Assist in developing training courses and curriculum on in forging processes and technologies and deploying local resource for continuous improvement at cluster level

5.2.3. *Financial incentives for EE Technology adoption*

Need Assessment:

Energy efficiency generally perceived as a secondary aspect when compared to the core business activity or is only considered when it directly links to increase in production/output. Higher cost of energy efficient technologies due to advanced features and lack of upfront capital in MSMEs remained one of the biggest hurdles in adoption of EE technologies

Proposed interventions:

Capital Subsidy scheme is most popular and see significant uptake as it offers to reduce the burden of high upfront cost of EE projects along with simplified process of availing subsidies.

5.2.3.1. *Capital subsidies on EE technology solutions*

We are proposing following interventions cater the needs of MSMEs. CLCSS has seen significant uptake in MSMEs and has been operational for two decades

a. Increasing the limit of capital incentives under CLCSS, both maximum subsidy amount (15 lakhs) and applicable loan amount (1 Cr.) under CLCSS
b. Higher % of capital subsidies on EETs for differentiating from productivity improvement
c. Increase the purview of technologies and sectors under existing subsidies schemes
    i. Robotic forging lines
    ii. Gas based billet heating and HT furnaces with PLC based control
    iii. Multi axis Machining center (5/6 Axis)
    iv. IoT based EMS
    v. Heat pumps and WHR for electroplating
    vi. Die development for flash less forging

Implementation roadmap:

a) Awareness and cluster level engagement is essential for capital subsidy scheme as well.

b) Some forging clusters have finds wider adoption of these schemes however majority of the units in the different clusters still lack the knowledge of the different schemes.

- Conducting the workshops for promoting the awareness of the financial schemes across clusters of Pune, Ludhiana, Jalandhar- Phagwara, Chennai, Rajkot etc.

c) Even though capital subsidy schemes are highly accepted in MSMEs it is vital that it incorporates important features like simple application process, quick approval and disbursement of subsidy, wide coverage of technologies & MSME clusters and awareness of the scheme.

d) Regional level consultations should be conducted across all forging cluster to draft the possible recommendations for the faster and wider adoption of these schemes.

e) After consolidating the inputs received, AIFI, CICU and other prominent regional industry associations along with BEE can conduct the stakeholder consultation with MoMSME for further simplification of the processes.

5.2.3.2. *Lower interest rates on EE loans and fasten disbursement*

The prime objective of this mechanism is to promote ease of financing for the adoption and implementation of energy efficiency measures across all the selected sectors (mainly demand side).

1. List of EE technologies applicable for interest subsidies based on minimum threshold
2. Building the capacities of Financial Institutes in loan appraisal for EETs
3. Quick and fast disbursement for adoption of EE technologies

5.2.3.3. *Differential taxes on EE technologies*

A tax exemption will allow the purchaser of an equipment, such as an energy-efficient technology, to be exempt from paying tax on that purchase. Tax credit can also be provided to allow MSMEs to deduct the tax credit amount from their annual taxes as a percentage of a purchase price.

1. Charging lower GST and differential tax breaks on purchase of EE technologies.
2. Different GST slabs based on EE potential of technologies

Implementation roadmap:

Regional level consultations should be conducted across all forging cluster to draft the possible recommendations for list of technologies that should be included in this scheme.

- We propose one workshop in each Custer for compiling the requirements of the different forging units.
- After consolidating the inputs received, AIFI can propose a consolation with BEE and relevant stakeholder consultation for addition of most relevant technologies in the list.

Benefits to sector stakeholders

a. Increasing affordability of energy efficient technologies
b. Faster replication and adoption of new & advanced technologies

Relevant stakeholders:

BEE	MoMSME	Commerical Banks	SIDBI

Role of various actors/ stakeholders

- **BEE:** Providing list of Energy efficient technologies applicable for incentives and subsidies
- **Commercial banks**- Developing in-house capacities on evaluation on EE technologies and ready reckoner for quick sanction & faster loan disbursement

- **MoMSME:** Revised guidelines for capital subsidies schemes and shortlisting EE technologies for GST breaks and differential taxes on EE technology solutions.
- **SIDBI –** Expanding the capacity building of industries and FIs, standardization of the project documents

5.2.4. *Collaboratives efforts among institutional stakeholders and IDAs*

Need Assessment:

State specific departments and institutes participate minimally in implementing centrally funded support programmes. The wider reach to state specific institutes coupled with increased ownership can significantly improve the outcome of existing schemes. Support from DICs, state ministries and departments are needed to facilitate better implementation.

Proposed interventions:

There is a need felt across clusters to leverage other institutes for promoting of EE interventions in the MSME forging clusters. We are proposing following interventions for institutional capacity building

5.2.4.1. *Collaborative Efforts among various institutes:*

a. Building capacity of SDAs/MSME-DI, to include a full time EE-MSME expert to facilitate MSMEs in availing benefits of existing cluster specific schemes

b. Support from SDAs and DICs is needed to facilitate better implementation and collect timely feedback on the performance of energy efficiency programmes.

c. The wider reach of state government agencies, coupled with increased participation can significantly improve the outcome of existing schemes

5.2.4.2. *Creating synergies with IDAs led existing EE interventions*

a. Identified IDA led (GIZ programme in secondary steel and paper sector) ongoing EE interventions in MSME clusters and exploring options for synergies for capacity building and technology demonstration activities

b. Combining IDA led EE financing schemes and revolving funds (EESL UNIDO EMRF fund) with technical assistance activities of BEE in forging MSME sector

Implementation roadmap:

a) Developing the common platform to map the different initiatives carried out for the forging sector by the different stakeholders. This will result into propagating the benefits and learning captured in different program through web portal accessible to forging units.

b) Strengthening of SDA, DICs and regional association for wider dissemination of the learning to the forging units in their respective regions.

c) Creating the common platform for exchange of thoughts and ideas among the regional stakeholders to identify the key areas for development.

d) Establishing the long-term programmatic interventions focused for specific cluster led by one IDA or collaborative efforts - including the capacity building programmes, technology demonstration, hand-holding support for implementations.

e) Developing new focused programs for forging clusters where limited or less program intervention has been carried out in the past. Developing long term energy management centers across clusters of Ludhiana Pune, Delhi, Rajkot etc.

f) Programmatic interventions should leverage cross -cluster learnings and interventions of different IDA in other clusters through knowledge exchange programmers and industry tours and hand-o training in center of excellences.

Benefits to sector stakeholders

a. Developing the collaborative ecosystem for wider outreach of programmatic activities
b. Different forging stakeholders will have increased awareness and access to various cluster specific interventions
c. Removing the duplication of efforts among various stakeholders.

Relevant stakeholders:

BEE	International development agencies	DICs/ MSME DI	SDAs

BEE: Engaging all stakeholders at the inception of the programme and ensure ownership from them by highlighting mutual benefits and opportunities for synergy

MSME DI: Creating awareness on current initiatives among MSMEs at cluster level and support during awareness workshops by inviting MSMEs in the cluster

International development agencies (IDAs)- Supporting ongoing BEE interventions through bundling with ongoing EE financing schemes and revolving funds

5.2.4.3. *Creating supporting infrastructure for EE technology upgradation-*

In addition to this lack of supporting infrastructure and regulatory support also limit the uptake of EE interventions in various MSME clusters in forging sector. *For example: MSMEs usually find difficulties in getting regulatory clearances to shift from Low Tension to High Tension connections which limits the uptake of induction furnaces.*

1. **Ease of regulations from DISCOMs**:
   a. Easing the upgradation from LT connections to HT connections, create a bridge between MSME industries & DISCOMs
   b. Additional financial incentives for technology upgradation which wit lower the overall projects costs related infrastructure upgradation
   c. Developing ready reckoner and list of documents required for getting the clearances

BEE appointed project consultant will understand the regulations and need assessment at MSME level.

2. **Extension of Natural Gas Pipelines:**
   During energy audits in Rajkot cluster, it was emerged that there are some industrial areas where Natural gas pipelines are not available.

   a. Strengthening & extension of the Natural Gas pipeline within clusters mainly in Ludhiana, Pune and some areas in Rajkot and Delhi -NCR

   b. Prioritizing availability of Natural Gas pipelines across all energy intensive forging MSME clusters

BEE appointed project consultant will do study to identify industrial areas where NG pipelines are not available

3. **Easing the net-metering policies** and wheeling charges support for solar roof-top installations in MSMEs

BEE appointed consultant with the help of MNRE, gap assessment and interventions required

Benefits to sector stakeholders

a. Evaluation of technical viability of EE technologies, cost benefit assessment
b. Access to cleaner fuel by switching to electricity and NG, hence reduction of emissions
c. Easy access to energy auditors in the clusters and support during implementations

Relevant stakeholders:

BEE	Industry Associations	Gas Authorities	DISCOM

Role of various actors/ stakeholders

Industry Associations: Holding the energy management cell in the cluster and outreach to forging MSME industries in the cluster

DISCOMs: Easing out the process of upgradation to HT lines and assist MSMEs in providing required documents for clearance and approval

MSME DI in collaboration with Gas Companies can assist in getting the clearances for extending Gas pipelines in industrial MSME clusters

BEE- Supporting in carrying out regulatory interventions in the cluster for HT connection upgradation and NG lines in the cluster

5.2.5. *Performance Achieve and Earn (PAE) Scheme:*

Learnings from the Perform Achieve Trade (PAT) scheme should be extended to the MSME sector. These mandatory programmes should not be perceived by MSMEs as an administrative burden; therefore, the incentives should be provided based on EE potential achieved.

Considering the fact that SMEs already face significant barriers to energy efficiency implementation, proposing a scheme which penalizes SMEs on non-compliance may widen the relationship gap between the government and enterprises and create extra burdens on these enterprises. Therefore, an incentive-oriented compliance mechanism (e.g., offering ESCerts based incentives) is proposed.

Proposed interventions:

Programme coverage: In the pilot phase for Forging across 10 clusters covering over 200. Different clusters that can be considered under the programme include- Rajkot, Pune, Coimbatore, Ludhiana, Jalandhar, Phagwara, Chennai , Bangalore.

A mandatory audit programme will help policymakers and regulators identify major energy efficiency bottlenecks and opportunities to intervene at scale. However, enterprises may perceive mandatory energy audits as an added administrative burden, hence, they can be incentivized by providing free/ subsidised energy audit services

Implementation Roadmap:

As a first step, energy audits must be made mandatory in the next 3-5 years for all energy intensive forging units having an annual turnover of more than INR 50 crore (medium scale units); this can later be extended to enterprises having turnover of more than INR 25 crore.

- The pilot for this program will cover about 10 MSME forging clusters across India.
- BEE team in close consultation with national forging association (AIFI) will navigate the execution of this programme.
- Interested SMEs can opt for the energy savings programme by reaching out to Industry Association. Industry associations will be given ownership to register the MSMEs for programme and to engage with them in a meaningful and sustainable way
- BEE will promote the voluntary uptake of energy conservation by carrying out the energy audits in MSMEs and assign targets for reduction of their specific energy consumption
- BEE appointed agency will carry out baseline energy audit as per prescribed format of BEE, recommend ECMs for energy saving and techno-commercial feasibility for EE solutions
- BEE will also provide handholding support to MSMEs during implementation phase
- SMEs that achieve or exceed the reduction targets would be issued ESCerts based monetary incentives. MSMEs will be required to achieve a minimum of 30% of the agreed targets
- BEE will also assist in building confidence of MSMEs by technology demonstration and create awareness on EE solutions and technologies.

Relevant stakeholders:

Stakeholders	***Key Activities and Task***
BEE	*Roll out of the pilot phase of PAE scheme, Selection and procuring services of EA agency for baseline energy audits, issuing ESCerts to MSMEs*
Project Consultants	*Carry out baseline energy audit as per prescribed format of BEE, recommend ECMs for energy saving and techno-commercial feasibility for EE solutions*
Industry Association	*Disseminate the programme objectives across different clusters through workshops and collating expression of interest from different forging clusters*
MSME	*Support EA agency appointed by BEE, facilitate EA study, sharing of the details and data requirement for baseline study*

Annexure

A. Production processes and technology adopted

A. Production process and technology adopted

Forging is the most energy intensive process and energy cost accounts for about 20–30 percent of the total manufacturing cost. The primary process steps in metal forging are metal cutting, metal heating, forging, heat treatment, and finishing. Of these, metal heating is the most energy-intensive operation and accounts for 50-70 percent of the total energy consumption in typical forging unit; while the balance is used in heat treatment, forging presses, shot blasting, trimming, coining & auxiliary operations.

Type of production processes in forging units

Different processes in the forging units can be classified under the following broad heads, as shown in Figure 18.

- Metal preparation
- Metal Heating
- Metal Forming
- Machining and Finishing

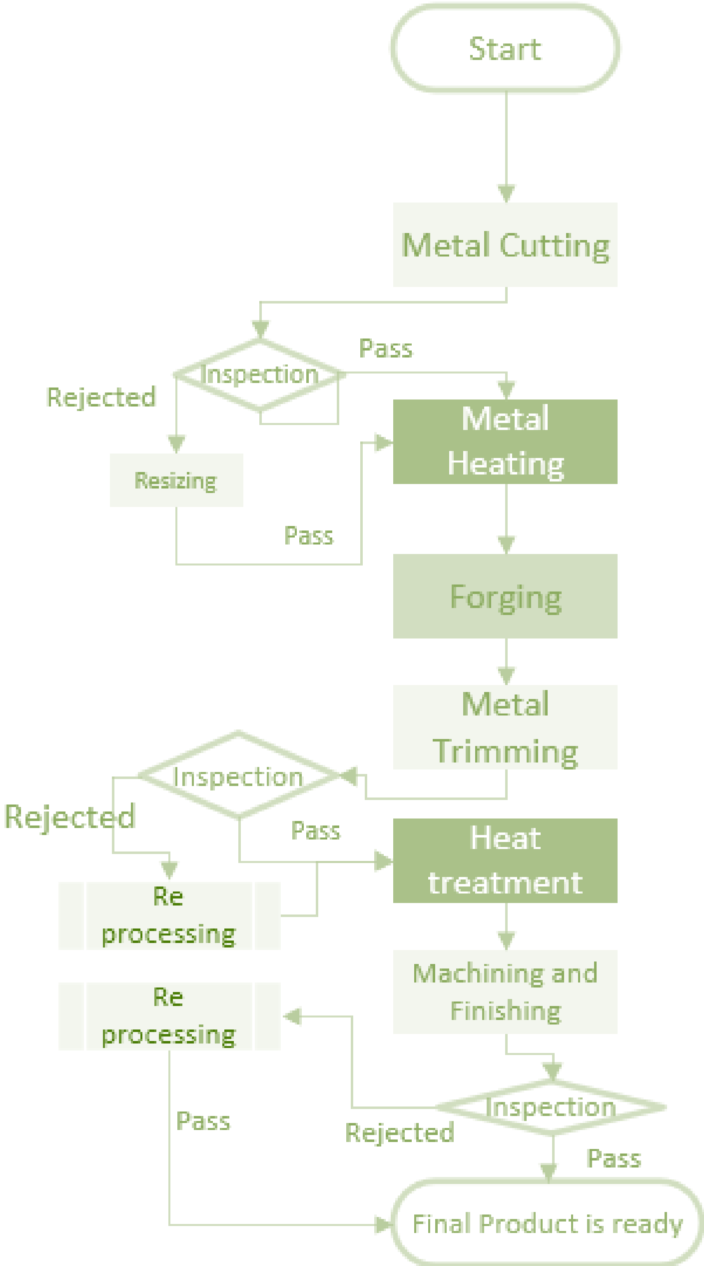


Figure 18 Typical production process in forging

Metal Preparation

Raw material for the forging process is received by the industries in form of billets, rods, bars etc. These are cut in bandsaw machine or shearing machine in the form of billets as per weight required and the desired size and length according to the product to be formed. Final sized metal piece is sent to next stage of metal heating

Bandsaw is predominantly used for billet cutting across the different forging clusters. However, some units in Ludhiana, Chennai and Bangalore also use shearing machines for cutting of the billets and strips.

Metal heating

Induction billet heaters/ oil and gas fired furnaces are used for metal heating processes. Metal is to be heated above the recrystallization temperature (around 75% of melting point) of the metal alloy. At this temperature metal can be easily deformed to the desired shape. Based on the grades of the ferrous alloys, billets are heated up to a temperature range of 1200 – 1250 ºC depending upon the composition of alloys (carbon %).

Induction based heating is predominately used for billet heating in the Pune, Chennai, and Bangalore forging clusters. Oil fired furnaces are predominantly used for metal heating in the Ludhiana and nearby forging clusters. Gas based heating is widely adopted for metal heating in the Delhi-NCR cluster.

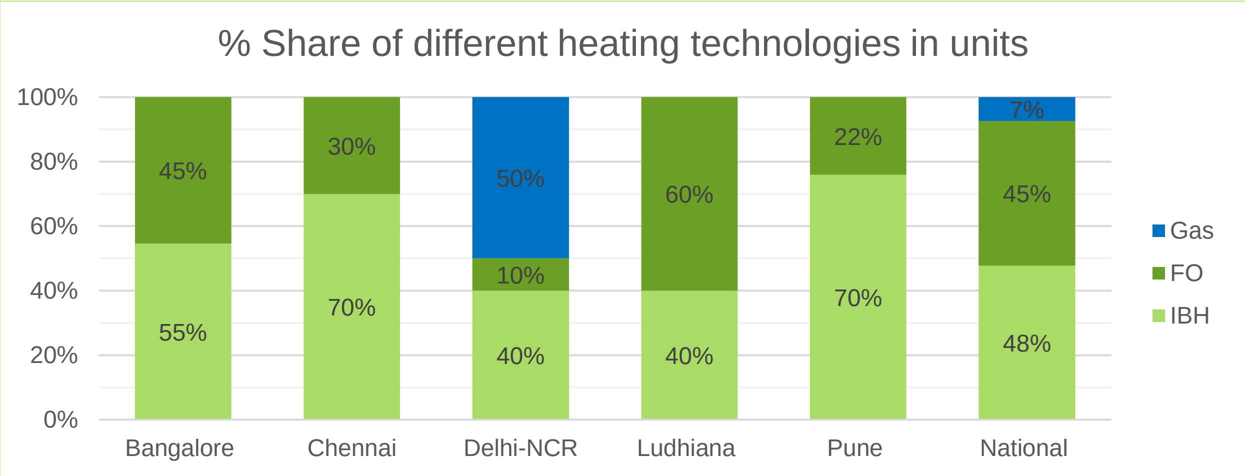


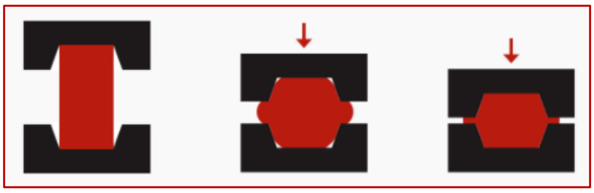
Figure 19: % share of metal heating technologies across prominent forging clusters

Induction share ~ 70% share in the metal heating for forged products (production volume in tonnes) followed by the oil fired furnaces which contributes to ~ 22% share of metal heating (production volume in tonne).

Metal forming

Metal forming process involves the deformation of the workpiece into the desired shape and size by the application of the external force. Forging (forming) process involves the plastic deformation of the workpiece through a single or number of deforming operations depending upon the complexity of the product. A temperature of about 1,250 °C is maintained for forging operation

Closed Die forming process



Closed die metal forming (impression die forging) is a process in which a piece of metal is formed under high pressure to fill an enclosed die impression. Using closed die forging, products with complex shapes and closer tolerances can be produced, which require less or no machining.

Special shapes require more than one forging operation to reach final shapes and dimensions. In closed die forging, metal pieces weighing from 500 gm to 5 tonnes are forged. It is performed either in presses or hammers.

Drop Hammers, Screw Presses and Pneumatic clutch operated electrical motor driven presses are used for the close die operations in different forging clusters.

Open Die forming process

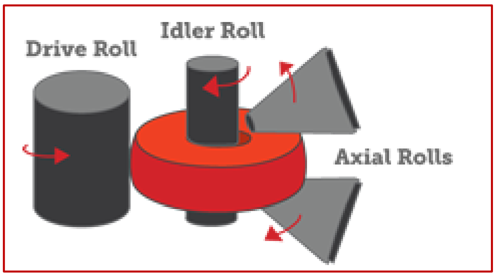
Open die forging generally caters to larger forged products. In this forming process hammer strikes and deforms the workpiece, which is placed on a stationary anvil. During forging process dies do not enclose the workpiece, allowing metal to flow except where contacted by the dies. It comprises many process variations, thus, allowing a broad range of shapes and sizes to be produced. Multiple hammer hits are required to get the desired shape

Using open die forging, products with finer grain size, better fatigue resistance and improved microstructure can be produced. In open die forging, metal pieces weighing from few kilograms to 10 tonnes are forged.

