COMPREHENSIVE ENERGY AUDIT REPORT

"PROMOTING ENERGY EFFICIENCY AND RENEWABLE ENERGY IN SELECTED MSME CLUSTERS IN INDIA"

Sabro Tools & Forgings

Basti Danishmandan, Jalandhar, Punjab-144 002

13-05-2015

Submitted to

BUREAU OF ENERGY EFFICIENCY

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DESL places on record its sincere thanks to Global Environment Facility (GEF), United Nations Industrial Development Organization (UNIDO) and Bureau of Energy Efficiency (BEE) for vesting confidence in DESL to carry out the assignment "Conducting energy audit and dissemination programs in MSME clusters" under their national project *"promoting energy efficiency and renewable energy in selected MSME clusters in India".*

As a part of this assignment, work in Jalandhar Handtools cluster was awarded to DESL and DESL is grateful to GEF-UNIDO-BEE PMU for their full-fledged coordination and support throughout the study.

The study team is indebted to Mr. Rakesh Kumar, Owner for showing keen interest in the energy audit and also thankful to the management of M/s Sabro Tools & Forgings for their wholehearted support and cooperation for the preparation of this comprehensive energy audit report, without which the study would not have steered to its successful completion. Special thanks to other members of the unit for their diligent involvement and cooperation.

It is well worthy to mention that the efforts being taken and the enthusiasm shown by all the plant personnel towards energy conservation and sustainable growth are really admirable.

Last but not the least, the interaction and deliberation with Mr. Sukh Dev Raj, President, Hand tool manufacturers association, Jalandhar, technology providers and all those who were directly or indirectly involved throughout the study were exemplary. The entire exercise was thoroughly a rewarding experience for DESL.

DESL Team

DESL Team

Project Head	**Mr. R. Rajmohan** Chief Executive Officer
Team leader and co-coordinator	**Mr. Suparno R Majumdar** Consultant
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ABBREVIATIONS

Abbreviations	Expansions
APFC	Automatic Power Factor Correction
BEE	Bureau of Energy Efficiency
CEA	Comprehensive Energy Audit
CFL	Compact Fluorescent Lamp
CRV	Chromium Vanadium
DESL	Development Environergy Services Limited
DG	Diesel Generator
EE	Energy Efficiency
EPIA	Energy Performance Improvement Action
FO	Furnace Oil
GEF	Global Environment Facility
HSD	High Speed Diesel
HVAC	Heating Ventilation and Air Conditioning
LED	Light Emitting Diode
LT	Low Tension
MD	Maximum Demand
MS	Mild Steel
MSME	Micro, Small and Medium Enterprises
MT	Metric Tons
MTOE	Million Tons of Oil Equivalent
MV	Mercury Vapour
No.	Number
PF	Power Factor
PID	Proportional-Integral-Derivative
PNG	Piped Natural Gas
PSPCL	Punjab State Power Corporation Limited
R & C	Radiation & Convection
RE	Renewable Energy
SEC	Specific Energy Consumption
SEGR	Specific Energy Generation Ratio
SLD	Single Line Diagram
SME	Small and Medium Enterprises
UNIDO	United Nations Industrial Development Organization
VFD	Variable Frequency Drives

EXECUTIVE SUMMARY

Bureau of Energy Efficiency (BEE) in association with the United Nations Industrial Development Organization (UNIDO) and Global Environment Facility (GEF) is implementing a project titled "Promoting energy efficiency and renewable energy technology in selected MSME clusters in India". The objective of the project is to provide impetus to energy efficiency initiatives in the micro, small and medium enterprises (MSMEs) sector in India.

As part of this project, DESL has been engaged to implement the project in the MSME hand tool cluster in Jalandhar, Punjab. There are about 400 units scattered over three industrial areas in Jalandhar, viz. focal point, old industrial area and basti area. The major products manufactured include spanners and wrenches, pliers, screw drivers, etc with an average annual production of 50,000 metric tons in the cluster.

The project awarded to DESL consists of six major tasks:

- Conducting pre–activity cluster workshop defining the agenda of this engagement.
- Comprehensive energy audit in 6 selected units.
- Development of cluster specific best operating practices document for the top 5 energy using equipments / processes in the industry.
- Identification of set of energy auditing instruments that should be used for carrying out periodic energy audits in the units.
- Enumeration of common regularly monitorable parameters at the process level which have impact on energy performance and listing of appropriate instrumentation for the same.
- Conducting 3 post energy audit training workshops based on preceding outputs of this activity.

Brief Introduction of the Unit

Table 1: Details of Unit

Name of the Unit	M/s Sabro Tools & Forgings
Constitution	Private Limited
MSME Classification	Small
No. of years in operation	NA
Address: Registered Office	Basti Danishmandan, Jalandhar, Punjab – 144002
Administrative Office	Basti Danishmandan, Jalandhar, Punjab – 144002
Factory	Basti Danishmandan, Jalandhar, Punjab – 144002
Industry-sector	Hand Tool
Products Manufactured	Hand tools, Garage tools & Gardening tools
Name(s) of the Promoters / Directors	Mr. Rakesh Kumar

Comprehensive Energy Audit

The study was conducted in 3 stages:

- **Stage 1:** Walk through energy audit of the plant to understand the process, energy drivers, assessment of the measurement system, assessment of scope, measurability, formulation of audit plan and obtaining required information
- **Stage 2:** Detailed energy audit data collection and field measurements for performance evaluation of equipments/ systems, estimation of savings potential, technology assessment and understanding of project constraints
- **Stage 3**: Data analysis, initial configuration of projects, savings quantification, vendor consultation, interaction with the unit and freezing of projects for implementation and preparation of energy audit report

The production process of the unit

The main process equipments in the unit include the following:

- The raw material is first cut using a cutting machine and then it is heated in a coal fired furnace. After heating, it is forged under a hammer to give the required shape. Then the material is punched and given shape using a shaping machine. Finally, it is polished in a vibrating polishing machine and sent for heat treatment in another plant.
- The main process equipments are furnace, hammer, vibrators, shaping machine.

Identified Energy Performance Improvement Actions (EPIA)

The comprehensive energy audit covered all the equipments which were operational during the field study. Thermal energy constitutes 81% and grid electricity constitutes 11% of the total plant energy. The identified energy performance improvement actions are given in Table – 2.

Table 2: Summary of EPIA

Sl. No.	Name of the project	Estimated energy savings						
		Coal	Electricity	HSD	Others	Monetary savings	Estimated investment	Simple payback period
		kg/y	kWh/y	Litre/y	Rs./y	Rs. lakh/y	Rs. lakh	y
1	Manual Excess air control	799.6	35.5		0.1	0.2	5.00	24.9
2	Energy Efficient fan		1200.0			0.1	0.30	3.2
3	EE fixture		1236.0			0.1	0.09	0.9
4	EE Motor for Press Machine		4351.7			0.3	0.23	0.7
	Total	799.6	6823.1	0.0	0.1	0.74	5.6	7.6

- With the implementation of these EPIAs, an overall energy saving of 12.51 % and overall cost saving Rs. 0.74 lakh can be achieved.

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1 INTRODUCTION

1.1 Background and Project objective

Bureau of Energy Efficiency (BEE) in association with the United Nations Industrial Development Organization (UNIDO) and Global Environment Facility (GEF) is implementing a project titled "Promoting energy efficiency and renewable energy technology in selected MSME clusters in India". The objective of the project is to provide impetus to energy efficiency initiatives in the micro, small and medium enterprises (MSMEs) sector in India.

The targeted 12 MSME clusters under the project and the indicative information are given below:

Table 3: List of 12 targeted MSME clusters covered under the project

Sl.No.	Sub – sector	Cluster
1	Brass	Jagadhri, Jamnagar
2	Ceramic	Khurja, Morbi, Thangarh
3	Dairy	Gujarat, Madhya Pradesh
4	Foundry	Belgaum, Coimbatore, Indore
5	Hand tools	Jalandhar, Nagaur

The objectives of this project are as under:

- Increasing capacity of suppliers of energy efficiency (EE) and renewable energy (RE) based products, service providers and financing institutions;
- Increasing the levels of end-use demand and implementation of EE and RE technologies and practices by MSMEs;
- Scaling up of the project to the national level;
- Strengthening policy, institutional and decision making frameworks.