Pneumatic hammers are widely used for the open die metal forming operations in Ludhiana Bangalore, Phagwara, Pune forging clusters.

Hydraulic hammers are widely adopted by the forging units in Delhi-NCR forging clusters.

Ring Rolling



Ring rolling produces seamless rings with forged properties, which results in optimum mechanical properties, and predictable and efficient machinability. In this process hot metal rods are flattened with the help of the drop hammers (flattening), then a piercing process is used to make the hole in the centre of the hot metal.

Donut shaped metal is then rolled between the rollers which move toward each other to form a continuously reducing gap and squeezing into a thin ring. Advantages of this process are lower tooling cost, better strength. These products find applications in heavy engineering, mining, off-highway equipment, and other critical applications.

Forging units in the Bangalore and Phagwara clusters carry out this forging processes to form the metal rings ranging from a few inches to a few meter (outer diameter).

Trimming and coining

Once finish-forging is completed, the flash (excess metal) is removed either manually or with trimming dies. Majority of units in Pune use trimming die for this purpose. Screw presses with electrical motors are used for trimming and coining operations.

Coining is predominantly done for the forged products where a circular hole is to be made, the metal is removed from the forged product by shearing process – often called coining.

Coining is predominantly. used for the multiple forging for the auto industry. Trimming is carried out for almost all forged products for flash removal.

Advanced metal forming machines are now capable of producing the flash less forged products which has almost no flash. Flash less forging is being done by fewer progressive and front runners MSMEs across the Ludhiana, Phagwara and Bangalore forging clusters.

Heat Treatment

Heat treatment (HT) process helps in removal of residual stress, improving the machinability of the forged product and enhancing the structural properties of the forged component. During the process the metal is heated above critical temperature and allowed to cool gradually. Holding the metal at a temperature for a period of time and gradually cooling the metal at a specific rate to obtain a desired microstructure.

During the process the metal is heated below the lower critical temperature and allowed to cool gradually. Depending upon the type of the product and application of the product, different heat treatment processes are carried out. Electricity, Gas, Oil, HSD are the main forms of energy used for heating the metal. Type of heat treatment processes are presented next.

Annealing

In this process the forged product is heated above critical temperature[17] and allowing to cool in the furnace itself after switching off the furnace is called annealing. This process increases the ductility and toughness but reduces the hardness in the forged component.

Normalizing

In this process the forged product is heated above critical temperature, soaking it at that temperature and cooling it in air is called normalizing. This process increases the strength and harden ss. This process is performed on forged components that are to be machined as normalizing improves the machinability of components.

[17] Steel undergoes a phase change - recrystallizing as austenite at the critical temperature (~ 700 ºC)

Quenching

Quenching is a process of rapidly cooling steel forgings from the austenitizing temperature (Heating of the forged alloy above critical temperature). In ferrous alloys this will often produce a harder metal by transforming the austenite to martensite. When the entire metal is heated and maintained at austenitic temperature and quenched, this process will cause the hardening of the entire forged part.

Case Hardening

Some components require higher hardness at surfaces than at cores. For such forged components surface hardening is done which hardens only the surface/ case. This is done to improve the wear and tear resistance of the component.

Tempering

Tempering is performed by elevating the steel to a set point below its lower critical temperature, typically following a hardening operation. Once this temperature is reached, it is held there for a specified amount of time. Material is gradually cooled, tempering also improves the machinability and formability of a hardened steel, and can reduce the risk of the steel cracking or failing due to internal stresses.

Finishing and Machining

Preparation of the final product might require additional machining operations to produce the final product with precise dimensions. Forged components are finally machined to deliver the final product in the specified shape, dimensions, and tolerances. Several machining operations such as drilling, shaping, truing, coining, boring, threading, grinding, stamping etc. are carried out with help of the special machines during the finishing process.

Technologies used in forging

Different equipment and machines and processes are adopted to process the different products, depending upon the type of the metal, size, mass, and complexity of the final forged product. Details of the different technologies and their applications in different processes are being illustrated in the section.

Metal heating (Billet heating)

Induction *billet heater*

Induction billet heaters are used by MSME forging units across different forging clusters for metal heating application. Induction heating furnaces are operated in continuous mode, with cycle time of heating the single billet generally varies in range of a few seconds to less than a minute. Cycle time depends upon the size of the billet and cycle time of the forging operation. Induction furnaces are available in wide capacities ranging from few kg/hour to few tonnes /hour. Induction furnace is made up of nonconductive refractory lining which is used to convey the billet to be heated, refractory is generally surrounded by multiple coils.

High frequency alternating current is passed through the coils which creates a rapidly reversing magnetic field, this magnetic field penetrates the metal changed in crucible. Alternating high flux magnetic field induces eddy currents (in charged metal), by process of electromagnetic induction. The eddy currents, flowing through the electrical resistance of the bulk metal produces the heating effect. Ferromagnetic materials like iron, the material is also heated by magnetic hysteresis, the reversal of the molecular magnetic dipoles in the metal. These eddy currents and magnetic hysteresis led to vigorous heating, which heats the billet to recrystallization temperature in very less time.

Insulated gate bipolar transistor (IGBT) based induction billet heating is widely used across the forging clusters.

During audit across multiple units in different forging clusters- the capacity of the induction billet heater was observed in the range of 50 kg / hour – 500 kg per batch, with a connected load of 75–1000 kW. *The specific energy consumption (SEC) of induction furnaces varies in the range of 370 kWh–450 kWh per tonne*.

IGBT based system are ideal for the high voltage high current operations. IGBT based system is capable of operating at higher frequency (up to 2-3 kHz) range as compared with SCR based system (up to few hundred Hz). These added benefits of IGBT help in better and precise control of the heating operations in IGBT based Induction heating furnaces.

SEC of the Induction billet heart observed during the energy audits under BEE energy and resource mapping study was in rang of 375- 580 kWh/ tonne for hot forging operations.

Table 21: Comparison of metal heating furnace technologies

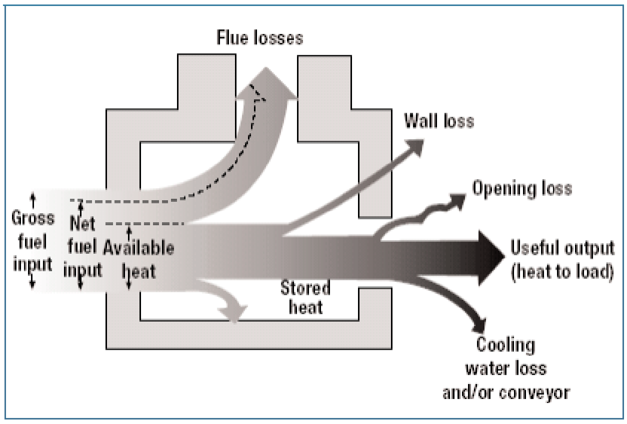
Sr. No.	Technology / Process	Applications / Advantages	Energy consumption
1.	Induction billet heating	• Precise metal temperature can be controlled • Advanced skill sets are required to operate the furnace • High installation cost, higher productivity & high-quality forging	370- 450 kWh per tonne

Oil fired metal heating furnaces

Oil fired metal heating (box type) furnaces is a conventional form of metal heating technology widely used across forging industries.

Oil is fired in the box type furnace with help of the burners, heat generated from the combustion is used for the heating the billets (metal). These furnaces typically take few hours during the cold start time. Once the temperature is attained it can be used for continuous operation.

Typical energy Sankey for the oil-fired metal heating furnaces is presented on the right.



Temperature of the furnace is manually controlled by the skilled operators by adjusting the flue and air flow rate to the burners. These furnaces have inherent inefficiencies such as dry flue gas loss, start up and shut down heat loss (thermal loss to refractory).

The specific energy consumption (SEC) of furnaces varies in the range of 100-300 kgoe/tonne.
Oil fired furnaces has highest pentation in the Ludhiana Jalandhar, forging clusters.

Gas fired metal heating furnaces

Gas fired metal heating (box type) furnaces is a slightly advanced form of metal heating technology use the cleaner lower carbon fuel (Natural Gas) for the metal heating. No soot is observed during the combustion. Gas fired furnaces have slightly higher efficiency than oil fired furnaces as lower quality of excess air is required for complete combustion of fuel. Lower excess air help in reducing the dry flue gas loss. Higher level of automation is possible with use of the sensors (temperature and excess air) and automatic control values (fuel and air) which further improves the overall efficiency of the furnace.

Gas is fired in the box type furnace with help of the specially designed gas burners, heat generated from the combustion is used for the heating the billets (metal). These furnaces typically take few hours during the cold start time. Once the temperature is attained it can be used for continuous operation.

Temperature of the furnace is generally controlled by manually controlled by the skilled operators by adjusting the flue and air flow rate to the burners. These furnaces have inherent inefficiencies such as dry flue gas loss, start up and shut down heat loss (thermal loss to refractory).

The specific energy consumption (SEC) of furnaces varies in the range of 100-130 kgoe/tonne. Gas (Natural gas) fired furnaces has highest pentation in the Delhi- NCR forging cluster, and very few units are using the LPG based furnaces in Jalandhar forging cluster.

Table 22: Comparison of metal heating furnace technologies

Sr. No.	Technology / Process	Applications / Advantages	Energy consumption[18]
1.	Induction billet heater	• Better temperature control • Lower scale loss • Higher production, very less start up time • Lower SEC and fuel saving, reduction in SO_x, NO_x	370-580 kWh/tonne
2.	Oil fired heating furnaces	• Lower efficiency, Higher scale loss • Used for heating larger billets • Oil is easily available across different clusters	100-300 kgoe/tonne
3.	Gas fired heating furnaces	• Better temperature control • Used for heating larger billets (multiple size) • Lower SEC and fuel saving, reduction in SO_x, NO_x • However, few clusters have access to NG Pipeline	100-130 kgoe/tonne

[18] SEC also depends upon the metal, technology and SOPs adopted by the specific unit and level of automation and allied processes.

Finishing and Machining

Forged parts generally have the excess metal at the edges in from of flash, which need to be removed in order to produce the final product with required dimension and tolerances. Coining is also required in few of the forged parts. Serval machining and finishing operations are carried out depending upon the type and application of the final product.

Trimming and coning : Forged products removed from the die after forging has flash and extra metal surrounding the forged component. Flash (excess metal) has to be removed either manually or with trimming dies.

Fewer of the medium and large units have adopted the state of art screw presses with VFD for coining and trimming operations.

Shot Blasting: Shot Blasting is a surface treatment process, using high velocity steel abrasive. Shot blasting is used to obtain excellent cleaning and surface preparation for secondary finishing operations, this process removes the scale, particles embedded on the surface of the forged product.

Centrifugal wheel-based shot blasting is the most common blast cleaning technique used in the forging industries.

Rotary turbine delivers abrasive shots by centrifugal force in a specific and controlled direction, speed, and quantity to help the cleaning operations. Turbine in the machine performs the operation similar to that of a fan or centrifugal pump. Shot blasting machines may use one or a multitude of turbines positioned in such a way that the abrasive blast pattern covers the entire surface of the material to be cleaned, material after shot blast provides the cleaner surface and higher surf finish. Operating time of the shot blast depends upon the type of the forging (clos die / open die) and surface finish required, precision and high surface finish forged (flash-less forging, forging formed from presses) require the lesser shot blast operations.

Machining Centres: Serval operations are carried out on the forged parts to get the final product, main machining operations are :Turning, Boring, Drilling , Threading, Grinding etc. These operations are carried out on Automated Lathe machines or Special purpose machines. Modern 3/4/5 axis machine centre provide the user with multiple programmable options to carry out the multiple operations with ease using the computer based programmable control.

State of art CNC and VMC provides higher productivity as compared with conventional machines, these machines don't have multi-directional tool movement. Multi axis CNC machines (5 axis, 6 Axis) provide the flexibility for the tools (multiple tools) movement, which reduces the production time (clamping and de-clamping the workpiece again and again) and improves the product quality

Grinders: Machined forged products are finished with the help of the grinders and finishing rollers to give the product desired surface finish and help in achieving the required tolerances.

Generally, two types of the grinders are used in the forging units – hand grinder and belt grinders. Different types of the grinding wheels are used to obtain the desired degree of surface finish to the final product.

Heat treatment

Heat treatment is an important step after forging. This helps in improving the mechanical properties of ferrous forging. During multiple operations - forging and metal forming stresses are in-creeped in the metallic grain structures. Heat treatment processes help the removing these creeped form the forged products, to make them strong enough or elastic enough for their final application. Use of the gradual heating and cooling of the forged components based on the metallurgy help in relieving the stress.

Different type of heat treatment furnaces are being used across different forging units in different clusters. The main types of HT furnace are presented next.

Oil fired heat treatment furnaces

Oil fired heat treatment furnace is most conventional from the furnaces used to heating of the forged products. These furnaces used different forms of the oils (LDO, LSHS, FO, Diesel) to generate the thermal heat requirement for the operations. These furnaces can be classified as two types based on the operations – box type or continuous (moving belt).

Fuel is fired in the furnace with the help of the specially designed oil burners which atomise the fuel and mixes it with adequate quality of air for the complete combustion. Heat generated by the combustion is used to heat the furnace and metal. Hot flue gas after the waste heat recovery is sent to the atmosphere.

Optimized control of the air fuel ratio; use of the modern EE burners; proper thermal insulation; WHR (limited the sulphur content in the fuel) from flue gas - helps in optimization of the SEC of the oil furnace.

Gas fired heat treatment furnaces

Gas fired heat treatment furnace is modern from the furnaces used to heating of the forged products, with lower emissions (Cleaner fuel). These furnaces used different forms of the fuel (NG, PNG, LPG etc.) to generate the thermal heat requirement for the operations. These furnaces can be classified as two types based on the operations – box type or continuous (moving belt).

Gas is fired in the furnace with the help of the specially designed EE gas burners which help in blending the gas and air in the designed proportion for the complete and efficient combustion.

Heat generated by the combustion is used to heat the furnace and metal. Hot flue gas after the waste heat recovery is sent to the atmosphere.

Optimized control of the air to gas ratio; use of the modern EE gas burners; proper surface thermal insulation; WHR from flue gas - helps in optimization of the SEC of the gas furnace.
Generally used the clusters where the Gas pipe is available, fewer units in the Norther region and Southern regions also use the LPG cylinders as gas source to operate the Gas fired HT furnaces.

Electrically heated heat treatment furnaces

Electrically operated HT furnaces are more efficient than the conventional heat treatment furnaces operated with oil or gas. Mostly gas / oil fired furnaces have higher SEC and lower efficiency due to inherent losses (dry flue gas loss, unburnt losses etc.). Operation of these furnaces require the complex air / fuel ratio control which is often not easily maintained without automation. They also require specially designed burners for precise temperature control in the furnace. Precise control of temperature across different zones or section of the furnace is also not easy to achieve with fuel fired burners.

Electrically operated heat treatment furnaces use multiple resistive heating coils spread across different furnace sections or zones, and hot air circulation fans for uniform heating. These furnaces provide precise temperature control, by use of PID control or advanced PLC controls for switching the electrical heating coils. Since electrical resistive heating inherently offers less variables and therefore less avenues for losses as compared to fuel firing, they are usually able to achieve better SEC than conventional fuel fired furnaces

Sealed Quench Furnace are most advanced form of the integrated heat treatment system which perform multiple operations like - heating, quenching, tempering, cooling, other heat treatment operations etc. SQF uses stationary table, hydraulic lifts, and charge transfer systems to move the forging components across the different sections. Operations are seamlessly performed with advanced automation and precise control with use of modern sensors and PLC systems, thus helping in energy conservation. Sealed quench furnace for various applications like case hardening and carburizing, carbonitriding, normalizing, annealing, ferritic nitrocarburizing, annealing and stress relieving.

Table 23: Comparison of metal heating furnace technologies

Sr. No.	Technology / Process	Applications / Advantages [19]
1	Oil fired	• Large number of LSP are providing the solutions • Can be used where gas pipeline is not available • Use of the advanced EE burners and Automation can help in reduction of the losses
2	Gas fired	• Better air to fuel control can be achieved, regulation of the gas flow / air flow can be automated

[19] Energy consumption of the oil / gas fired furnaces varies in range of 50-120 kgoe/ tonne, this varies with the type of the processes involved during the HT operations. SEC of the fully automated electrical furnace can vary in range of 30-80 kgoe/tonne and if also function of the operations (HT) and level of automation used in furnace.

Sr. No.	Technology / Process	Applications / Advantages [19]
		• Lower losses as compared with oil fired furnaces thus resulting in lower emissions
3.	Electrically operated Heat treatment furnaces	• Reduction in cold start time of furnace • Lower losses as compared with oil / gas fired furnaces thus resulting in lower emissions • Use of multiple coils across the furnace (walls), help in controlling the heating more precisely- resulting in higher quality

Metal forming technologies [20]

Metal heated in the furnace is then deformed to the desired shape by the application of the compressive forces. Different metal forming technologies are presented in below section:

Belts drop type hammer

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 ranges between 0.5 to 3 tonnes.

Electric motors 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 to 3,500 TPA.

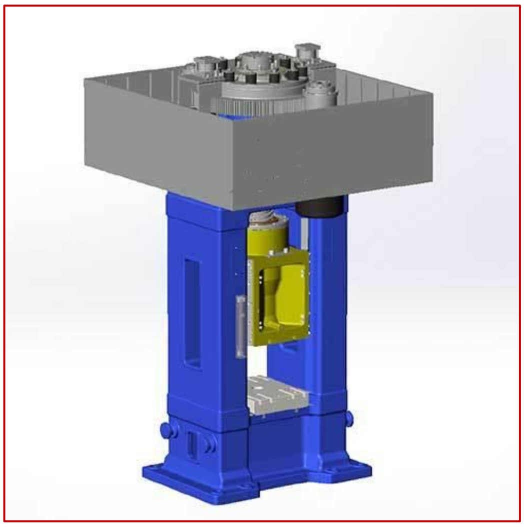
The hammer strikes and deforms the workpiece. Belt drop type hammers are used for forging of hot billets into various shapes. The capacity of the forging hammers typically is in range of 0.5 to 3 tonnes. The board drop hammer is a drop forging machine tool that relies on gravity.

Once the ram is raised to the height needed, the rollers can be pulled apart and the apparatus will be released, sending the forging hammer on its way. 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. The hammer's base is equipped with a rubber padding to act as noise and vibration absorber.

The capacity of the open die hammers is in the range of 0.5 tonnes to 5 tonnes. Unlike in close die hammers, no top and bottom dies are used. Instead, only the hammer and the base on which the job rests (called anvil) are used. Basic jobs forged on these hammers are certain types of shafts and flats.

[20] https://www.forging.org/forging/design/523-ring-rolling-process.html *Accessed on 16-Jul-2020*

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 to 150 HP. Screw presses with electrical motors of 5 to 30 HP are used for trimming and coining operations.

These presses are operated with pneumatic clutch and brake and screw is used for adjusting the height of stroke length. It is used mostly with shaft end heating jobs.

Screw presses are predominantly used for the close die forging applications. Modern flash less forging also use the modern screw presses.

Pneumatic hammers and Hydraulic hammers

Pneumatic hammers are conventional forms of the forming machines primarily used for open die forging operations. There are two type of the pneumatic press one type is with inbuilt compressor and other presses have central air compressors. Compressed air is used to move the piston which moves the ram – used for metal forming operations.

Motors used for the compressors for these presses vary in range of 50-150 kW. These hammers are used to forge the large, forged products. Weight of the forged products varies from few hundred kilo grams to few tonnes.

Pneumatic hammers are predominantly used in Ludhiana and Bangalore forging clusters to forge the products for oil & gas industry Maintaining the air pressure and controlling the air leakages are the main challenges with these hammers.

Hydraulic hammers are also used by limited forging units to carry out the open die forging operations. Hydraulic pressure is used to move the ram, this ram is used to forge the metal to desired shape. These hammers are used to forge the large, forged products. Weight of the forged products varies from few hundred kilo grams to few tonnes.

Hydraulic hammers are predominantly used across the Delhi-NCR forging cluster and few units in Bangalore forging cluster.

Pneumatic clustch operated electrical press

Modern electric presses with pneumatic clutches are widely used in the forging industry to produce the higher quality and higher precision forging products. Presses are operated with electrical motors and during the stroke cycle the pneumatic clutch is used to engage the rotating flywheel to the ram, which moves the ram down to deform the metal in the designed shape.