1.2 Scope of work of Comprehensive Energy Audit

The general scope of work for comprehensive energy audits is as follows:

- Data Collection
    - Current energy usage (month wise) for all forms of energy from April-2014 to March-2015 (quantity and cost).
    - Data on production for corresponding period (quantity and cost).
    - Data on production cost and sales for the corresponding period (cost)
    - Mapping of process
    - Company profile including name of the company, constitution, promoters, years in operation, products manufactured, turnover and net profit during each of the preceding three years
    - Existing manpower and levels of expertise
    - List of major equipments and specifications

- Data required for preliminary environmental and social screening

- Analysis:
  - Energy cost and trend analysis
  - Energy quantities and trend analysis
  - Specific consumption and trend analysis
  - Performance evaluation of major energy consuming equipments / systems
  - Scope and potential for improvement in energy efficiency
- Correlate monthly production data with electricity and fuel consumption for a period of 12 months of normal operation for individual sections of the overall plant.
- Detailed process mapping to identify major areas of energy use.
- To identify all opportunities for energy savings in the following areas
  - Electrical: Power Factor, transformer loading, power quality, motor load, compressed air systems, conditioned air systems, cooling water systems, lighting load, electrical metering, monitoring and control system.
  - Thermal: Furnaces, steam and hot water systems (including hot water lines tracing, pipe sizes, insulation), heat recovery systems etc.
  - Water: Pumping systems
- Evaluate the energy consumption vis-à-vis the production levels and to identify the potential for energy savings / energy optimization (both short term requiring minor investments with attractive payback, and mid to long terms system improvement needing moderate investments and with payback period of 24.9 years).
- Classify parameters related to EE enhancements such as estimated quantum of energy savings, investment required, time frame for implementation, payback period, re-skilling of existing manpower, etc. and to classify the same in order of priority.
- Design an "energy monitoring system" for effective monitoring and analysis of energy consumption, energy efficiency.

1.3 Methodology

1.3.1 Boundary parameters

Following boundary parameters were set for coverage of the audit:

- Audit covered all possible energy intensive areas and equipments which were operational during the field study
- All appropriate measuring systems including portable instruments were used
- The identified measures normally fall under short, medium and long-term measures

1.3.2 General methodology

Following flow chart illustrates the methodology followed for carrying out different tasks:

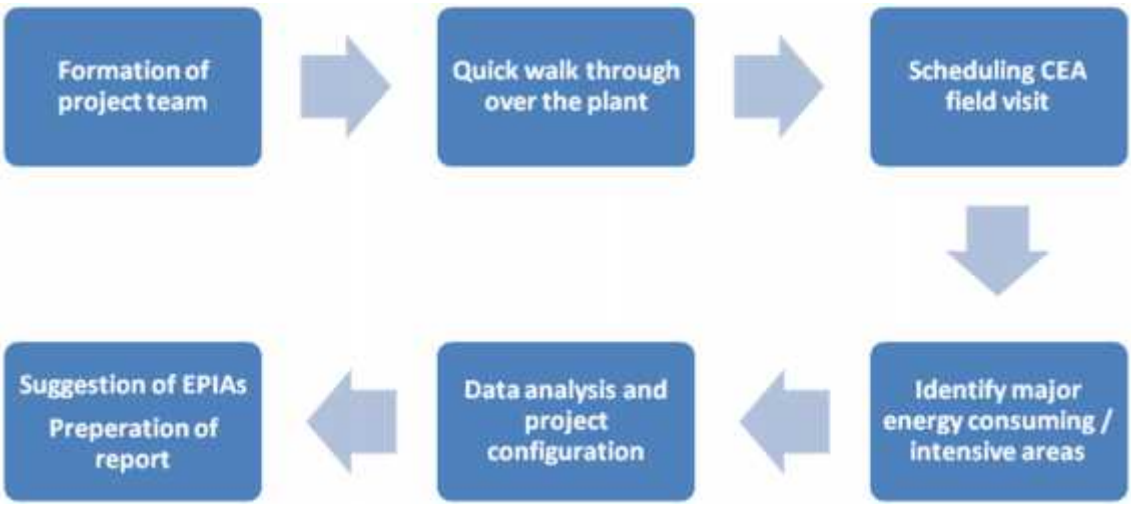

Figure 1: General methodology

The study was conducted in 3 stages:

- **Stage 1:** Walk through energy audit of the plant to understand the process, energy drivers, assessment of the measurement system, assessment of scope, measurability, formulation of audit plan and obtaining required information
- **Stage 2:** Detailed energy audit-testing and measurement for identification of saving potential, technology assessment and understanding of project constraints
- **Stage 3**: Data analysis, initial configuration of projects, savings quantification, vendor consultation, interaction with the unit and freezing of projects for implementation and preparation of energy audit report

1.3.3 Comprehensive energy audit – field assessment

A walk through was carried out before the audit with a view to:

- Understand the manufacturing process and collect historical energy consumption data
- Obtain cost and other operational data for understanding the impact of energy cost on the units financial performance
- Assess the energy conservation potential at macro level
- Finalize the schedule of equipments and systems for testing and measurement

The audit identified the following potential areas of study:

- Heating and Forging
- Electrical motors used in process
- Fans and lighting loads

The further activities carried out by the team after walk through study included:

- Preparation of the process and energy flow diagrams
- Study of the system and associated equipments

- Conducting field testing and measurement
- Data analysis for preliminary estimation of savings potential at site
- Discussion with the unit on the summary of findings and energy efficiency measures identified

Audit methodology involved system study to identify the energy losses (thermal / electrical) and then finding solutions to minimize the same. This entailed data collection, measurements / testing of the system using calibrated, portable instruments, analyzing the data / test results and identifying the approach to improve the efficiency. The various instruments used for energy audit are followings:

Table 4 Energy audit instruments

Sl. No.	Instruments	Make	Model	Parameters Measured
01	Power Analyzer – 3 Phase (for un balanced Load) with 3 CT and 3 PT	Enercon and Circutor	AR-5	AC Current, Voltage, Power Factor, Power, Energy, Frequency, Harmonics and data recording for minimum 1 sec interval
02	Power Analyzer – 3 Phase (for balance load) with 1 CT and 2 PT	Elcontrol Energy	Nanovip plus mem	AC Current, Voltage, Power Factor, Power, Energy, Frequency, Harmonics and data recording for minimum 2 sec interval
03	Digital Multi meter	Motwane	DM 352	AC Amp, AC-DC Voltage, Resistance, Capacitance
04	Digital Clamp on Power Meter – 3 Phase and 1 Phase	Kusam - Meco	2745 and 2709	AC Amp, AC-DC Volt, Hz, Power Factor, Power
05	Flue Gas Analyzer	Kane-May	KM-900	O2%, CO2%, CO in ppm and Flue gas temperature, Ambient temperature
06	Digital Temperature and Humidity Logger	Dickson		Temperature and Humidity data logging
07	Digital Temp. & Humidity meter	Testo	610	Temp. & Humidity
08	Digital Anemometer	Lutron and Prova	AM 4201	Air velocity

Sl. No.	Instruments	Make	Model	Parameters Measured
			And AVM-03	
09	Vane Type Anemometer	Testo	410	Air velocity
10	Digital Infrared Temperature Gun	Raytek	Minitemp	Distant Surface Temperature
11	Contact Type Temperature Meter	Testo	925	Liquid and Surface temperature
12	High touch probe Temperature Meter	CIG		Temperature upto 1300 deg C
13	Lux Meter	Kusum Meco (KM-LUX-99) and Mastech		Lumens
14	Manometer	Comark	C 9553	Differential air pressure in duct
15	Pressure Gauge	Wika		Water pressure 0 to 40 kg