Presses are used in the forging industry for the close die operations. Capacity of the presses varies from 1000 tonnes to 4000 tonnes across MSMES forging units. Presses are driven with the help of electrical motors and capacity of motors varies from 50 HP to 200 HP. Compressed air for the pneumatic clutch is served by the help of the auxiliary air compressor which delivers the air around 5-7 bar as per the design of the clutch. Modern presses are equipped with VFD, which further help in the reduction of the energy consumption.

Table 24: Comparison of metal forming technologies

Sr. No.	Technology / Process	Applications / Advantages
1.	Drop Hammer	• Mainly used in close die operations • Higher surface fishing of the forged product • Lower flash generation
2.	Pneumatic clutch operated electric presses	• Mainly used in close die operations • Higher surface fishing of the forged product • Lower flash generation, higher quality forging
3.	Screw Press	• Mainly used in close die operations • Higher surface fishing of the forged product • Used with dies for flash-less forging operations
4.	Pneumatic hammer	• Flexibility of the operation and used for open die forging • Higher noise and vibration
5.	Hydraulic Hammer	• Higher productivity, lower energy consumption • Lower noise and vibration • Mainly used for open die forging and limited application in close die forging

Utilities

Utilities like compressed air, cooling water, oil, etc. are being used to support the forging operations. Compressed air is mainly used in the core preparation, knock out and in machining section. Cooling water is used to cool the machines, induction coils and machines etc.

Several utilities are required to support the forging operation in the industry. Most commonly used utility along with applications are presented in below:

Cooling Tower

Cooling tower helps in rejecting the heat from the induction furnace and maintaining the required temperature of the induction coils and panel cooling of induction heater. Cooling towers are also used along with centralized cooling units. Cooling water from cooling tower helps in removal of the heat from Induction billet heaters, air compressors, and other utilities.

Most of the units use the FRP based cooling towers for the cooling applications. Fewer units (<5%) also use the fan less FRP based cooling tower to the processing cooling requirement.

Air Compressor

Compressed air in the forging operations - mainly in pneumatic clutches for presses grinders, shot blast and cleaning.

Reciprocating screw compressors are generally used by micro and small forging units to meet the compressed air requirement of the unit. Screw compressors are mostly used by the medium scale forging performing open die operations.

A few units in the Pune have also adopted the modern state of art Permanent magnet screw compressor to meet the process air requirement. SEC for these compressors are ~ 0.13-0.14 kW/cfm as compared to 0.25-0. kW/cfm for reciprocating compressors.

Motors and Pump Sets

Motors are used for power – hammers presses, grinding, shot blast, CNC, drilling, turning and other machines for the machining and finishing operation. *IE2 is predominantly used across the forging clusters, progressive clusters like Ludhiana Bangalore also use the modern EE IE3 motors*. IE4 *motors have 5-10% higher efficiency as compared with conventional IE2 motors.*

Pump sets

Pump sets are used to pump the cooling water and other liquid utilizes in the plant. Induction billet heaters require cooling of coils in IBH and cooling electronic panel. Pumps running on DM water serve this purpose.

Pumps are used along with induction heating furnaces to maintain the panels and coil cooling applications. Forging in general have end suction mono-block pumps serving the purpose.

B. Energy Consumption and Benchmarks

B. Energy Efficiency Technology compendium

Energy efficient technologies are usually sector specific but also governed by type of the products manufactured in the cluster, fuel availability along with the awareness, technology availability and level of sophistication etc.

Different clusters have different requirements depending upon the present level of technologies being used and progressiveness of the specific cluster. We have evaluated and subsequently prioritized EE technologies for different forging clusters based on various parameters such as investment cost, energy savings potential, payback period, replication potential etc

Average investment cost	Scalability/ replicability in other similar industries	Technical feasibility (Energy savings potential)	Financial feasibility- IRR, NPV, payback period

Project team has carried out the in-depth review of the EE technologies based on primary data collection, energy audits carried out in the cluster and in close consultation with IAs and technology providers. EE technologies relevant to the forging clusters are explained in below section:

Team has segregated the EE technologies in two categories based on their applicability in the short-term (next 5 years) and long-term (next 10 years). For all identified EETs replication potential is estimated and segregated into following four categories:

- Low Potential: Less than 10% MSMEs in cluster have replication potential
- Medium Potential: 10%-30% MSMEs in cluster have replication potential
- High Potential: 30%-60% MSMEs in cluster have replication potential
- Saturation: More than 60% MSMEs in the cluster have implemented EET

Process specific Energy conservation measures

Table 25: Process specific replication potential of ECM across forging clusters

S. No.	Technologies	Energy savings potential	Replication Potential in short-term (till 2025)			Replication Potential in long-term (till 2030)		
			Micro	Small	Medium	Micro	Small	Medium
1.	New generation IBH with IGBT control along with IoT based alerts and automation	10-30%	High	Medium	Saturation	Saturation	Saturation	Saturation
2.	Use of modern pneumatic clutch all electric presses with VFD for forging	5%	Low	Medium	Medium	High	High	Saturation
3.	Installation of automatic robotic forging lines	5%		Medium	High	Low	Saturation	Saturation
4.	Fuel switch in Oil- NG	5-10%	Low	High	High	Saturation	Saturation	Saturation
5.	Relining of furnaces / Insulation	5-10%	High	High	Saturation	Saturation	Saturation	Saturation
6.	Electrically operated Heat treatment / Annealing / Normalization furnaces	20-30%	Low	High	Saturation	High	Saturation	Saturation
7.	Flash less forging	5-10%		Low	High	Low	High	Saturation
8.	Installation of robotic automation in forging lines (Hammers and Presses)	3-5%		Low	Low	Low	High	Saturation
9.	Automatic continuous lines	10-20%			Low		Low	Low
10.	Use of Hydraulic Hammers instead of Pneumatic Hammers	30-40%		Low	High		Saturation	Saturation
11.	Multi axis Machining centre (5 / 6 Axis with automatic tool changer)	5-10%	Low	Medium	High	Medium	Saturation	Saturation
12.	IoT based EMS	2-5%	Low	Medium	Medium	Medium	Saturation	Saturation

Utility specific Energy conservation measures

Table 26: Utility specific replication potential of ECM across forging clusters

S. No	Technologies	Energy savings potential	Replication Potential in short-term (till 2025)			Replication Potential in long-term (till 2030)		
			Micro	Small	Medium	Micro	Small	Medium
1	IE3/IE4 motors	5-15%	Low	Low	Medium	High	High	Saturation
2	EE FRP Cooling towers with temperature control and VFD / Fan less Natural draft FRP based cooling tower	5-10%	Low	Medium	Medium	High	High	Saturation
3	Appropriate size of air compressor / Arresting air leakage and pressure optimization	10-30%	Medium	Medium	Low	High	High	Saturation
4	PM Screw Compressor with waste heat recovery	20-30%		Medium	High	High	Saturation	Saturation
5	Heat Pump	10-30%			Low			High
6	Use of EE Hydraulic power pack (with Servo drive) for Clamping application	20-40%	Low	Low	High	Medium	Saturation	Saturation
7	EE retrofit of low friction metallic pipe for compressed air system	10-30%	Low	Medium	Saturation	High	Saturation	Saturation
8	Energy Efficient Transformers	20-50%	High	Medium	Saturation	Saturation	Saturation	Saturation
9	EE Air conditioner / Chillers	10-25%	Low	Saturation	Saturation	Saturation	Saturation	Saturation
10	Automatic Power factor Controller	5-10%	Medium	Medium	Saturation	Saturation	Saturation	Saturation
11	Energy Efficient Blower	20-30%	Medium	Low		High		
12	Energy Efficient Pumps	20-30%	Medium	Saturation	Saturation	High	Saturation	Saturation
13	LED lights	10-50%	Saturation	Saturation	Saturation	Saturation	Saturation	Saturation

EE technologies for metal reheating, heat treatment and forging process

Forging industry is energy intensive and energy cost accounts for about 20–30% of total production cost. Metal reheating accounts for 30-70% while heat treatment and forging process account for 20-50% of the total energy consumption in the forging industries. Specific Energy Consumption (SEC) for the induction-based heating furnace range between 250-700 kWh per tonne of liquid metal, Furnaces have a huge potential for energy conservation, around 20-35% of the energy can be saved - by selecting right type and size of equipment, automation of processes, and by adopting best operational practices.

Conversion of conventional furnaces to IBH

IBH is the most efficient technology for the metal heating, electromagnetic energy is used for heating the metal to desired temperature. IBH is considered as the cleanest technology for metal heating free from the emissions, use of the IBH also helps in the reduction of the metal in form of scale. Precise temperature can be maintained using the billet heater with IGBT control system.

FO fired furnace

Induction Billet Heater

Figure 20: Installing IBH in place of Oil-fired furnace

Features

- **Lower fuel consumption**
- **Precision temperature control**
- **Reduction in scale loss, scale loss in range of 1-2% only, less as compared with oil and gas fired furnaces**
- **Lower emissions**
- **Average Payback Period: ~ 18-30 months**

Case Study (Oil fired Furnace to IBH)[21]

EE measure has been carried out in one of the MSME unit with average production of 930 tonne per year for metal heating furnace, under **BEE-WB-GEF-SIDBI programme**. FO -box fired furnace inefficient furnace (operating efficiency around 10%) is replaced with IBH furnace (capacity 500 kg/hour, 200 kW rated IBH) for metal heating, this intervention in the unit has led to saving of **72%** of the energy consumption of the furnace with simple payback period of 19 **months**.

[21] http://www.sameeeksha.org/pdf/CS_Forging_Pune-P1.pdf- Accessed on 13th August 2020

Fuel switch in furnace FO to NG

Use of the natural gas is better than the use of the furnace oil for the furnaces. Natural gas is cleaner fuel compared with Oil. Gas fired burners are having higher efficiency as compared with oil fired burner due to better air to fuel mix, also lower quantity of excess air is required for gas fired system vis-à-vis oil fired system – thus leading to lower flue gas loss. Emissions (SOx, NOx) from the NG are lower and can be controlled better.

FO Fired Furnace **NG Fired Furnace**

Figure 21: Low friction compressed air piping and fittings

Features

- **Higher efficiency due to lower flue gas loss**
- **Higher combustion efficiency**
- **Lower emissions**
- **Cleaner workspace**
- **Average Payback Period: ~ 18-24 months**

Case Study[22]

EE measure has been carried out in one of the MSME unit with average production of 1,000 tonne per year for three heat treatment furnaces, under **BEE-WB-GEF-SIDBI programme**. This intervention in the unit has led to saving of ***12%*** *of the energy consumption of the furnace* with simple payback period of 21 ***months***.

[22] http://www.sameeeksha.org/pdf/CS_Forging_Pune-P4.pdf- Accessed on 13th August 2020

Automation of fuel feeding in furnaces

Automation for the fuel feeding and combustion air control is widely used to control the appropriate combustion in the furnaces. Excess air control is monitored in the flue gas and fee forward control is being used to control the combustion of the fuel in the furnaces. Precise maintenance of the controlling is not possible with use of the automation via PLC with looped with data signals of the sensors helps in improving the overall efficiency of the furnace. Further resulting in lowering the emissions (SOx, NOx) from furnace.

Inefficient Forging Furnace

Energy efficient Forging Furnace with automated control systems

Figure 22 Automated control systems

Features

- **Higher efficiency due to lower flue gas loss**
- **Higher combustion efficiency – lower dry flue gas loss**
- **Lower emission**
- **Average payback period: ~18-24 months**

Case Study[23]

EE measure has been carried out in one of the MSME unit with average production of 1,248 tonne per year for FO fired heat treatment furnaces, under **BEE-WB-GEF-SIDBI programme**. This intervention in the unit has led to saving of 29% of the energy consumption of the furnace with simple payback period of less than **6 months**.

[23] http://www.sameeeksha.org/pdf/CS_Forging_Pune-P13.pdf- Accessed on 13th August 2020

Recuperative Burners

Heat treatment process involves re-heating of metal in the range of 500-800 degree centigrade. Most of the units use FO/Gas fired furnaces for heat treatment. Temperature of exhaust flue gas from the heat furnace varies in range of 150-400 °C. Higher the exhaust flue gas temperature higher will be dry flue gas loss from the furnace.

Recuperative burners are equipped with heat exchanger to preheat the incoming combustion air with the exhaust gases from combustion (Figure 23)[24]. These systems can lead to energy savings up to 30% and lower fuel consumption and emissions. The burners can be retrofitted to existing heating systems. The recuperative burners are also economical due to their simpler construction among the non-conventional burner systems.

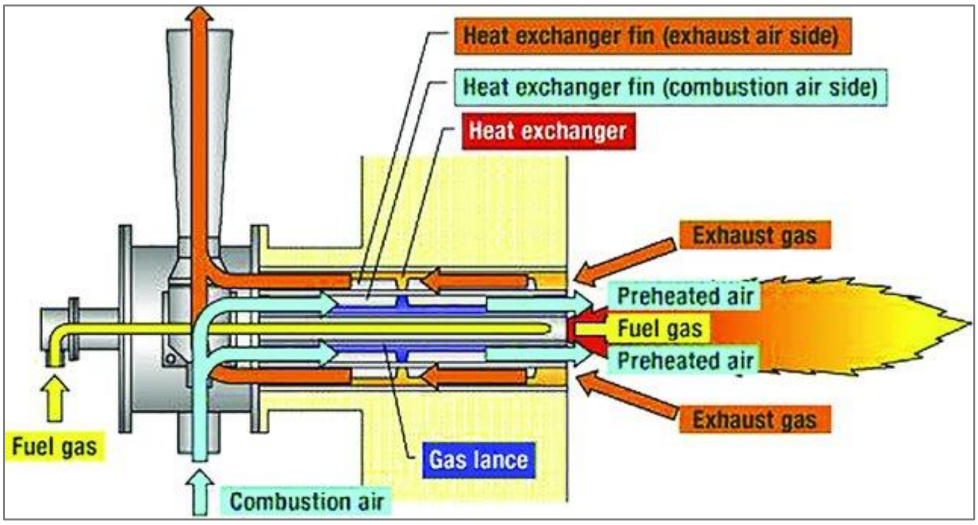


Figure 23 Operation of Recuperative Burners

Features

- **Lower fuel consumption**
- **Lower emissions**
- **Simple construction and control**
- **Reduction on flue gas exit temperature**
- **Recovery of the waste heat and increased operating efficiency of the furnace**
- **Every 22°C reduction in flue gas exit temperature helps in improving efficiency by 1%**

Case Study (Retrofitting recuperative burner system to diesel burners) [25]

EE measure has been carried out in one of the forging units with 450 kW burner capacity and annual consumption of 56,160 kg of diesel. The investment cost of the recuperative burner system is estimated to be INR 6.33 lakhs. This intervention in the unit has led to savings of 5% of the annual energy consumption with simple payback of 5.9 years and 14.8% IRR.

[24] Jouhara, H. et al. (2018). Waste Heat Recovery Technologies and Applications. Thermal Science and Engineering Progress. 6. 10.1016/j.tsep.2018.04.017.
[25] *Powermag.com*

PLC based automation for Oil/Gas to air ratio for Blower

For the complete combustion of the fuel, adequate supply of air is required. In a typical furnace, the excess air and CO in flue gas are not monitored. Lower air to fuel ratio leads to incomplete combustion (CO loss) thus leading to energy losses. Conversely, higher quantity of combustion air will result in higher fraction of dry flue gas losses. The PLC based automation system for blower monitors the composition of flue gases and controls the air flow required to enhance complete combustion products and lower the emissions. The system can also control the temperature of the metal.

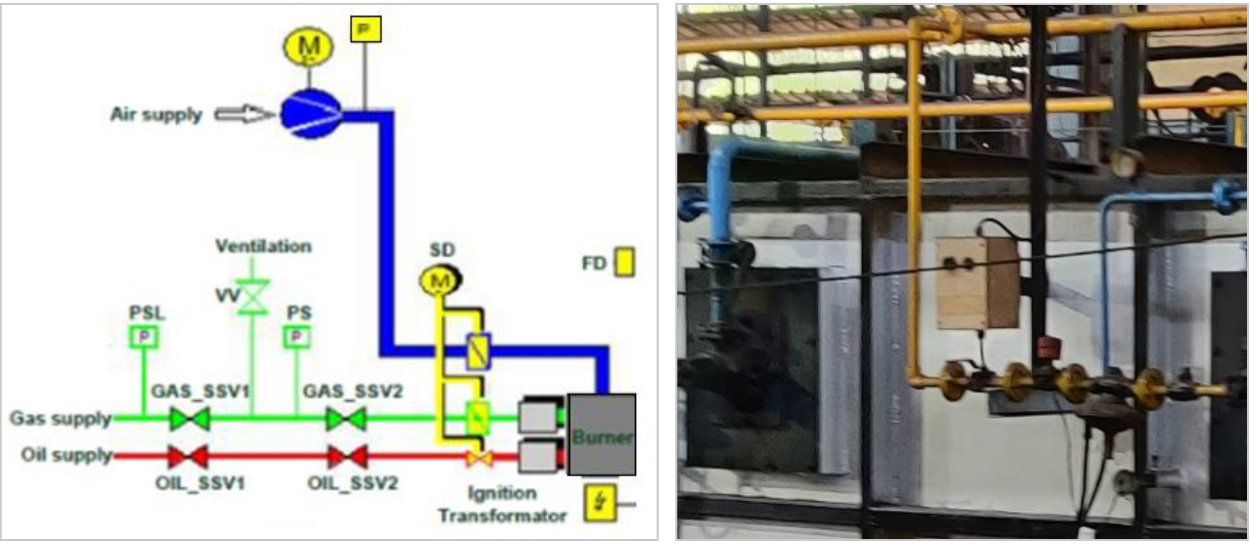


Figure 24 PLC automation system for Fuel to Air Ratio Control

Features

- **Higher combustion efficiency**
- **Lower Gas/Oil consumption**
- **Lower unburnt in the fuel (lower CO level in flue gas)**
- **Better temperature control of the metal**
- **Average payback period: ~ 6-12 months**

Replacement of pneumatic hammers with Hydraulic hammers

Pneumatic hammers are used to forge the large forge products in range of 100-1000 kg/piece (Products – flanges, shafts etc.). Pneumatic / Steam hammers had been used as the conventional technology by most of the forging units.

Higher capacity compressors along with larger receiver capacity are required to meet the forging operation, thus making it most energy intensive process.

Hydraulic hammer with fully hydraulic die forging hammer is high-end and new innovative EE technology which results in saving of 30-40% of energy consumption. Typical type of hammers commonly used to forge the products are – close die hammer (high precision products), counter blow hammers (flanges, shafts) etc.

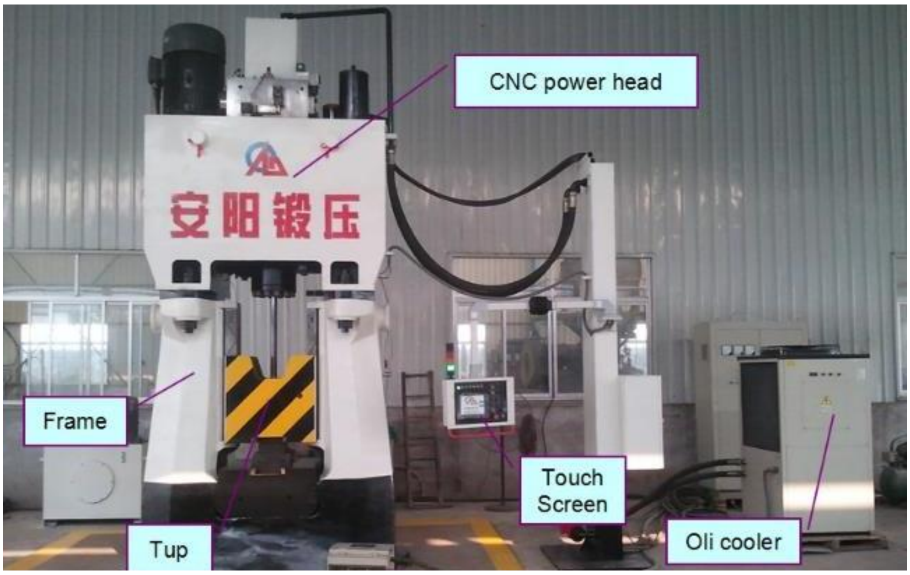


Figure 25 Hydraulic hammers

Features

- **Higher precision products, lower operation time**
- **Possibility of automation**
- **Higher efficiency, lower energy consumption**
- **Lower noise and vibration**
- **Average Payback Period: ~ 24-36 months**

Application of veneering module in furnace

Heating and heat treatment furnaces used in the forging application are used to heat the metal to desired temperature. During the heating process the walls of the furnace are also absorb the heat. Hot surface of furnace causes the loss in form of radiation and convection (Furnace Walls) to atmosphere leading to the loss of the energy. Other major loss in furnaces is due of heat storage in the walls, during the start-up and shut down the thermal energy is stored in the furnaces wall, leading to loss of the energy. Veneering is a technology where in the thermal barrier is created between the walls of the furnace and inner combustion chamber, this thermal barrier helps in reduction of the temperature of the furnace walls, which helps in reduction of the thermal losses and improving the overall efficiency of the furnace. Further resulting in lower fuel consumption, lowering the emissions (SO_x, NO_x) from furnace. (Figure 26)

Before Veneering

After Veneering

Figure 26: Application of veneering module in LPG Fired Normalizing Furnace

Features

- **Lower fuel consumption**
- **Precision temperature control**
- **Reduction in scale loss, scale loss in range of 1-2% only, less as compared with oil and gas fired furnaces**
- **Lower emissions**
- **Average Payback Period: ~ 18-30 months**

Case Study[26]

EE measure has been carried out in one of the MSME unit with average production of 1,500 tonne per year for 600 kg/hour LPG fired normalizing furnaces with operational efficiency of around 10%, under **BEE-WB-GEF-SIDBI programme**. This intervention in the unit has led to saving of Rupees 11 lakhs/ year ***with*** simple payback period of less than 6 ***months***.

[26] http://www.sameeeksha.org/pdf/CS_Forging_Pune-P8.pdf- Accessed on 17th August 2020

Application of appropriate ceramic insulation on hot surface

Heating and heat treatment furnaces used in the forging application are used to heat the metal to desired temperature. During the heating process the walls of the furnace are also absorb the heat. Hot surface of furnace causes the loss in form of radiation and convection (Furnace Walls) to atmosphere leading to the loss of the energy. Use of the appropriate insulation helps in isolation of the hot furnace environment form the external atmosphere. This thermal helps in reduction of the temperature of the furnace walls, which helps in reduction of the thermal losses and improving the overall efficiency of the furnace. Further resulting in lower fuel consumption, lowering the emissions (SOx, NOx) from furnace.

Before **After**

Figure 27: Application of ceramic fibre insulation on hot surface

Features

- **Reduction in cold start time of furnace**
- **Lower temperature in workspace leading to increased comfort to work near the furnace, helps in reduction of fatigue in work force- leading to higher productivity**
- **Lower emissions**
- **Average Payback Period: ~ 6 months**

Case Study[27]

EE measure has been carried out in one of the MSME unit with average production of 3,600 tonne per year for 200 kg/hour NG fired forging, under **BEE-WB-GEF-SIDBI programme**. This intervention in the unit has led to saving of Rupees 4.8 lakhs/ year ***with*** simple payback period of less than 6 ***months***.

Forging Presses (Pneumatic clutch electrical presses)

Electrical presses with pneumatic clutches are available for the forging industry to produce the higher precision forged products; presses are used to forge the products ranging from few grams to few kilograms. Forged products from these presses are having superior quality; presses also help in reducing cycle time. Use of the VFD on the motor help in optimization of energy consumption.

Features

- **Higher precision products, lower operation time**
- **Possibility of automation**
- **Lower machining required**
- **Average Payback Period: ~ 18-30 months**

[27] http://www.sameeeksha.org/pdf/CS_Forging_Pune-P8.pdf- Accessed on 18th August 2020

Relining of the heat treatment furnace

During field study temperature of the furnace surface was in range of 40-139°C. Higher surface temperature leads to higher heat losses from the surface. Appropriate relining of the furnace internal surfaces resulted in saving of about 5-10% in energy consumption.

Thermal loss through surface

Surface temperature profile after thermo-ceramic coating

Figure 28: Relining of heat treatment furnace

Case Study

Features

- **Lower heat loss from surface, fuel saving, better working environment in the vicinity of the furnace**
- **Lower emissions**
- **Average Payback Period: < 7 months**

EE measure has been carried out in one of the MSME unit with average fuel savings of 7,000 kg of fuel and monetary savings of Rs. 4.3 lakh. The equivalent GHG reduction was about 20.5 tCO_2/year.

VFD for Press motors and Screw press

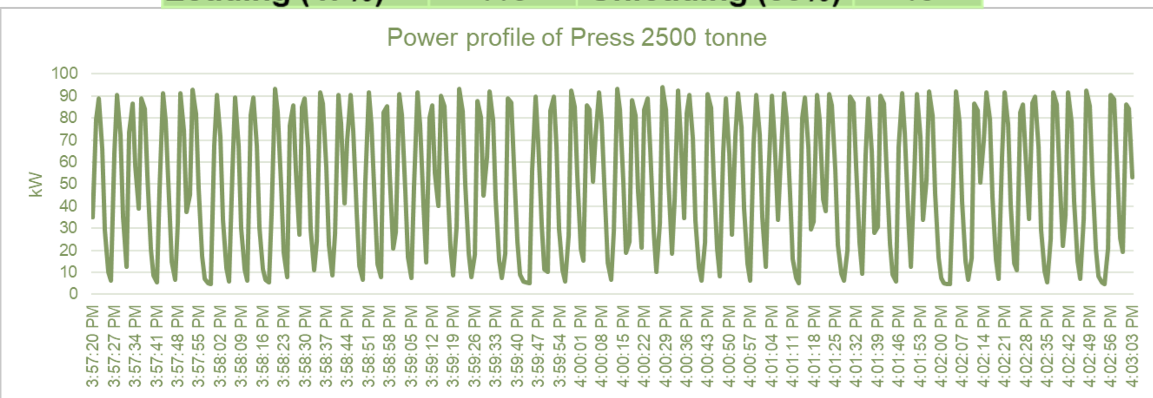
Motors of the presses operate continuously during the forging operations. During the reverse cycle, motor speed can be controlled to conserve the energy. Also, some of the forging operations have a time lag between cycles. During that time VFD can be used to control the motor loading for energy saving.

Using same press for multiple forging operations, if some forging products can be formed at lower rpm, then frequency controlling will help in optimization of energy.

Features

- **Energy savings in press during unloading cycle**
- **Lower emissions**
- **Average Payback Period: Varies upon loading and unloading pattern**

Energy consumption (kWh /day)			
Loading (47%)	413	**Unloading (53%)**	46



Energy consumption (kWh /day)			
Loading (53%)	402	**Unloading (47%)**	4.8

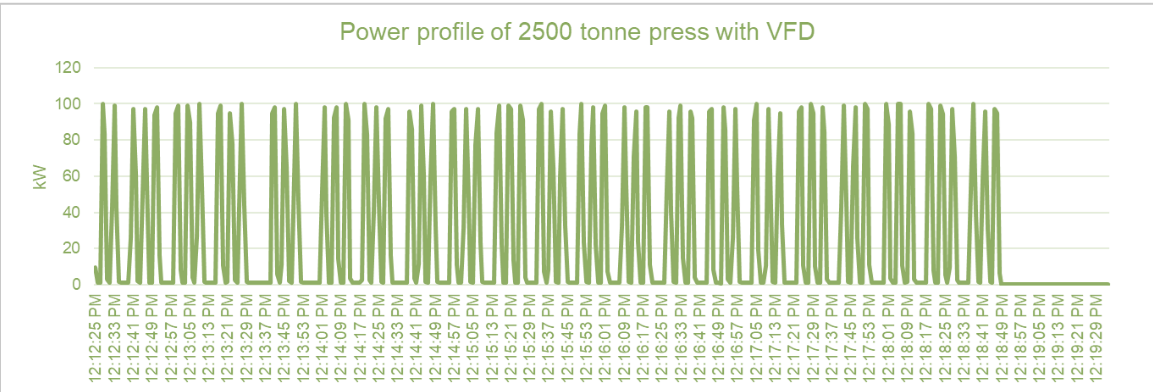


Figure 29 VFD for Press Motors and Screw Press

Electrical Heat treatment / Annealing / Normalization furnaces

During the heating process the walls of the furnace are also absorb the heat. Hot surface of furnace causes the loss in form of radiation and convection (Furnace Walls) to atmosphere leading to the loss of the energy. Use of the appropriate insulation helps in isolation of the hot furnace environment form the external atmosphere. This thermal helps in reduction of the temperature of the furnace walls, which helps in reduction of the thermal losses and improving the overall efficiency of the furnace.

Figure 30 Electrical furnace for heat treatment

Features

- **Reduction in cold start time of furnace**
- **Lower losses as compared with oil / gas fired furnaces, resulting in lower emissions**
- **Use of multiple coils across the furnace (walls), help in controlling the heating more precisely- resulting in higher quality**

Multi – Axis CNC machine

Most of the small and medium forging units use the CNC, VMC machines, and micro forging still use the conventional lathe, drilling etc. machines for the machining operations. CNC and VMC provides higher productivity as compared with conventional machines, these machines don't have multi-directional tool movement. Multi axis CNC machines (5 axes, 6 axes) provide the flexibility for the tools (multiple tools) movement, which reduces the production time (clamping and decamping the workpiece again and again) and improves the product quality (Figure 31)[28].

Figure 31 Multi Axes CNC Machine

Features

- **Improves the productivity and product quality**
- **Higher efficiency – use of IE4 and higher motors**
- **Average payback period: ~18-36 months**

[28] *Makino, Vertical 5-Axis,* https://www.makino.com/en-us/machine-technology/machines/vertical-5-axis

Energy monitoring system - IoT Based Platform[29]

Real time energy data (fuel used in heating furnaces, electricity consumed in Inducting billet heating furnaces, Compressor, pump sets) in the MSME forging units is not monitored. With use of IoT based application enabled with reliable high speed internet data, smart metering systems makes it viable to - record, save and transmit energy data of each equipment and communicate to the energy manager. Use of the data and trends, with auto generated alerts and flags will help operations team to identify opportunities to reduce the energy consumption on real time basis. With use of the IoT based EnMS there is potential of energy saving in range of 2-5%.

Features

- **Real time monitoring and preventive actions**
- **Reduction in failures and breakdowns**
- **Improve availability and reliability of the process, resulting in lowering SEC of the unit**
- **Average payback period: ~18-36 months**

Case Study[30]

IoT based system has been implemented one forging unit **in Pune** with production capacity of 300 tonne/ month. IoT based system is used to derive the baseline energy scenario of the unit over the period of 15 days. Use of the ***AI*** along with **real time data monitoring** has helped the unit to identify the losses in the *compressed air system, pumping system and transformer losses*.

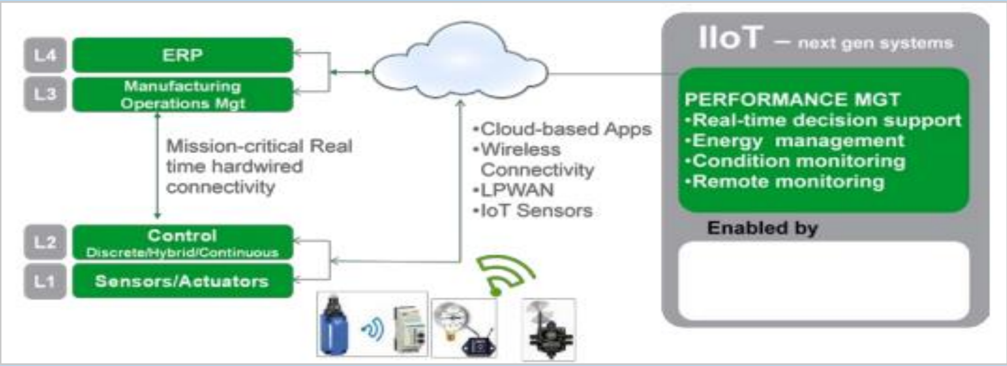


Figure 32: IoT based real time energy management

With advanced analytic and feedback received from IoT platform, unit can save –

- **~300 kWh/day** in compressed air system
- **~50 kWh/day** in water pumping system
- **~ 25 kWh/day** in transformer network

[29] https://download.schneider-electric.com/files?p_enDocType=White+Paper&p_File_Name=998-2095-10-16-15BR0_EN.pdf&p_Doc_Ref=998-2095-10-16-15BR0_EN

[30] Implemented in one unit in Pune

EE retrofits (Utilities)

Several low investment EE retrofits are available which helps in reduction of energy consumption in the equipment and utilities, without impacting the process parameters. Details of the EE retrofits relevant to the forging industries is presented in this section along with the case studies from the past interventions under BEE programs.

EE motor for Hammer and Presses

Higher efficiency class motors IE3, IE4 are more efficient than with IE2 and IE1 motors. Lower efficiency of the motor leads to the higher energy consumption. Re-wound motor is less efficient than new motors, with every re-winding efficiency of the due to quality of wire, increase in resistance per phase etc.[31].

Features

- **Lower energy consumption**
- **Higher efficiency**
- **Average payback period: ~ 18-30 months**

Use of FRP blades in cooling tower fans

Fibre Reinforced plastic (FRP) blades are now widely used in the forced draft cooling towers, FRP based blades are lighter as compared with the conventional metallic blades (Figure 33), lighter weight of the blades helps in the reduction of the energy consumption. These blades have the better aerodynamic properties as compared with conventional metallic blades. Use of these blades improves the life of the drive system.

Metallic bladded fan **Fibre reinforced blended plastic fan**

Figure 33: FRP blade cooling tower

Features

- **Lower energy consumption**
- **Improved corrosion and erosion resistance**
- **Low noise level**
- **Average payback period: ~ 12-18 months**

[31] https://beeindia.gov.in/sites/default/files/4Ch5.pdf- Accessed on 14th August 2020

Use of appropriate size air compressor

Inadequate size of the compressors leads to the frequent loading and unloading of the compressors. There is loss of the energy during this activity and during the unloading time there in minimal energy requirement. Thus, leading to higher energy consumption and higher SEC.

Existing Air Compressor

Downsized EE Compressor

Figure 34: Appropriate size compressor

Features

- **Reduced unloading time**
- **Variable speed drives help in the fine adjustment of the operating parameters**
- **Better SEC of the system**
- **Average payback period: ~ 18-24 months**

Use of Hydraulic power pack

Hydraulic power packs are used on machines for operating hydraulic actuators. Hydraulic actuators may be used for slide movement, job clamping - decamping etc. The conventional hydraulic power pack has a continuously operated hydraulic pump which maintains the pressure required for the operation. On conventional machines, the hydraulic systems provide peak power for a very short time and the hydraulic system is over-rated for most of the time. When there is no requirement of actuation (or during hold condition), the conventional hydraulic power pack operates continuously, even during times like setting of machines for new job, breaks etc. Further resulting in lower energy consumption, lowering the emissions (SOx, NOx) from furnace. VFD controls frequency of AC electrical power and, in turn, can control the speed of a synchronous motor to always maintain the required pressure.

Features

- **Reduce the use of the energy during holding time**
- **Use of VFD along with hydraulic power pack helps in reduction of heat loss and lowering the load on cooling tower**
- **Reduction in noise and less wear and tear of machine**
- **Average payback period: ~ 12-24 months**

Permanent Magnet Screw air compressor with waste heat recovery

Permanent magnet-based screw air compressors are one the premium air compressors available that provides the lowest SEC. Compressor uses the premium IE5 equivalent motors and waste heat generated from the compressor can be used to heat the water via heat exchanger. Hot fluid (water) can be used for process applications. SEC of the compressor varies in range of (12-14 kW/100 cfm)[32].

Features

- **Lower energy consumption**
- **Efficiency of motor up to 95-96% can be achieved**
- **Hot water/ air from WHR can be used for process heating application**
- **Average payback period: ~ 30-42 months**

Use of Heat Pump for waste heat recovery

Heat pumps can be used to recover the lower temperature (50-100°C) waste heat from different applications. Heat pumps utilize low grade - hot water, exhaust gases, fuel any combination of these heat sources, to pump heat. Heat pumps can be used to recover 10-35% of waste heat from the process. Presently only less than 1% of the units use the heat pump technology.

Features

- **Recovery of low temperature WHR recovery**
- **Hot water can be used for heating application of washing, electroplating etc.**
- **Lower emissions**
- **Average payback period: ~ 24-48 months**

EE motor for water pump set

Higher efficiency class motors IE3, IE4 are more efficient than with IE2 and IE1 motors. Lower efficiency of the motor leads to the higher energy consumption. Re-wound motor is less efficient than new motors, with every re-winding efficiency of the due to quality of wire, increase in resistance per phase etc.[33].

Features

- **Lower energy consumption**
- **Higher efficiency**
- **Adequate flow and head**
- **Average payback period: ~ 6-15 months**

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[32] 7 bar pressure for service air

[33] https://beeindia.gov.in/sites/default/files/4Ch5.pdf- *Accessed on 14th August 2020*

Use of Metallic low friction piping for compressed air system

High surface finish aluminium based compressed air piping system helps in the reduction of the pressure drop in the piping network; use of the leakage proof fittings helps in lowering the compressed air leakage from the piping network. Implementing this retrofit will help in reduction of the discharge pressure (due to lower pressure loss) from the compressor; Lower demand of the compressed air quantity (due to lower leakages) (Figure 35) helps in reduction of the total energy consumption of the compressed air system. Reduction of 1 bar generation pressure at compressor alone results in 6-10% reduction in energy consumption at compressor[34].

Figure 35: Low friction compressed air piping and fittings

Features

- **Reduced pressure drop**
- **Reduction in leakages**
- **Reduced energy consumption in compressed air system**
- **Average payback period: ~ 12-24 months**

Case Study[35]

EE retrofit has been carried out in one of the MSME unit, under **BEE-UNIDO programme –** *"Promoting Energy Efficiency and Renewable Energy in selected MSME clusters".* This intervention in the unit has led to saving of ***20%*** *of the energy consumption for the compressed air system****.*** with simple payback period of ***15 months***.

[34] *https://beeindia.gov.in/sites/default/files/3Ch3.pdf - Accessed on 13th August 2020*
[35] *http://www.sameeeksha.org/pdf/5-cs-Installing-new-pipeline-compressed-air-Belgaum.pdf Accessed on 13th August 2020*

Automatic Power Factor Controller (APFC)

The forging units have components running on inductive loads. These loads lead to lagging power factor of the unit overall. The low power factor is responsible for higher power consumption and penalty from utility beyond the particular set range. The Automatic Power Factor Controller (APFC) is a microprocessor based control which maintains the power factor close to unity by providing appropriate capacitive/leading load at the transformer level.

Features

- **Lower energy consumption**
- **Lower electricity bills**
- **Reduced losses**
- **Average payback period: ~ 6-15 months**

Energy Efficient Lighting System

Lightings consume 5-10% of the overall energy in the units. Several units are still using the conventional lighting systems such as incandescent bulbs, CFL, metal halide lamps etc. The new energy efficient LED lighting system consume one third to a half of the energy to provide equivalent illumination. Furthermore, automation of these lighting system based on occupants or time of day in certain locations can lead to additional savings. Alternatives such as light pipe can also be used to maximize daylight usage for illumination.

Features

- **Lower energy consumption**
- **Longer lifetime**
- **Reduced O&M cost**
- **Average payback period: ~ 12-24 months**

Use of appropriate size motors

As the loading on the motor decrease the efficiency of the motors decreases, at loading below 60% the efficiency of the motor fall at faster rate as presented[36] in Figure 36. Thus, operating the motors at lower capacity than rated leads to the inefficient operation leading to higher energy consumption in the system.