1.3.4 Comprehensive energy audit – desk work

Post audit off-site work carried out included:

- Revalidation of all the calculations for arriving at the savings potential
- Quick costing based on DESL's database or through vendor interactions as required
- Configuration of individual energy performance improvement actions
- Preparation of draft audit report

2 ABOUT THE MSME UNIT

2.1 Particulars of the unit

Table 5: General particulars of the unit

S. No	Particulars	Details
1	Name of the unit	M/s Sabro Tools & Forgings
2	Constitution	Private Limited
3	Date of incorporation / commencement of business	NA
4	Name of the contact person	Mr. Rakesh Kumar
	Mobile/Phone No.	+91 – 9878376843, +91-181 - 2251843
	E-mail ID	NA
5	Address of the unit	Basti Danishmandan, Jalandhar, Punjab 144002
6	Industry / sector	Hand Tools
7	Products manufactured	Hand tools, Garage tools & Gardening tools
8	No. of operational hours	10
9	No. of shifts / day	1
10	No. of days of operation / year	330

3 DETAILED TECHNICAL FEASIBILITY ASSESSMENT OF THE UNIT

3.1 Description of manufacturing process

3.1.1 Process & Energy flow diagram

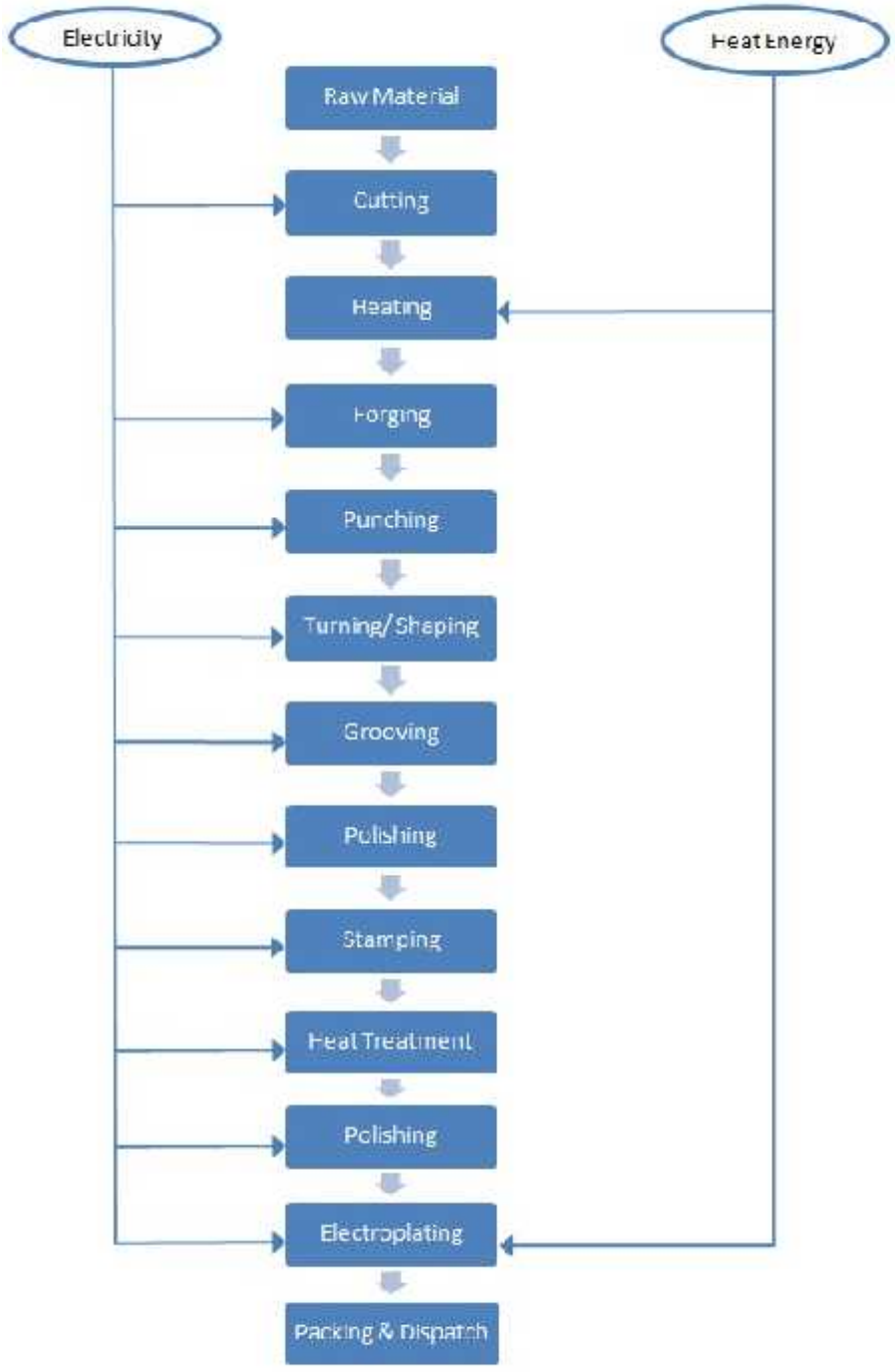

Figure 2: Process flow diagram

3.1.2 Process description

M/s Sabro Tools & Forgings is a manufacturer of spanners, wrenches, pliers, pincers, vices, clamps, etc.

The process description is as follows:

Raw Material

The main raw materials used are flat and round MS and CRV steel.

Cutting

It is a process in which metal work piece is removed from the primary metal strip and the piece removed is called blank metal scrap.

Heating

The heating of the work piece is done in a coal fired furnace.

Forging

The red hot work pieces coming out of the furnace are placed on the lower fixed die (above the anvil). A ram (above the upper die) moves downwards with gravity. Below the ram, fixed is the upper die. After several strokes of the ram, the work pieces take the desired shape.

Punching

In punching a small hole is made using a punching press.

Turning/ Shaping

It is done for providing better surface finish to the work piece by removing all the blurs at the edges.

Grooving

It is also done to provide better surface finish on the edges.