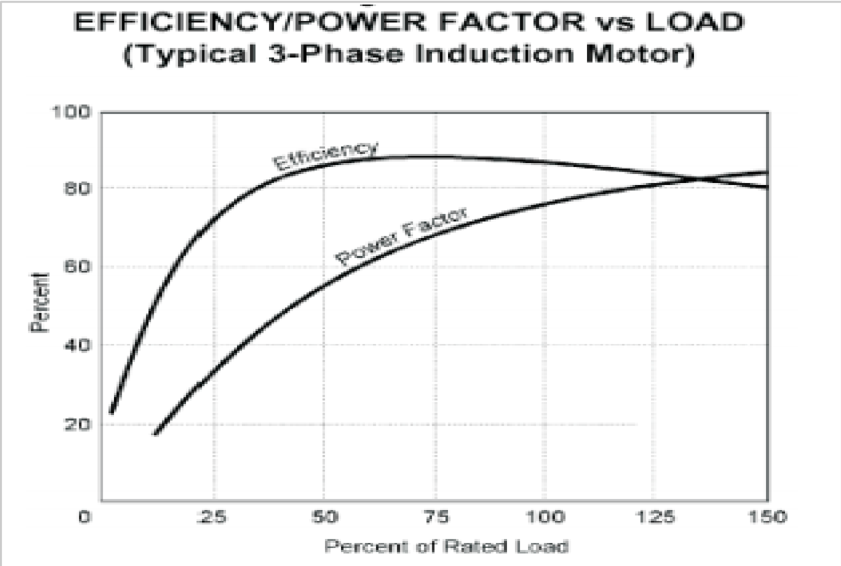


Figure 36: Efficiency v/s loading of motors

Features

- **Lower energy consumption**
- **Higher efficiency**
- **Average payback period: ~ 6-30 months**

Case Study[37]

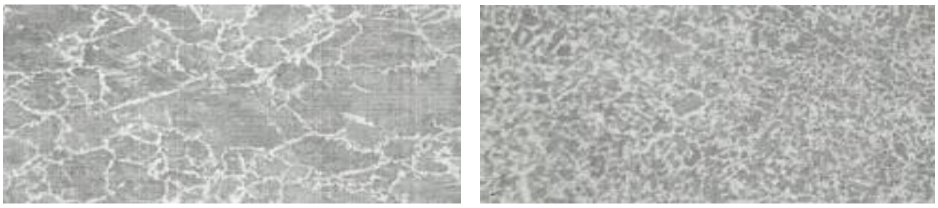
EE measure has been carried out in one of the MSME unit with under **BEE-UNIDO programme** – *"Promoting Energy Efficiency and Renewable Energy in selected MSME clusters".* Replacing the one 4 kW, two 2 kW and three 1.5 kW motors in place of 7.5 kW, 4 kW and 2 kW motors in shank grinder, stone grinder, and furnace blower, helps in reduction of the energy consumption. This intervention in the unit has led to reduction in 9 kW of installed capacity, monthly energy saving of 2,684 kWh. This intervention is having simple payback period of less than 10 months for this EE retrofit.

[36] https://beeindia.gov.in/sites/default/files/3Ch2.pdf- *Accessed on 14th August 2020*
[37] http://www.sameeeksha.org/pdf/2-cs-New-Eff-motor-lower-capacity-Jalandhar.pdf *Accessed on 14th August 2020*

State of the Art Technologies in Metal Forging

Flash-less Forging

Forging operation often produce the flash around the forged product that requires additional material for and additional energy for heating that material. Alternatively, the precision enclosed impression die forging operation can produce near net or net shape forging. The operation is independent of flash formation. Thus, the trimming process requirements are eliminated. The enclosed die also ensures a better grain structure as shown in Figure 39. Flash less forging can be used for variety of products as shown in Figure 37[38] and Figure 38[39].



Hot Forging **Flashless Forging**

Figure 39 Grain Structure Comparison

Figure 37 Flashless forging sleeve yoke

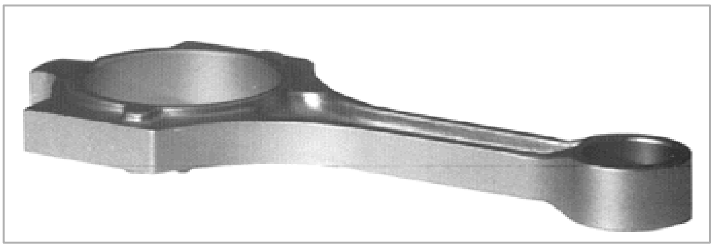


Figure 38 Flash less forging connecting rod

Features

- **Minimal flash generation, higher yield**
- **Elimination of trimming operations, and cracking capability**
- **Higher strength due to the optimum grain flow and inherent full density**
- **Lower energy consumption and lower emission**

Case Study for Yield optimization (Sleeve Yoke)38,39

Table 27: Case Study flash -less forging

Parameters	Drop Forging	Flash less Forging
Input weigh of billet (kg)	1.47	0.945
Forged weight (kg)	1.41	0.938
Final weight of forging (kg)	1.05	0.937
Flash weight (kg)	0.36	0.001
% flash	24.5%	0.1%
% Yield	75.5%	99.9%
Mass of metal saved / 1000 pieces (kg)	**525**	
SEC of billet heater (kWh/tonne) *	400	
Energy saving from heating (kWh/ 1000 piece) **	**210**	

[38] Dwivedi, O. P. *et. al., (2014),* A Case study for near net Shape – Flashless forging for full yoke (Sleeve Yoke omni), IJMER Vo. 4, Iss. 4, http://www.ijmer.com/papers/Vol4_Issue4/Version-1/H044014664.pdf
[39] Forging Industry Association, 6.10 Case Study No.10 Flashless Forged Connecting Rod, https://www.forging.org/forging/design/610-case-study-no10-flashless-forged-connecting-rod.html

Continuous Forging and HT Lines

IBH Most forging units use single coil to heat multiple size jobs. IBH works most efficiently when the coil diameter (IBH) is same as the metal piece diameter. Higher coil size leads to loss of the energy through the air gap leading to Higher SEC. To maintain the clearance and provision of the metal expansion due to heating, slight tolerance of 1-2 mm is considered over the piece for smooth operations. In a typical forging line, the work piece temperature post forging operation is still over 500 °C and stored until it is ready for heat treatment. As a result, the work piece loses heat and needs to be heated again from room temperature to heat treatment temperature. Apart from heat loss, the material may also develop stresses. Alternatively, in a continuous forging and HT lines can improve the productivity and reduce the energy consumption of the heat treatment process.

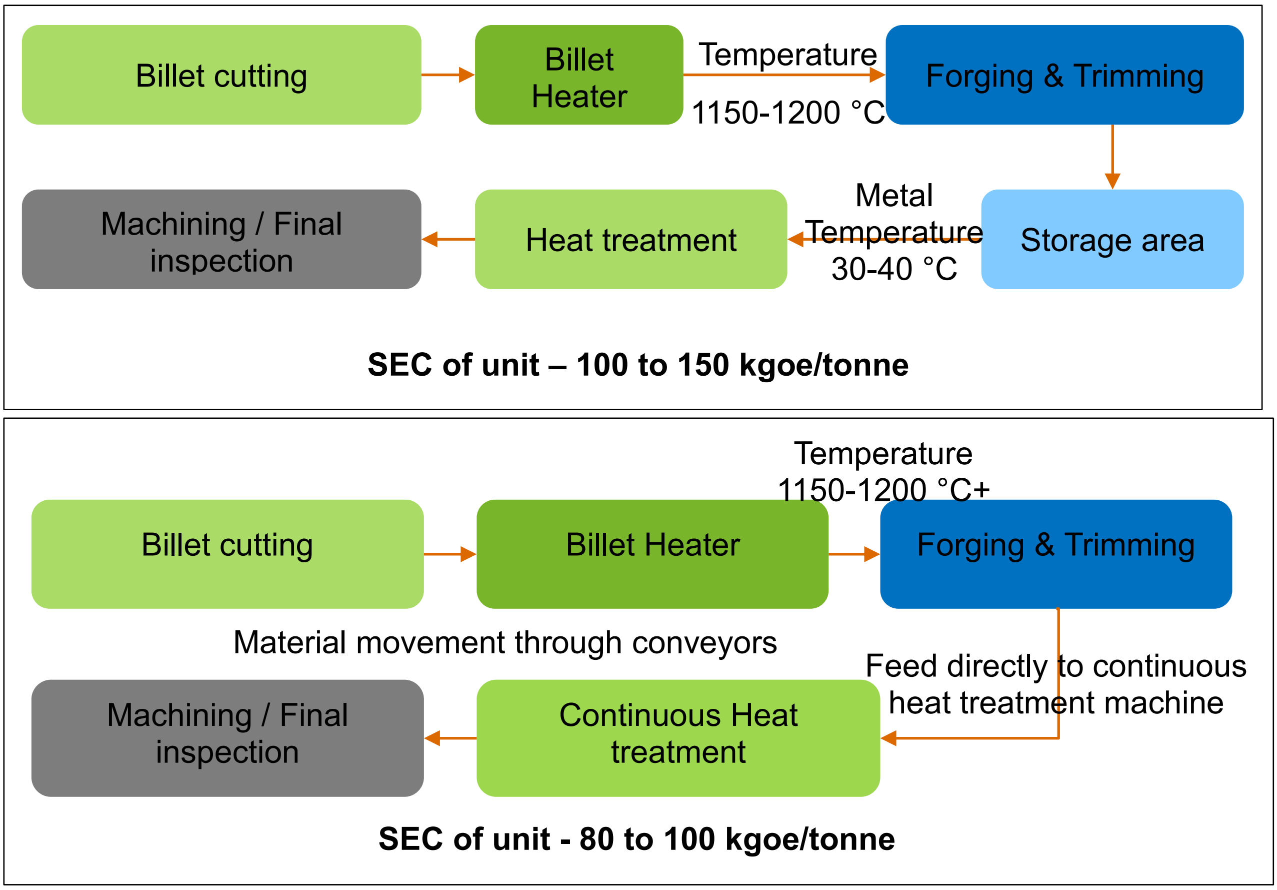


Figure 40: Continuous forging lines comparative

Robotic Forging

One of the most advance solution in forging sector is full automation of the forging process through robots. These robots can handle the heavy products and perform metal reheating, hammering and heat treatment operations in an islanding mode with remote supervision of humans. State of the art systems offer end-to-end integrated systems capable of forging products from 3 kg to 1300 kg. These robots have high dexterity and heat resistance which enables hot forging of complex shapes and high productivity with high amount of safety.

Features
- **Lower SEC of the entire process**
- **Automation of process can be done using the conveyors**
- **Higher productivity and lower drops outs**
- **Depends upon the layout and space availability**

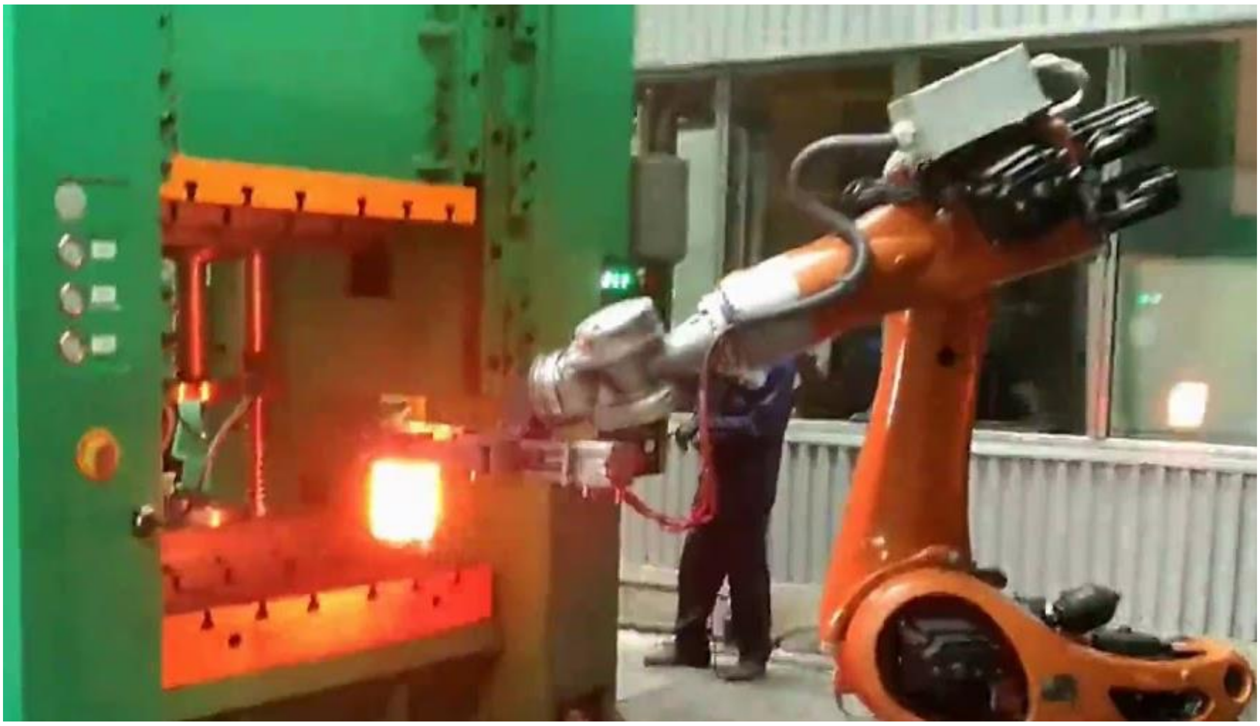


Figure 41 Fully automated forging process

Features

- **High productivity**
- **Improved accuracy, better quality, and reduced rejection rates**
- **Limited human intervention required**
- **Reduction in forging time enables temperature optimization**

Oxyfuel burners

Conventional burner technologies use air directly in an open environment. Oxyfuel combustion technology uses pure oxygen instead of air for combustion of the fuel. The oxyfuel combustion of hydrocarbon fuels such as natural gas can reduce the flue gases including NOx emissions by 75-80% and 55% lower fuel consumption. Oxyfuel combustion can also reach higher temperatures up to 1500°C[40,41,42]. Some oxyfuel systems optimize combustion to achieve flameless operation which promotes uniform heating and extends useful life of refractory lining. These systems are compact and rugged and can be retrofitted to existing burner systems A schematic representation of oxyfuel burners is shown in Figure 42. The comparison of different burner systems is presented in Table 28.

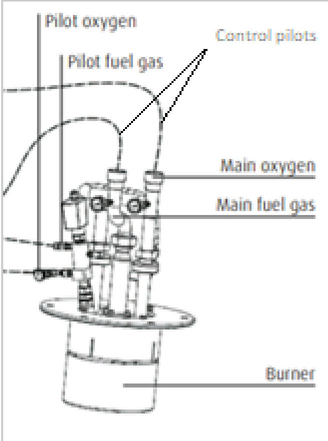


Figure 42: Oxyfuel burner

Table 28 Comparison of performance parameters and costs across burners

System Considerations	Cold Air	Hot Air (Recuperative)	Regenerative	Oxy-Fuel
Thermal Efficiency	Low	Medium	High	High
Fuel Usage	High	Medium	Low	Low
CO_2 Emissions	High	Medium	Low	Low
Maintenance Required	Low	High	High	High
Initial Cost	Low	Medium	High	Medium
Operating Cost	High	Medium	Low	High

Features

- **Lower fuel consumption**
- **Higher temperature possible**
- **~40-70% energy savings**
- **Uniform heating**
- **Lower emissions**
- **Average payback period: ~ 3-5 years**

Case Study (Retrofitting Oxyfuel system to diesel burners)[43]

EE measure has been carried out in one of the steel unit with annual consumption of 2,284 MWhe of diesel with 1600 kW capacity. The investment cost of the oxyfuel burner system is estimated to be INR 1.27 crore. This intervention in the unit has led to savings of 40% of the annual energy consumption with simple payback of 3.9 years and 24.8% IRR[44].

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[40] *von Scheele, J., Mahoney, W., Ritzén, O., Linde, Hydrogen Steelmaking Solutions for Melting, Reheating, and Gasification, 2020, https://www.researchgate.net/publication/349215137*
[41] *Air Products, APCOS™ Technology—Air Products Cupola Oxy-fuel System for Iron Production, https://www.airproducts.com/equipment/oxy-fuel-systems-cupolas*
[42] *Messer group, OXIPYR™ for Ladle Preheating, https://specialtygases.messergroup.com/oxipyr*
[43] *Linde Gas, Maximize efficiency in ladle preheating with OXYGON®, https://www.linde-gas.com/en/industries/steel_metal/steel/oxyfuel-solution-for-ladle-preheating/index.html*
[44] *Linde Gas*

Regenerative Burner System

Regenerative burner system is an energy efficient alternative to conventional burners for metal heating purposes. Regenerative burner system has two burners which operate alternatively in regenerative and combustion modes respectively. In regenerative mode, the incoming combustion air to the burner is preheated by the flue gas from the combustion mode of the other burner (Figure 43). Thus, these systems offer continuous high thermal efficiency operations. The regenerative systems can reduce the energy consumption by 30-70%[45] along with emissions. These systems can achieve preheating temperatures over 1000 °C. A comparison of different burner systems is presented in Figure 43.

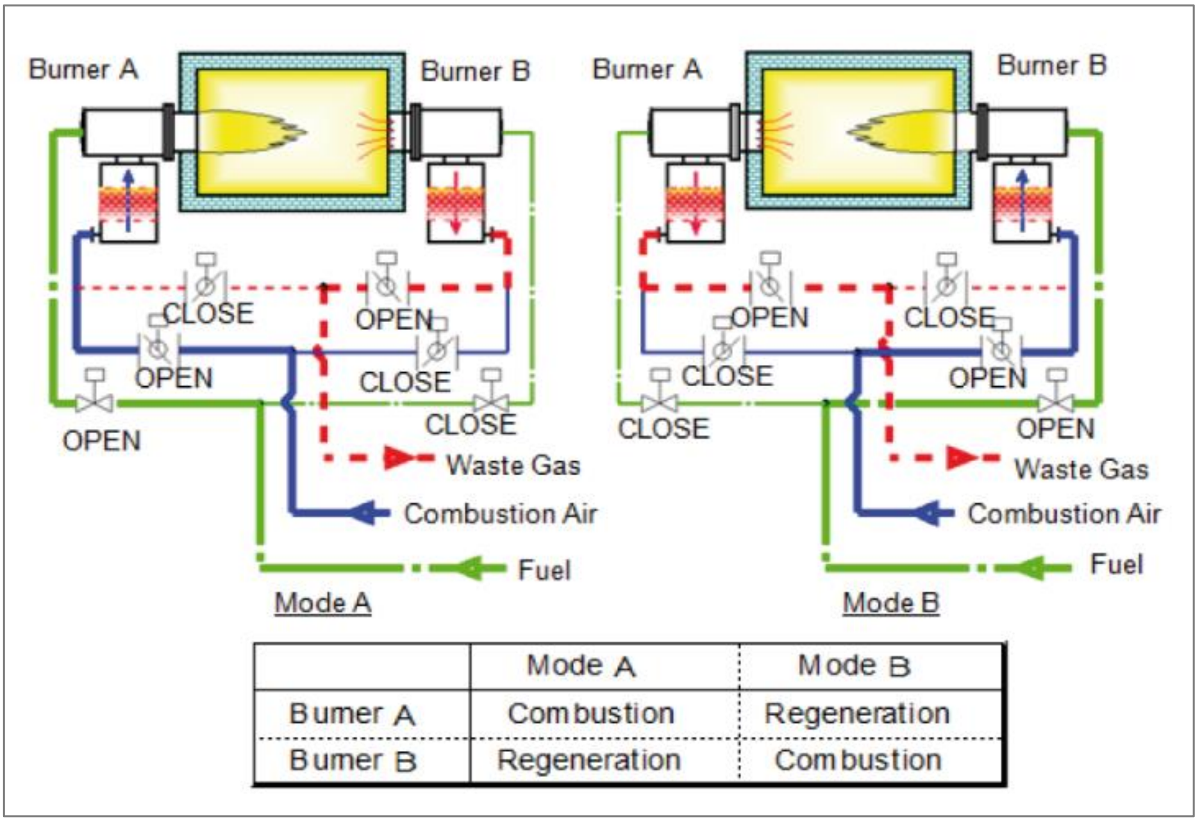

Figure 43 Operation of Regenerative Burners

Features

- **Lower fuel consumption**
- **Higher heating temperature**
- **~30-70% energy savings**
- **Lower emissions**

[45] *Nutec Bickley, Regenerative Burner Retrofits, https://www.nutecbickley.com/what-we-do/metal-furnaces-and-ovens/products-for-metals/regenerative-burner-retrofits*

Hydrogen as a fuel

Use of hydrogen as a fuel can reduce the CO_2 emissions by 100%. Hydrogen can be used in various stages of metal heating processes. Hydrogen can be used in oxyfuel burners for a flameless operation as a standalone fuel or in mixture with other fuels. Hydrogen and oxyfuel combination can also be used for steel reheating. State-of-the-art oxyfuel hydrogen reheating solution such as Linde REBOX can achieve uniform temperatures within a margin of 5 °C[46]. A hydrogen fired oxyfuel burner under operation is shown in Figure 44. Hydrogen can also be used to provide protective atmosphere in heat treatment furnaces for processes such as annealing, hardening and brazing[47]. The hydrogen atmosphere can reduce iron oxide to iron and control carbon percentage steel. Also, with oxygen, hydrogen can provide thermal energy for heat treatment.

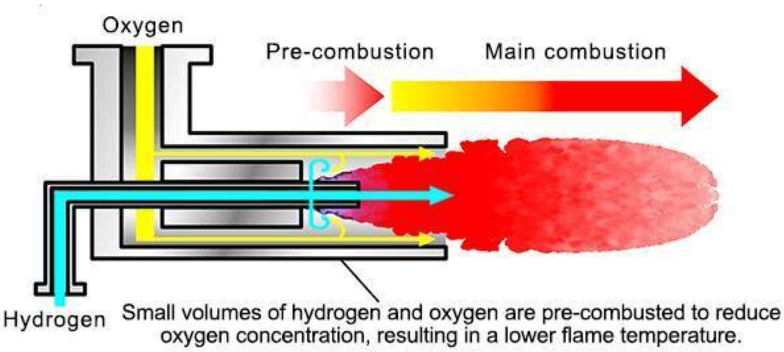

Figure 44: Hydrogen fired oxyfuel burner

Features

- **Lower fuel consumption**
- **Higher temperature possible**
- **Lower NOx and CO2 emissions**
- **Possible production from renewable energy sources**
- **Decreased scaling losses**

[46] *von Scheele, J., Mahoney, W., Ritzén, O., Linde, Hydrogen Steelmaking Solutions for Melting, Reheating, and Gasification, 2020,* https://www.researchgate.net/publication/349215137

[47] *L&L Furnace, Heat Treatment Furnace Atmospheres: Inert Gas and Hydrogen, 2019,* https://llfurnace.com/blog/heat-treatment-furnace-atmospheres-inert-gas-and-hydrogen/

Best Operating Practices[48]

Best operating practices (BOP) with the regular monitoring helps in the maintaining the best operational efficiencies, regular monitoring of equipment also help in reduction of the failure of the system. To support the MSMEs with quick guidelines to monitor the equipment and utilities, BEE had launched the energy conservation guidelines for MSME sectors in 2019. This section covers the BOP, monitoring parameters and SEC/Efficiencies defined for forging as per energy conservation guidelines by BEE. MSMEs shall also carry out the regular maintenance and of the equipment's as specified by the OEMs.

Table 29: Best Operating practices for forging and heat treatment furnaces

Equipment	Best Operating Practices	Parameters to be monitored	SEC/Efficiency range

Fuel Fired Furnaces	• Maintain the appropriate air fuel ratio
	  ○ Liquid fuel – 1.15-1.20
	  ○ Gaseous fuel – 1.12-1.15
	• Maintain the appropriate surface temperature
	  ○ Ceiling – 110-120 ºC
	  ○ Side wall – 85-100 ºC
	• Flue gas exit temperature – 250-300 ºC
		• Fuel flow rate (litre/hour)
		• Material flow rate (tonne/hour)
		• Fuel gas temperature
		• Surface temperature of furnace
		• Temperature of hot metal
		• Air fuel ratio
			• 70-100 litre per tonne

Induction furnaces	• Use appropriate coil size for the job • Maintain the furnace surface temperature 70-90 ºC	• Temperature of the hot metal • Cooling of the coil • Power consumption by furnace (kWh/hour) • Material flow rate (tonne /hour) • Surface temperature of furnace	• Forging furnace: 350-450 kWh/tonne • HT furnace: 120-150 kWh/tonne

Table 30: Best Operating practices for Utilities in forging industry

Equipment	Best Operating Practices	Parameters to be monitored	SEC/Efficiency range
Compressed Air system	• Operate the compressor at the optimal pressure requirement • Limit the compressed air leakage within 3% to 10%. • Maintain operating SPC within the design range as provided by the OEMs. • Periodic cleaning of the suction filters	• Power consumption • Air flow • Pressure of compressed Air • Loading and Unloading time • Pressure drop in piping system • Pressure drop across the filters	• Reciprocating – 0.20-0.25 kWh/cfm • Screw single stage – 0.14-0.25 kWh/cfm • Screw multistage – 0.18-0.25 kWh/cfm

[48] https://beeindia.gov.in/sites/default/files/Annexure%202.pdf- *Accessed on 12th August 2020*

Equipment	Best Operating Practices	Parameters to be monitored	SEC/Efficiency range
	• Ensure the optimal dryer operation • Maintain specified air temperature after intercooler		
Pump and Pumping system	• Operate the pump close to the design values • Replace rewound motors in pumps with IE3 motors or higher efficiency class • Ensure the no leakage in piping system and valves shouldn't be throttled as much as possible • Use star rated pump sets if size is small and available with BEE star label	• Pressure at pump discharge • Pressure drop in the system • Flow at the pump discharge • Power consumption by the pump set	• Efficiency of the pump set 60-85%, depending upon the flow and head of the pump set (Refer the pump curve supplied by the manufacturer)
Fans and blowers	• Operate the pump close to the design values • Replace rewound motors in pumps with IE3 motors or higher efficiency class • Periodic cleaning of the suction filters	• Energy consumption • Draft across the suction and delivery • Temperature of the air entering the fan	• Backward curve aerofoil shaped blades – 79-83% • Modified radical curve blades -72-79% • Radial blades- 69-75% • Pressure blower – 58-68% • Forward curve blades – 60-65%
Cooling towers	• Maintain cycle of concentration (COC) of 8 to 10 for optimum performance. • Maintain approach of 4 °C – 5 °C. • Control the drift loss 0.001% – 0.005% of circulating flow rate. • Replace rewound motors in pumps with IE3 motors or higher efficiency class	• Ambient dry and wet bulb temperature • Cooling water inlet and outlet temperature • Circulating water flow rate • Make up water flow rate • TDS in the make-up water	• COC – 8-10 • Approach 4-5 degree centigrade • Range 8-9 degree centigrade • Drift Loss – 0.002% - 0.005%
Electric Motors	• Use IE3 or higher rating motors • Use BLDC motors for fans, blowers etc. • Maintain voltage and current imbalance as low as possible as prescribed by IEEE • Replace the motor after rewinding once	• Voltage • Current • Power factor • Harmonics • Electricity energy consumption	• Refer Efficiency of Motor as per catalogue of motor manufacturer • Efficiency varies in rage of 75%-95% for different rating of the motors from 0.3 kW- 500 kW
Transformer	• Maintain winding temperature within 100 °C –120 °C. • Maintain oil temperature within 90 °C.	• Voltage , Current, Power factor • Oil temperature • Winding temperature • Harmonics (Voltage and Current)	• Refer Efficiency as per catalogue of manufacturer or refer star

Equipment	Best Operating Practices	Parameters to be monitored	SEC/Efficiency range
	• Maintain unity power factor at the transformer.	• Tap position if available	label[49], generally efficiencies are in rage of 97-99%
Lighting System	Maintain the appropriate lux levels • Administrative building 50–400 • Administrative corridor 100 • Shop floor lighting (process) 150–300 • Workshop 150–300 • Warehouse storage area 100–150 • Use 3-5 star rated LED lights	• Monitor the lux level • Monitor the power consumption • CRI to be monitored where required	• 90-120 watt/lumen[50]

[49] https://www.beestarlabel.com/Content/Files/DTnoti.pdf- Accessed on 13 August 2020
[50] BEE Star rated appliances - https://www.beestarlabel.com/Content/Files/LED_schedule.pdf Accessed on 13 August 2020

Compressed Air Management

Use of multiple compressors to cater to variations in compressed air requirement, can lead to non-optimal operation, and can lead to higher energy consumption depending on the relative efficiencies and operating times of the compressors (**Error! Reference source not found.**). The sequential air management systems can be used to manage the compressed air flow requirements through sequential control of air compressors connected to a common air distribution system. The most efficient compressor operates for majority of the time and the higher air requirements are progressively achieved by switching other compressors as and when required in the succession of the previous one. Thus, compressor modulation based on air flow requirements can lead to energy savings of up to 30% (**Error! Reference source not f**

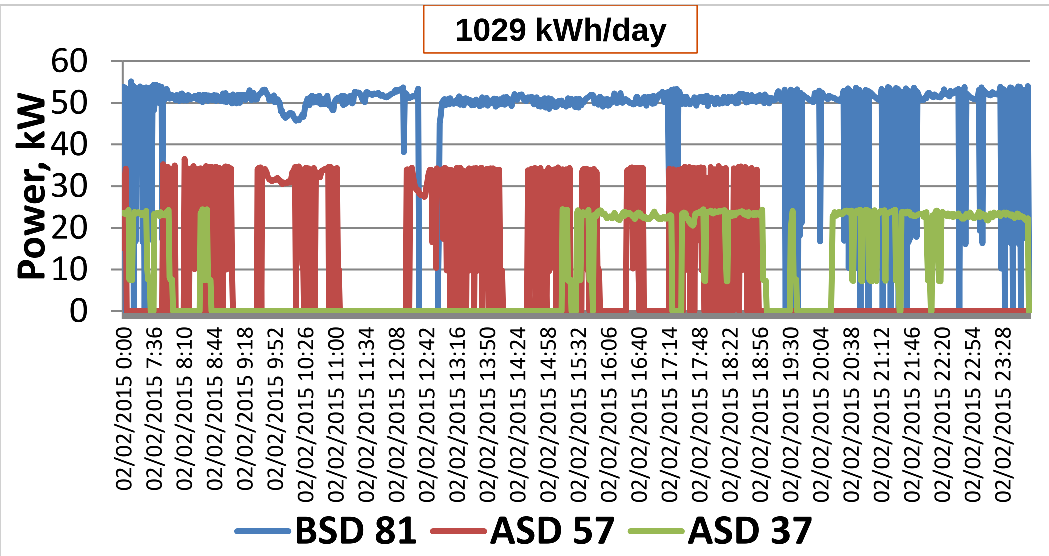

Figure 46 Sub-optimal operation of compressors

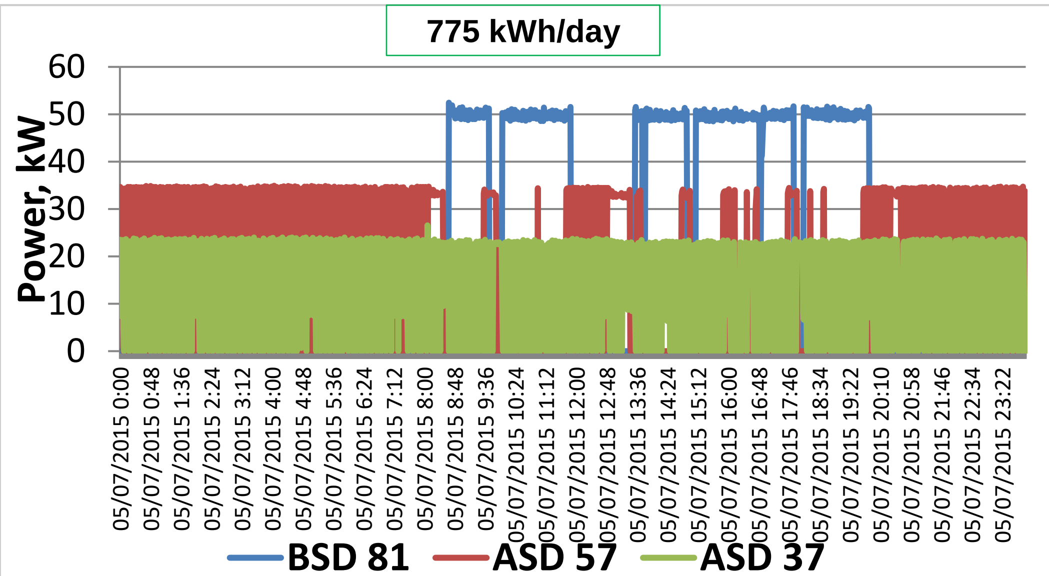

Figure 45 Compressed Air Management System

ound. & 46).

Use of Appropriate coil diameter for IBH

IBH Most forging units use single coil to heat multiple size jobs. IBH works most efficiently when the coil diameter (IBH) is same as the metal piece diameter. Higher coil size leads to loss of the energy through the air gap leading to Higher SEC. To maintain the clearance and provision of the metal expansion due to heating, slight tolerance of 1-2 mm is considered over the piece for smooth operations.

Features

- **Lower loss of the energy**
- **Lower SEC of IBH**
- **Average Payback Period: ~ 12-36 months**

Optimal Capacity air blower

Use of the natural gas is better than the use of the furnace oil for the furnaces. Natural gas is cleaner fuel compared with Oil. Gas fired burners are having higher efficiency as compared with oil fired burner due to better air to fuel mix, also lower quantity of excess air is required for gas fired system vis-à-vis oil fired system – thus leading to lower flue gas loss. Emissions (SOx, NOx) from the NG are lower and can be controlled better.

Low capacity air blower **Optimum capacity air blow**

Figure 47: Optimal capacity combustion air blower

Features

- **Higher efficiency due to lower flue gas loss**
- **Higher combustion efficiency**
- **Lower emissions, Cleaner workspace**
- **Average Payback Period: ~ 18-24 months**

Case Study[51]

EE measure has been carried out in one of the MSME unit with average production of 1,000 tonne per year for three heat treatment furnaces, under **BEE-WB-GEF-SIDBI programme**. This intervention in the unit has led to saving of ***12%*** *of the energy consumption of the furnace* with simple payback period of 21 ***months***.

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[51] http://www.sameeeksha.org/pdf/CS_Forging_Pune-P13.pdf- Accessed on 13th August 2020

Cogged V-Belt

The Cogged V-Belt are 3-5% more efficient than the normal V-let thus, it is recommended to replace the standard V-belt with cogged V-Belt this will help in reducing the energy consumption as they reduce the slippage between rotating parts. The cogged V-belt also has improved useful life. The cogged V-belt cost between INR 10,000 to 20,000 depending on the load requirements. Replacing with these belts on transmission systems can reduce 1-3% of the electricity consumption of the motors.

Before: Flat V-belts used

After: Use cogged V-belts

Figure 48 Use of Cogged V-Belt

Key Feature: Reduction of heat loss from surface

Case Study

In a steel unit, it was estimated that replacement of V-belts with cogged V-belts can improve the transmission efficiency by 3%. This EE intervention led to 183 kWh of savings per year. The monetary investment required was INR 20,000 with a simple payback of 7 years.

Solar PV installations

Forging unit have higher level of vibrations due du to forging operations (Hammers and presses) also have slightly dust environment. Life of the panels is lowered due to higher vibrations in the unit and solar panel efficiency deteriorates drastically in the dusty environment. Dust environment along with flue gases also reduced the life of the solar structure. Moreover, most of the MSME forging units have very limited rooftop space, also trusses and shed structure are not adequately designed to withstand the load of the solar panel.

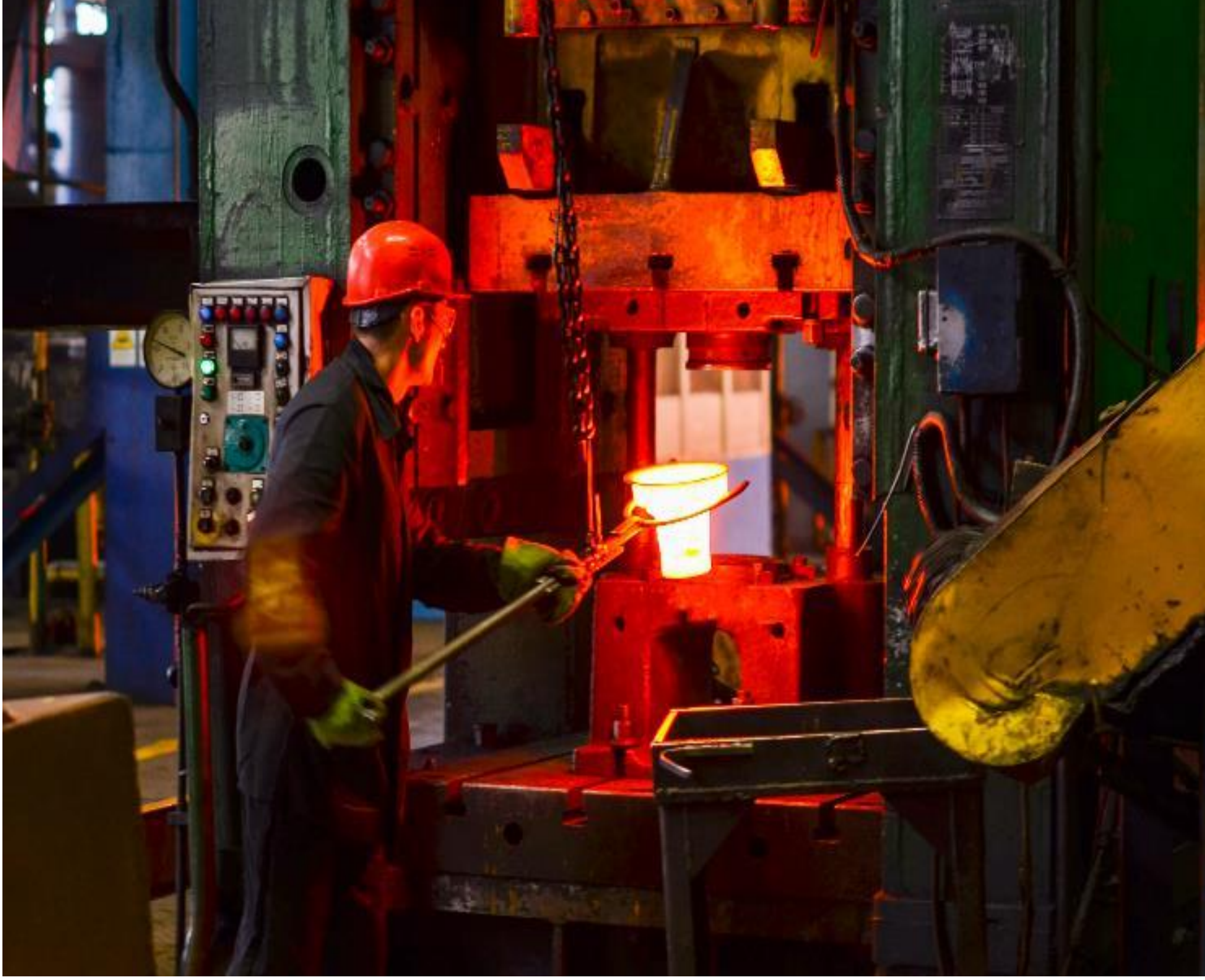
However, implementation of the solar PV is only possible with regular maintenance and cleaning practise, unit an explore the options considering the feasibility of the solar Based on the capex and opex cost of the Solar PV, especially considering the working conditions of the forging units. While opting for solar PV unit should install the mono-crystalline PV panels (up to 20%) which have best efficiencies.

List of Vendors / Suppliers of Energy Efficient Technology Solutions

Table 31: List of prominent technology vendors

Technologies	Prominent vendors / Suppliers	Contact details	Email ID
IGBT based Induction Billet heater	Plasma Induction	Mr. Hardik Khant	hardikkhant99@gmail.com
IGBT based Induction Billet heater	Inductotherm	Mr. RD Mehta	rdmetha@inductothermindia.com
IGBT based Induction Billet heater	Megatherm	Mr. Suchintya Paul	suchintya.paul@megatherm.com
Induction heating coils	Plasma Induction	Mr. Mayur Suhagiya	ms@plasmainduction.com
Induction heating coils	Inductotherm	Mr. RD Mehta	rdmetha@inductothermindia.com
Induction heating coils	Megatherm	Mr. Suchintya Paul	suchintya.paul@megatherm.com
Gas based re-heating furnace	Dilwal Vigyan Praudyogikee Pvt. Ltd.	Mr. Anshul Kaushik	dilwalkaushik@gmail.com
Gas based re-heating furnace	Locally fabricated		-
Recuperator / Waste heat recovery	Locally fabricated		-
Waste heat recovery	Spirax Sarco	Mr. Nitin Sharma	Nitin.Sharma@in.spiraxsarco.com
EE Burners	Wesman Burners		delhi@wesman.com
Drop Hammer and Presses	NKM Hammers		nkhhammer@yahoo.co.in
Drop Hammer and Presses	Rattan Hammers		98761-20925
Screw Air compressor with VFD and WHR	Atlas Copco	Ms. Divya Purohit	Divya.Purohit@in.atlascopco.com
Screw Air compressor with VFD and WHR	Kaeser compressors	Mr. Amit Rajpal	amit.rajpal@kaeser.com
Screw Air compressor with VFD and WHR	Elgi	Mr. Gopal Krishna	gopikrishna@elgi.com
Cooling towers	Delta cooling towers	Mr. Ankur	delta@deltactowers.com

Technologies	Prominent vendors / Suppliers	Contact details	Email ID
Heat Pump	Promethean Energy	Mr. Ashvin K.P.	ashwinkp@prometheanenergy.com
Blowers	Generally locally fabricated		-
Blowers	Alfa blowers	Ms. B Sarita	sales@alphablowers.com
Blowers	Srilaxmi Air control	Mr. Raju	raju@srilaxmiair.com
IE3 / IE4 motors	Siemens	Mr. Anshul Luthra	anshul.luthra@siemens.com
IE3 / IE4 motors	Crompton Greaves	Mr. Sukhraj Singh	sukhraj.singh@cgglobal.com
Aluminum compressed air piping	Parker Legris	Mr. Joy Dewan	joy.dewan@parker.com
Aluminum compressed air piping	Samarthair Pneumatics Pvt. Ltd	Mr. Chetan Damle	sales@samarthair.in
Aluminum compressed air piping	Luthra PNEUMSYS	Mr. A Appare	rl@pneumsysenergy.com
EE pump sets	Grundfos	Mr. Laxesh Sharma	laxesh@grundfos.com
EE pump sets	Kirloskar Pumps	Mr. L Joshi	Laxmikant.Joshi@kirloskar.com>
IoT based EnMS	Schneider Electric	Mr. Rohit Chashta	Rohit.Chashta@schneider-electric.com
IoT based EnMS	Enerlly	Mr. Nilesh Shedge	nil.shedge@gmail.com
IoT based EnMS	Sensegrow	Mr. Krishanu Sudi	krishanu.sudi@sensegrow.com
BLDC fans	Sinox	Mr. Himanshu Ajudia	sinoxpower@gmail.com
BLDC fans	Atomberg	Mr. Rohit Vohra	rohitvohra@atomberg.com
VFD drives	Schneider Electric	Mr. Rohit Chashta	Rohit.Chashta@schneider-electric.com
VFD drives	Siemens	Mr. Anshul Luthra	anshul.luthra@siemens.com
VFD drives	ABB	Mr. Vinay Tiwari	vinay.tiwari@in.abb.com
Automation control Systems	JTES	Mr. Parvinder Singh	jtes.india@gmail.com
Thermo-ceramic / Insulation coating	ISCT	Mr. Nikhilesh	isct.nikhilesh@gmail.com
Thermo-ceramic / Insulation coating	A-ONE INSULATIONS	Mr. Parth	contactinsulation@gmail.com



C. Strategies for Decarbonization and Circular Economy

C. Strategies for Decarbonization and Circular Economy

Forging sector is one of the energy intensive sectors. As a result, the sector also has a considerable impact on the GHG emissions. The total estimated emissions related to the MSME forging sector in India is ~2.4 million tonnes annually. The electricity, FO are a major source of energy for forging in India. However, as the Indian electricity grid is highly dependent on the coal for power generation, the forging units are responsible for GHG emissions indirectly. Whereas the natural gas, oil used in forging units lead to direct emissions on-site.

The industries have a significant role to play in mitigating the effects of climate change and meet the climate commitments made by India. Hence, it is necessary to explore strategies for decarbonization of the forging sector. Apart from energy efficiency measures, the technologies such as use of renewable energy sources such as solar, wind and biomass can play a vital role in decarbonizing the energy demand of the forging in India. Furthermore, hydrogen is an emerging energy source which also has an important role to play in a long-term low carbon future of the sector and the economy as a whole. These technologies are discussed in subsequent sections.

Biomass Gasifier

Biomass is a net carbon-neutral alternative to fossil fuels when procured from sustainable sources such as groundnut shells and saw dust. Biomass gasifier can be used to generate producer gas from the biomass source through a sequence of thermo-chemical reactions. The producer gas mainly consists of carbon monoxide (~20%), hydrogen (~17%), CO_2 (~10%) and nitrogen (~50%) apart from methane, water vapor and hydrocarbons in trace amounts. The producer gas can replace the fossil fuels used in forging units - natural gas, FO and LDO. The construction and working of two types of biomass gasifiers, updraft and downdraft, is shown in the following figure.

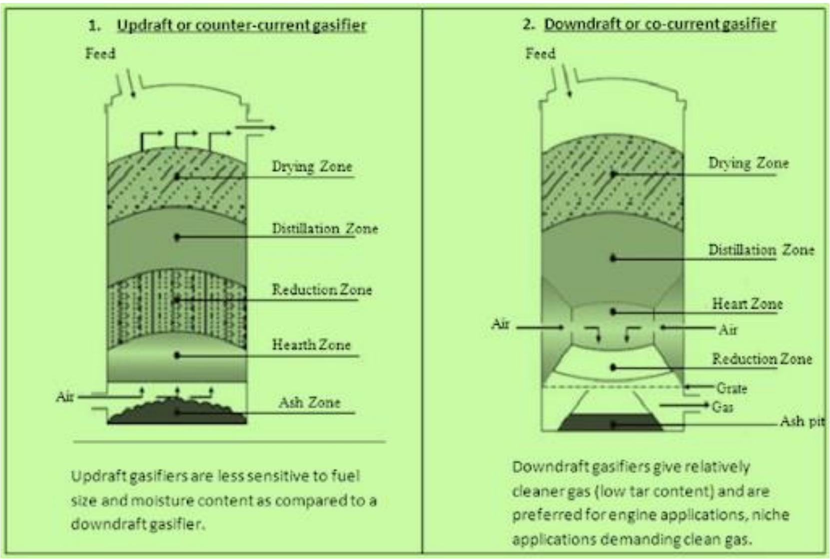


Figure 49 Working principle of Biomass gasifier

The biomass gasifier has several areas of applications relevant to forging units such as:

- Metal heating

- Preheating furnace, and
- Heat treatment furnace

The producer gas has lower calorific value (~2500 kCal/kg) as compared to the fossil fuels. However, substitution with biomass gasifier can be cost effective and decarbonizing measure for a forging unit. The payback of less than one year has been achieved in one of the foundry units at Kolhapur using LDO for heat treatment furnace.

Figure 50 Biomass Gasifier installation

Other strategies for decarbonization of the forging sector include fuel switching such as from furnace oil to natural gas which have been discussed in the previous sections in detail.

Hydrogen

Hydrogen has high gravimetric energy density as compared to other fossil fuels typically used presently. However, hydrogen production currently is not economically viable but several countries as well as private players have committed to provide technological and policy environment to accelerate the development of 'green hydrogen'. These measures are projected to reduce the cost of hydrogen production drastically in the coming decade. Green hydrogen is the hydrogen produced from electrolyzers using renewable energy sources. The use of green hydrogen as a fuel will effectively reduce 100% reduction in CO2 emissions.

In the metal heating, hydrogen can be used in various stages of the processes. Hydrogen when used as fuel can be used to replace the existing sources completely or in combination of the fuel such as natural gas co-firing. Some of the major applications are presented next.

Hydrogen for Metal heating in furnaces

Hydrogen can be used in oxyfuel burners for a flameless operation as either a standalone fuel or in mixture with other fuels. Hydrogen and oxyfuel combination can also be used for steel reheating. State-of-the-art oxyfuel hydrogen reheating solution such as Linde REBOX can achieve uniform temperatures within a margin of 5 °C[52]. A hydrogen fired oxyfuel burner under operation is shown in Figure 44.

Hydrogen for heat treatment

Hydrogen can also be used to provide protective atmosphere in heat treatment furnaces for processes such as annealing, hardening and brazing[53.] The hydrogen atmosphere can reduce iron oxide to iron and control carbon percentage steel. Also, with oxygen, hydrogen can provide thermal energy for heat treatment.

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[52] *von Scheele, J., Mahoney, W., Ritzén, O., Linde, Hydrogen Steelmaking Solutions for Melting, Reheating, and Gasification, 2020, https://www.researchgate.net/publication/349215137*
[53] *L&L Furnace, Heat Treatment Furnace Atmospheres: Inert Gas and Hydrogen, 2019, https://llfurnace.com/blog/heat-treatment-furnace-atmospheres-inert-gas-and-hydrogen/*

Features

- **Lower fuel consumption**
- **Lower NO_x and CO_2 emissions**
- **Possible production from renewable energy sources**

Rooftop Solar

Installation of solar PV on the rooftops is being taken up by industrial and commercial consumers in the past few years due to reducing cost of solar panels. The rooftop solar PV can reduce the electricity cost of the consumer and also help them in decarbonizing their energy demand. Rooftop solar also offers flexibility to sell the excess power to the grid for additional revenue for the units. However, there are several challenges associated with installation of rooftop solar:

- Space availability: For installation of solar panels, the MSME should have sufficient rooftop space available. Furthermore, the installation should be on a strong and stable structure which requires roof to have sufficient load bearing capacity. The efficiency of solar PV ranges between 15-22% depending upon the type of PV module. Estimated energy generation across different states where prominent forging clusters are present in India is provided in the table below.

Table 32: Solar energy generation potential across different stated with prominent forging clusters[54]

Region	Estimated Annual Generation (kWh/year)[55]
Punjab	16,790
Karnataka	18,250
Gujarat	18,250
Delhi	16,790
Maharashtra	18,250

- Regular Cleaning: Due to various processes in the forging units and dust environment, the solar panels are susceptible to acquiring dust which can reduce their performance significantly. The degradation of output with dust is shown in the figure[56]. Hence, regular cleaning and maintenance of solar panels is required which may lead to additional cost.
- Higher level of vibration in the forging press shops can failure of the solar modules, thus hampering the long-term energy generation, hence panel should be installed with dampers or away from the vibrating trusses.
- Policy challenges: The net metering policies are not favorable in many states and the sale of power to distribution company may not lead to significant revenue for the unit.

Renewable Power Procurement

The rooftop solar offers power generation only to limited extent due to space constraints. Hence, the direct procurement of renewable power through power purchase agreements is becoming a viable option for industrial consumers for satisfying their power demand and thereby decarbonizing the production. The PPA tariff is for renewable energy has been falling in the past

[54] https://solarrooftop.gov.in/rooftop_calculator
[55] Energy generation is estimated for the roof top of 100 square meter available for installation of solar PV without any shadow effect during the day – estimated using the data from - https://solarrooftop.gov.in/rooftop_calculator
[56] Maghami, M., *et al.,* Power loss due to soiling on solar panel: A review, Renewable and Sustainable Energy Reviews, Volume 59, 2016, Pages 1307-1316, ISSN 1364-0321, https://doi.org/10.1016/j.rser.2016.01.044.

few years between the industrial consumers and renewable energy developers is also possible. The hybrid wind-solar projects are also capable of supplying round the clock clean electricity to their consumers. The effective electricity tariff lower than the grid electricity has been achieved in various consumer segments whereas with falling cost of generation from renewables will also lead to increasing viability for other consumer segments as well. For open access procurement of renewable energy (wind and solar), the MSME units can opt for group captive as well as power purchase agreement (PPA) with third-party RE developers.

A comparison of industrial tariff with the open access modes for major states having foundry/forging cluster is provided in the Table below. The open access tariff for solar as well as wind can be observed to be competitive or even lower than the existing industrial tariff set by the utilities. Thus, in addition to reducing the environmental impact of the MSME units, these RE solutions also have potential to reduce the financial expenditure on energy. The group captive open access can be driven by the regional industrial associations. These measures can significantly improve the global competitiveness of the Indian foundry/forging units.

MSME can save on the landed cost the energy (kWh) in range of Rupee 0.44 – 3.0 / kWh (captive cost vis- a – vis the cost of power procured from DISCOM) though captive power plant (solar / wind) installed in the same state where MSME is operating.

While drawing power from third party the MSME units need to pay the additional taxes and duties levied by the state. MSME units can also explore the options for withdrawing power through open access / long term PPA though group captives across the state borders, at relatively attractive rates.

Wheeling power though central transmission network (across different states), MSMEs may incur additional charges and different states levy different taxes and duties. Wheeling of RE power especially through the third party route can be more expensive in certain scenarios considering the taxes duties and additional changes levied by the state where power is produced and state where the power is drawn. Hence MSME units can explore suitable RE partners and evaluate the viability of landed cost of RE power at their unit in case of third party procurement. Detailed ranges of the tariffs based on multiple combinations discussed above, are presented next.

Table 33: Comparison of electricity tariff DISCOM / Open access [57]

Withdrawal State	Industrial Tariff (Rs./kWh)	Injection State	Solar (Rs./kWh)		Wind (Rs./kWh)	
			Captive	Third Party	Captive	Third Party
Karnataka	7.08	Karnataka	4.08	6.18	4.04	6.14
		Rest of India	4.84 – 5.91	6.94 – 8.02	4.80 – 5.75	6.90 – 7.85
Punjab	6.60	Punjab	4.59	6.07	4.48	5.96
		Rest of India	5.37 – 6.44	6.85 – 7.92	5.25 – 6.20	6.73 – 7.68

[57] https://cef.ceew.in/intelligence/tool/open-access accessed on 31st January 2022

Withdrawal State	Industrial Tariff (Rs./kWh)	Injection State	Solar (Rs./kWh)		Wind (Rs./kWh)	
			Captive	Third Party	Captive	Third Party
Gujarat	4.58	Gujarat	5.04	7.21	4.64	5.80
		Rest of India	5.81 – 6.85	7.98 – 9.02	5.39 – 6.31	5.56 – 7.47
Maharashtra	7.30	Maharashtra	6.80	8.51	6.63	8.34
		Rest of India	7.61 – 8.73	7.86 – 10.44	7.44 – 8.36	9.15 – 10.07
Tamil Nadu	8.40	Tamil Nadu	4.12	4.62	3.88	4.55
		Rest of India	4.89 – 5.92	5.39 – 6.42	4.63 – 5.55	5.30 – 6.22
West Bengal	7.15	West Bengal	5.50	9.04	5.50	9.04
		Rest of India	6.38 – 7.51	9.92 – 11.05	6.38 – 7.39	9.92 – 10.93
Jharkhand	5.57	Jharkhand	5.14	6.55	4.82	6.23
		Rest of India	6.02 – 7.13	7.43 – 8.54	5.69 – 6.67	7.10 – 8.08

Summary of the power cost for the different forging clusters are presented next

Details of RE across different clusters

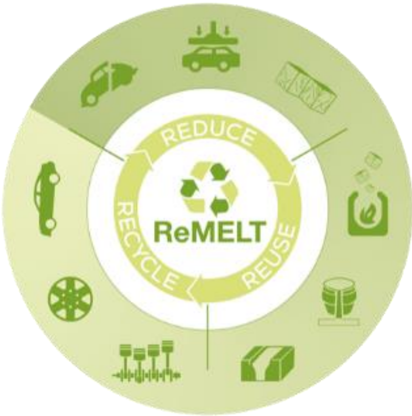
Table 34: Comparative analysis of the GRID power and RE power cost for different clusters

Cluster Name	Cost of Electricity (per unit)# INR / kWh	Cost of RE from Grid (per unit) ## INR / kWh	Total Electricity Consumption (MWh)	Total cost of electricity (INR Crore)	Cost of power if RE component is: (INR/kWh) 30%	50%	80%
	A	B	C	B x C	(Wt. Average of A, B)		
Ludhiana	6.6	4.5	645	293	6.0	5.6	4.9
Bangalore	7.1	4.1	40	16	6.2	5.6	4.7
Pune	7.3	6.7	155	104	7.1	7.0	6.8
Chennai	8.4	4.0	98	39	7.1	6.2	4.9
Delhi	5.8	4.3	172	73	5.3	5.0	4.6

 # Only cost of energy INR /kWh is considered – demand charges and other specific changes will be levied by as per SERC guidelines.

Only average cost captive generation is considered presented in the column

Circular resource utilization



Major components of the circular economy 3R:-

- Reduce
- Reuse
- Recycle

Reduce – Most of the progressive forging in India have adopted the state of art technologies and management system to control the production processes, these implementations help forging units to optimize the use of the resources. Key Performance Indicators (KPI) which drive the optimal utilization of the resources in the forging, are identified as – process yield, production efficiency, capacity utilization, energy consumption, scale loss etc. Use of the simulation in the forging units and foreign die development to produce fleshless and net shape forging will help the forging industries to cut down the metal loss. Use of the induction billet heater with controlled heating and temperature interlock helps the foreign units to reduce the scale loss during metal heating operations.

Adoption of the new and state of technologies (flash less forging, simulation-based die and product development) can help forging units to improve the yield up to 99% for some forgings, thus will help in forging units to conserve the energy, water, metal and other resources while maintaining the quality of the forged products. Details of the technologies are presented along with case studies presented in technology compendium.

Reuse – Forging units consume water for the cooling operations the rejected water from the cooling tower, process and other operations can be treated and re-used. Re-use will also help forging units to conserve the energy and optimization the usage of the resources.

Recycle – Forging waste along with machining waste in form of – flash, coins, burr, scale is rejected from the industry is used by the foundries. 100% of metallic rejects produced by the industries in the sector, can consumed by the foundry sector – thus supporting the ecosystem of recycling. Metal rejects and metallic waste are remelted by foundry sector to form new components and products (billets and bars) these can be re-used by the forging industries to form the forged products. Forging sector depends upon the foundry sector for the recycling of the waste and rejections.

D. Existing EE policy initiatives and programmes for the sector

D. Existing EE Policy initiatives and programmes for the sector

Realizing the importance of creating enabling environment for MSMEs- BEE, MoMSME and various international development agencies have been devising key programmatic interventions and policies for the MSME sector.

MoMSME has developed special subsidies schemes and funds to support Energy efficiency in MSME sectors. BEE had initiated an SME program during the year 2009 with an objective to improve the energy performance of MSME sector. EE in the MSME sector has also remained on the programme agenda of several institutes and development agencies, including GIZ, World Bank, UNIDO, UNDP, IFC and JICA for a significant time now.

The activities undertaken under these interventions include ranging from direct financial and technical support to capacity building and knowledge dissemination activities

- **Financial support**- Capital subsidies, soft loans, interest subventions, risk guarantee mechanism
- **Technical support**- Energy audits, preparing IGDPRs and hand-holding support for EE implementations
- **Knowledge and capacity building**- Preparation of cluster manuals, technology compendium, energy benchmarks and awareness creation through workshops, exhibitions, and technology demonstration

MSME specific EE policies, schemes, and programmatic interventions are categorized into mainly following:

Govt. (MoMSME) supported subsidies scheme

- Credit Linked Capital Subsidy Scheme
- Technology and Quality Upgradation (TEQUP)
- Financial Support to MSMEs in ZED Certification Scheme

IDA led programmatic interventions

- GEF UNIDO BEE Program- Promoting EE and RE in Selected MSME Clusters
- GEF-World Bank BEE SIDBI Project- Financing Energy Efficiency at MSMEs

BEE Supported schemes

- BEE SME Programme- including Energy mapping studiy for MSME clusters
- Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE)

Although these interventions have demonstrated the effectiveness of the energy efficient technologies however, the need of enabling eco-system for large-scale deployment of EE technologies in MSMEs has been extremely limited.

MoMSME supported schemes

The Government launched National Competitiveness Programme in 2005 with an objective to support the Small and Medium Enterprises (SMEs) to become competitive and adjust the competitive pressure caused by liberalization and moderation. MSME Ministry employs the programme under the guidance of the National Manufacturing Competitiveness Council. Main components of the programme were aimed to address MSME competitiveness issues. 10 components of the programme are illustrated below-

- Support related to entrepreneurial and managerial development of SMEs by means of incubation
- Improving quality through Quality Management Standards in addition to technology Tools
- Technology up-gradation and quality certification assistance to SMEs
- Marketing assistance to MSMEs
- Marketing assistance for SMEs and technology up-gradation activities
- Design clinic scheme to convey design or innovation expertise
- Promotion of ICT
- Setting up the Mini Tool Room in addition to Training Centers
- Building awareness on Intellectual Property Rights
- National Programme related to the function of Lean Manufacturing

Few of these initiatives help in improvement in the efficiency of the MSMEs, adoption of the new energy efficient technologies and developing the ecosystem for energy efficiency, lean manufacturing, ZED leading to lowering the emission.

Credit Linked Capital Subsidy Scheme (CLCSS) for Technology Upgradation of the Small-Scale Industries[58]

The Credit Linked Capital Subsidy Scheme (CLCSS) facilitates subsidy to 51 sub-sectors/products. The main objective of the scheme is to facilitate technology up-gradation in MSMEs by providing an upfront capital subsidy for installation of well-established and improved technology in the specified sub-sectors/products approved. This scheme provides capital subsidy of 15% on actual term loan sanctioned and disbursed, with maximum limit of eligible loan of 1 Cr (maximum 15 lakhs of subsidy)

At present the Scheme is under revision and will be launched soon after obtaining the necessary approvals. Capital Subsidy disbursed under the scheme reaches to Rs. 2360 crore. The fund expenditure incurred for FY 20 was Rs. 438.59 Crore with 87.15% of allocated funding was disbursed for FY 2020-21.

Table 35: Key features of the CLCSS scheme

Feature	Description
Objective	Facilitate technology up-gradation in MSEs by providing an upfront capital subsidy
Eligibility Criteria	Installation of appropriate eligible and proven technology approved under scheme (list based) (Covers technologies from 51 sectors/ sub-sectors)
Type of support	15% Capital Subsidy, with maximum limit of eligible loan of 1 Cr (15 lakhs of subsidy)

[58] http://dcmsme.gov.in/CLCS-TUS%20Guidelines-14-8-2019.pdf - Assessed on 29 August 2020

Feature	Description
Nodal agencies	Supported by MoMSME. 11 nodal agencies including SIDBI and 10 other PSU banks
Budget Allocation and disbursed till date	All allocated funds were disbursed. 65,000 beneficiaries and 4000 Cr. Funds disbursed
Current Status (along with Year of inception)	Inception 2000, At present the scheme is under revision and running under sunset clause

Technology and Quality Upgradation (TEQUP)

Main objective of this scheme was to sensitize MSME Sector by conducting Awareness workshops to adopt Energy Efficient Technologies and acquire Product Certification/ Licenses from National/ International Bodies.

This scheme also supported the MSME with financial assistance in the form of subsidy to the extent of 25% of the project cost for implementation of Energy Efficient Technology (EET). The maximum amount of subsidy will be Rs. 10 Lakh for project cost of Rs. 40 Lakhs.

This activity is implemented through various nodal banks. The scheme was in operation59 till 30.09.2017 and over 4500 MSMEs have been reached through workshops conducted under this scheme; total of 202 awareness workshops were conducted in different MSME clusters. 300 MSMEs were assisted for energy efficient technologies, and 1100 units were assisted for production certification under the programme. Financial outlay of 90 crore has been supported government for this scheme since inception.

Table 36: Key features of the TEQUP scheme

Feature	Description
Objective	1. Sensitize and encourage the manufacturing MSMEs to the use of EE Technologies and Manufacturing Processes 2. Encourage the MSMEs to acquire Product Certification/ Licenses from National/ International Bodies
Type of support	Technical Assistance along with capital subsidy based on eligibility based on technical studies
Benefits under the scheme	1. Provide Financial Assistance in the form of subsidy to the extent of 25% of the project cost for implementation of Energy Efficient Technology (EET). The maximum amount of subsidy will be Rs. 10 Lakh. 2. Provide subsidy to MSME units to the extent of 75% of the actual expenditure incurred by them for obtaining Product Certification Licenses, maximum subsidy of 2 lakh
Eligibility Criteria	The Detailed Project Report (DPR) to be prepared by a Qualified Energy Manager/Auditor. The EET machinery installed should have minimum of 15% energy saving, and EA audit report also to be submitted
Nodal agencies	Supported by MoMSME. SIDBI is the nodal agency and 6 FIs are empanelled including SIDBI

59 http://www.dcmsme.gov.in/schemes/TEQUPDetail.htm Assessed on 19 August 2020

Feature	Description
Disbursement and status	Total no. of beneficiaries 1188, total disbursement 89.94 Cr. (only 40% of allocated funds were disbursed) i. MSME assisted for EET ~ 300, ii. Units assisted for product certification ~ 1100
Current Status	Launched in FY 2010-11, The scheme is not fully operation since 2017, very few disbursements in recent years

Financial Support to MSMEs in ZED Certification Scheme[60,61]

Main objectives of the scheme include inculcating Zero Defect & Zero Effect practices in manufacturing processes, ensure continuous improvement and supporting the Make in India initiative. This scheme was launched to provide support the MSMEs for:-

- Development of an ecosystem for Zero Defect Manufacturing in MSMEs
- Promote adaptation of Quality tools/systems and Energy Efficient manufacturing.
- Enable MSMEs for manufacturing of quality products.
- Encourage MSMEs to constantly upgrade their quality standards in products and processes.
- Drive manufacturing with adoption of Zero-Defect production processes and without impacting the environment.

Financial outlay of 100 Crores was contributed by Government of India[62] during 2019-20 under the ZED programme for MSME sector.

Lean Manufacturing Competitiveness Scheme (LMCS)[63]

The Pilot Phase of Lean Manufacturing Competitiveness Scheme was approved for 100 MSME Clusters. Main objective of the Scheme was to enhance the manufacturing competitiveness of MSMEs through the application of various Lean Manufacturing (LM) techniques by:-

- Reducing waste
- Increasing productivity
- Introducing innovative practices for improving overall competitiveness
- Inculcating good management systems
- Imbibing a culture of continuous improvement

This scheme has supported over 4500 MSMEs since the inception of the programme in 2007, financial support of over INR 58 crore has been provided by the government for this program since inception till 2017.

Programmatic Interventions by Multilateral and Bi-lateral Development Agencies / Banks

Public funding plays crucial role in the field of energy efficiency for MSMEs and a key source of public funding in addition to government funded EE interventions is multilateral / bi-lateral development banks, which help developing economies like India where the EE potential is

60 https://msme.gov.in/3-technology-upgradation-and-quality-certification Assessed on 19 August 2020
61 https://msme.gov.in/technology-and-quality-upgradation Assessed on 19 August 2020
62 http://www.dcmsme.gov.in/schemes/FAQ_ZED_11619.pdf - Assessed on 29 August 2020
63 http://www.dcmsme.gov.in/Guidelines%20Lean.pdf Assessed on 19 August 2020

maximum. Energy Efficiency in the MSME sector has also remained on the programme agenda of development agencies, including IFC, World Bank, UNIDO, UNDP, JICA and GiZ etc. for a significant time now.

"Financing Energy Efficiency at MSMEs" – BEE-SIDBI-WB-GEF programme

Financing Energy Efficiency at MSMEs was a GEF funded projected aimed at increasing the demand for energy efficiency investments in target micro, small and medium enterprise clusters and to build their capacity to access commercial finance. The GEF implementing agency was the World Bank and it was jointly executed by BEE and SIDBI. The project budget was USD 63.61 million.

The project is focused on 4 components:

- Activities to Build Capacity and Awareness
- Activities to Increase Investment in Energy Efficiency
- Knowledge Management
- Project Management Support

FEEM was conceived to complement the World Bank's engagement with GoI on the $520 million IBRD-funded SME Finance and Development Project. The GEF-funded FEEMP was designed to increase the flow of capital for EE measures and address institutional weaknesses and capacity constraints of FIs that restricted them from supporting MSMEs.

- Increase demand for EE investments in target MSME clusters.
- Build capacity of MSMEs to access commercial finance.

A few important achievements of FEEM are:

- Project was carried out in three phases, Phase -I interventions were carried out in five clusters, later this programme was extended to twenty-five MSME clusters across India
- Programme covered 13 states and union territories including forging clusters in Pune, Rajkot, Faridabad, Coimbatore etc.
- A total of 1,120 experts from 75 FIs and 750 energy audit professionals were trained to develop energy audit reports on the basis of which commercial finance could be sought.
- 1,257 IGDPRs were prepared exceeding the initial target of 730
- INR 3,322 million direct EE investments from project
- Performance linked grant was given to 67 early adopters
- The project supported SIDBI's "End-to-End Energy Efficiency (4E) scheme, the WB supported revolving fund provided a maximum interest subsidy of 2.5 percent (increased to 3.58%)

Promoting Energy Efficiency and Renewable Energy in selected MSME clusters of India" BEE -GEF - UNIDO Project

Scheme Duration: April 2011 – Ongoing

Promoting EE & RE in MSME in India is a GEF funded project aimed at introducing energy efficient technologies and enhancing the use of renewable energy technologies in process applications in energy intensive MSMEs in 5 sectors (brass, ceramics, dairy, forging, foundry, and hand tools). The GEF executing partner is UNIDO and other executing partners are BEE, MoMSME, MNRE.

The project has 4 main components as detailed below:

- Increased capacity of suppliers of EE/RE product suppliers/service providers/finance providers to support the expansion of EE/RE in the clusters.
- Increasing the level of end-use demand and implementation of EE and RE technologies and practices by MSMEs.
- Scaling up of the project to a national level.
- Strengthening policy, institutional and decision-making frameworks.

A few important achievements from the scheme are:

22 Pilot projects implemented, 212 DPRs developed	7894 toe annual energy savings
478 EE & RE measures implemented	6.62 million US$ monetary savings
78 Workshops organized with 2250 participants	7.19 million US$ co-financing
220 case studies prepared	49896 tonnes of co2 emissions avoided

Programme supported hand tool clusters in Jalandhar and Nagaur, 144 projects were supported under this programme in Jalandhar and 43 projects in Nagaur, leading to saving of over 768 tonne of oil equivalent and reduction of over 5400 tonne of carbon dioxide annually.

BEE -SME programme [64]

Considering the urgent need to develop, demonstrate and disseminate energy efficient technologies at the cluster level, "National Programme on Energy Efficiency and Technology Upgradation in SMEs" was evolved by BEE to address the various challenges faced by SMEs in India, subsequently BEE initiated the BEE-SME programme in 2009.

Over 375 Bankable DPR's for energy efficiency projects were prepared in 35 clusters across India. Under the programme several initiatives were taken for capacity building of Local Service Providers/Technology Providers. BEE facilitated implementation of Energy Efficiency Measures through development of DPRs in 29 out of the 35 clusters for which baseline studies were undertaken.

In recent years, under BEE SME programme various initiatives are being carried out as described below, to boost energy conservation in the SME clusters.

Energy and Resource mapping of SME sector

BEE is presently conducting an energy and resource mapping study in the most energy intensive MSME sectors in the country. Study is presently being carried out in nine energy intensive sectors (Forging, Foundry, Bricks, Chemicals, Dairy, Glass and refractory, Pharma, Steel) in 45 MSME clusters across the country. Main objectives of the study are

- Evaluate the present specific energy consumption of the different MSME clusters for nine sectors
- Evaluate the extent of EE improvement potential across these sectors
- Estimation of energy efficiency improvement, energy saving potential for each sector.

Key expected outcome of the study will include – preparing of roadmap for these sectors to make them energy & resource efficient. Study will also prepare list of policy level recommendations required for faster adoption of the energy efficiency measures in these sectors.

Development and Launch of knowledge portal for SMEs

[64] https://beeindia.gov.in/sites/default/files/Situation%20analysis.pdf- Assessed on 20 September 2020

A knowledge management portal - *Simplified Digital Hands-on Information on Energy Efficiency in MSMEs (SIDHIEE)* has been developed by Bureau of Energy Efficiency which hosts variety of knowledge resources like case studies, best operating practices, details of latest energy efficient technologies etc. Dissemination of Recognizing the importance and effectiveness of well-presented success stories to ensure widespread replication of efficient technologies and practices, BEE has developed around 50 multimedia presentations showcasing successful case studies of implemented EE interventions for different MSME sectors. These are now being widely disseminated and are hosted in the Knowledge Management Portal "SIDHIEE" created under the BEE-SME Programme.

Promoting Energy Efficiency and Technology Upgradation in SMEs through ESCO

BEE has institutionalized Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE), which provides a partial coverage of risk involved in extending loans for Energy Efficiency projects. PRGFEE guarantees up to 50% of loan amount or Rs. 10 crore per project, whichever is less. PRGFEE support has been provided to government buildings, private buildings, municipalities, SMEs, and industries. This guarantee is extended to participating financial institutions which will extend loans to ESCOs for implementing EE projects.

Under the IFC Eco-cities programme supported by BEE, investment grade DPRs are presently being prepared for energy efficiency investments at MSMEs in 4 ECO-Cities across India, wherein a pipeline for loans benefitting from PRGFEE is expected to be created.

Dissemination of EE technologies and Awareness:

a. More than 60 Capacity building cum Knowledge dissemination programme were organized in SME clusters for dissemination of available energy efficient technologies in SME sectors. National Summit on Energy Efficiency in SMEs was also organized in consultation with leading stakeholders for further scaling up the project for transformational results.
b. Identification of Local Service Providers and Suppliers: About 70 local service providers were identified for offering services and supplies of various technologies in 5 clusters for ensuring the replication of the identified technologies in the clusters.

GiZ Initiative *for secondary steel sector (including Forging)*

Baseline energy audit and benchmarking study for secondary steel sector in India

GIZ is fully owned by the German Federal Government that supports developing the multiple programs with partner countries on behalf of the German Government with ultimate goal of sustainable development. The Federal Republic of Germany and the Government of the Republic of India have, under the Indo-German Technical Cooperation, agreed to jointly promote the *"Indo-German Energy Programme" (IGEN)* with the aim to promote energy efficiency/conservation, renewable energy, access to energy, etc. and in turn improve the environment/climate protection. GiZ India team works in collaboration with the Bureau of Energy Efficiency (BEE), for the implementation of the Energy Conservation Act (EC Act, 2001), focusing on energy efficiency and conservation.

GiZ is undertaking "*Energy Efficiency in Industry and Data"* for secondary steel sector in India with boarder objectives –

- Building the capacity of State Designated Agencies (SDAs) to promote energy efficiency in plants under the secondary steel sector, that are not covered in the PAT scheme

- Developing tools and knowledge products for Non-PAT secondary steel and pulp and paper plants with access to information on key energy efficiency processes and technologies
- Promote peer-to-peer learning among SDAs and Non-PAT secondary steel industrial clusters
- National Energy Efficiency dialogue for secondary steel and pulp and paper sector between policy makers, research institutions and business associations.
- Developing the energy consumption baseline for Non-PAT industries in secondary steel sector
- Promoting the adoption of energy efficiency measurers
- Empowering the stakeholders with necessary information for energy efficiency related decision making
- Preparing the long-term energy efficiency scenarios of the sector for policy makers

Uptake of existing and past EE interventions and schemes

Indian govt. has undertaken several policies, schemes and programs targeted at promoting energy efficiency in the MSME sector. Energy Efficiency in the MSME sector has also remained on the programme agenda of development agencies such as WB, JICA, IFC, GIZ, UNIDO, UNDP etc.

As single scheme/ interventions cannot eliminate all technical. financial and capacity building barriers faced by MSMEs while adopting energy efficiency enhancing projects. Accordingly, various schemes/ interventions have been introduced to promote MSMEs and energy efficiency or with a focus of promoting energy efficiency centric activities in MSMEs.

While these programmatic interventions have made an impact, there is a long way to go before majority of MSMEs voluntarily increase their uptake of energy efficiency interventions. The observations on the current and past EE schemes & interventions are presented below

Table 37: Major features and key takeaways from different schemes

Major Feature	Key Schemes	Observations/Takeaway
Capital Subsidy schemes	Credit Linked Capital Subsidy Scheme (CLCSS) **High uptake**	• High uptake of the scheme due to direct financial benefits such as capital subsidies • Widely disseminated through comprehensive list of lending institutes • List-based approach simplifies the process
Subsidy linked to Energy audits	Technology Up-gradation Scheme for MSMEs (TEQUP) **Low uptake**	• Scheme requirements such as Energy DPR increases the transaction cost and lead time • Lack of promotion and awareness of the scheme among MSMEs
Risk guarantee mechanism	PRSF, PRGFEE- **Low uptake**	• ESCO eco-system, required for scalability, is not yet developed, • Need of energy study & M&V process increases the project cost at MSME level
	CGTSME- **High uptake**	• Simple procedural norms, less documents • No need of project report for availing guarantee under the scheme
Long term Technical Assistance	WB-GEF FEEMP **High Uptake** BEE SME Programme	• TA programs create awareness on EE amongst different MSME stakeholders • Create culture for EE in clusters due to long term support, but not market driven

Major Feature	Key Schemes	Observations/Takeaway
	High Uptake UNIDO-GEF EE & RE Adoption- **High Uptake**	• Able to cater to part of the MSME sector, as outreach to limited number of clusters
List based scheme	JICA SIDBI – **High uptake**	• Long list of EETs helped in faster loan appraisal, hence higher uptake • SPEED Plus scheme promotes collaboration with OEMs/ vendors
Revolving funds for EE	SIDBI 4E Scheme- **Medium uptake**	• Requires pipeline generation at cluster/ sector level for faster up-taking

State of art technology research institutes

The National Institute of Foundry and Forge Technology, Ranchi[65]

National Institute of Foundry and Forge Technology (NIFFT) is a public engineering and research institution in Ranchi. It was established in 1966 by the GoI in collaboration with UNDP to provide qualified engineers and specialists for running foundry and forge industries.

Since its inception, institute has been supporting the Foundry and Forging sector to meet the technology advancement and demand of trained skilled manpower. Institute is the front runner in supporting the foundry and forging sectors by development and research in the area of Metallurgy and Materials Engineering and other in Manufacturing Engineering. The institute hosts world class publications[66] and research papers for the continuous improvement in the sectors with aim of developing the new technologies to meet the future requirement of the forging, foundry, and manufacturing sector.

There is need felt across the AIFI regional chapters to leverage this premium institution for preparing the new skillset for the work force in the forging sector. This premium institution can play the leading role in developing the new age of the skillset required by the forging industry to meet next generation of technological advancement

State level *initiatives*

Promotion of Energy Audit and Conservation of Energy (PEACE)[67]

Government of Tamil Nadu has launched the PACE scheme with broader objective to foster the EE culture across the MSME sector. Main objectives of the scheme are –

a. Creating awareness and promoting the advantages of new EE technologies.
b. Identification of the gaps and barriers hindering the uptake of the for-energy conservation and promoting adoption of suitable techniques for energy efficiency and energy conservation.
c. Promoting the culture for conducting the energy audits to improve energy efficiency and implementing the fuel substitution and monitoring the implementation of recommendations suggested by energy auditors.

[65] http://www.nifft.ac.in/Home.aspx - Assessed on 25 august 2020
[66] http://www.nifft.ac.in/UserView/PublicationUserView.aspx?TypeID=3 - Assessed on 25 august 2020
[67] https://www.msmeonline.tn.gov.in/incentives/html_cye_peace1.php

d. Subsidy offered to MSMEs - 50% of the Energy Audit cost subject to a maximum of 75,000 thousand Rupees per energy audit per unit.

Financial Incentives for MSMEs in state of Punjab[68]

Energy department in state of Punjab supports the MSMEs in the region with multiple financial incentives to promote the adoption of the new EE technologies and promote the uptake of the energy audit in the MSME units. Broader objective of the incentives offered by the state government is to promote the sustainable cluster of conserving energy in the MSME units. Some of the key financial incentives offered by the government are –

a. In addition to the 15% up front capital subsidy offered by GoI under CLCSS scheme, state Government is supporting MSMEs with additional interest subsidy @ 5% up to a maximum of 5 lakhs per year for a period of 3 years.
b. Assistance for technology acquisition for MSME, state government is offering the subsidy up to 50% on the cost for adopting technology from recognized National Institutes subject to maximum of 25 lakh Rupees.
c. State government is supporting MSMEs with 100% reimbursement of guarantee fee charged by the financial institution from the MSME up to one lakh Rupees under CGTSME scheme offered by the GoI.
d. Reimbursement of expenses incurred on Energy Audit to MSMEs, up to 75% of the cost of energy audit (pre-audit and post energy audit) is reimbursed to MSMEs with maximum value up to Rupees two lakh.
e. Reimbursement of expenses incurred on Water Audit to MSMEs, up to 75% of the cost of energy audit (pre-audit and post water audit) is reimbursed to MSMEs with maximum value up to Rupees one lakh.

Financial Incentives for MSMEs in state of Gujarat[69]

Government of Gujrat (GoG) is frosting the culture of energy efficiency and energy conservation for the MSMEs. GoG with multiple schemes and polices supports MSMEs financially to uptake the new EE technologies. Key incentives offered by the state government are –

a. Reimbursement of expenses incurred on Water Audit to MSMEs, up to 75% of the cost of energy and water audit is reimbursed to MSMEs with maximum value up to Rupees fifty thousand and 25% of cost of equipment recommended by the auditing authority subject to maximum INR 20 lakhs.
b. To encourage innovation and adoption of new EE, cleaner production and sophisticated technologies by MSME, GoG provide fiscal support to MSMEs for purchase of new technologies as well as in acquisition of patented technologies from foreign companies. MSMEs are entitled by the GoG for financial assistance up to 65% of the cost payable with upper limit of Rupees 50 lakhs for acquisition of technology.

[68] https://investpunjab.gov.in/assets/docs/Detailed_Schemes_and_Operational_Guidelines2018.pdf
[69] https://eoibrasilia.gov.in/?pdf11603