Polishing

It is done with the help of ceramic stones to remove the scales from the work piece in a vibrator machine.

Stamping

It is used to imprint the name on work piece using a power press.

Heat Treatment

It is done externally in another plant using a furnace.

Polishing

It is also done externally in another plant for giving smooth glazing to the surface.

Electro plating

This process is also done externally at another plant.

3.2 Inventory of process machines / equipments and utilities

Major energy consuming equipments in the plant are:

- **Cutting machine:** In this machine, the raw material is cut into required shape before it is heated in the furnace.
- **Furnace:** Coal fired furnace is used for heating the material.
- **Hammer:** Hammers are used for forging process in which material is pressed against a die using a drop hammer.
- **Shaping machine:** This machine is used to remove materials from edges s to give a better edge finish. Large motors are employed in this machine for this purpose.
- **Vibrator machine:** It is used for polishing the work pieces. Ceramic stones and the work pieces are placed together in the vibrator machine. The ceramic stones are used to remove the scales from the work pieces by rubbing against them due to the vibrating action caused by the vibrating machine.

3.2.1 Types of energy used and description of usage pattern

Both electricity and thermal energy are used in different manufacturing processes. The overall energy use pattern in the unit is as follows:

- Electricity is obtained from two different sources:
  - From the Utility, Punjab State Power Corporation Limited (PSPCL)
  - Captive backup Diesel Generator sets for the whole plant
- Thermal energy is used for following applications:
  - Fuel Oil for forging furnace

Total energy consumption pattern for the period April-14 to March-15, from different sources are as follows:

Table 6: Energy cost distribution

Particulars	Energy cost distribution		Energy use distribution	
	Rs. Lakhs	% of Total	MTOE	% of Total
Grid –electricity	1.86	50	0.9	10.99
Diesel –DG	0.33	9	0.6	8.08
Thermal – coal	1.56	42	6.5	80.93
Total	**3.75**	**100**	**8.0**	**100**

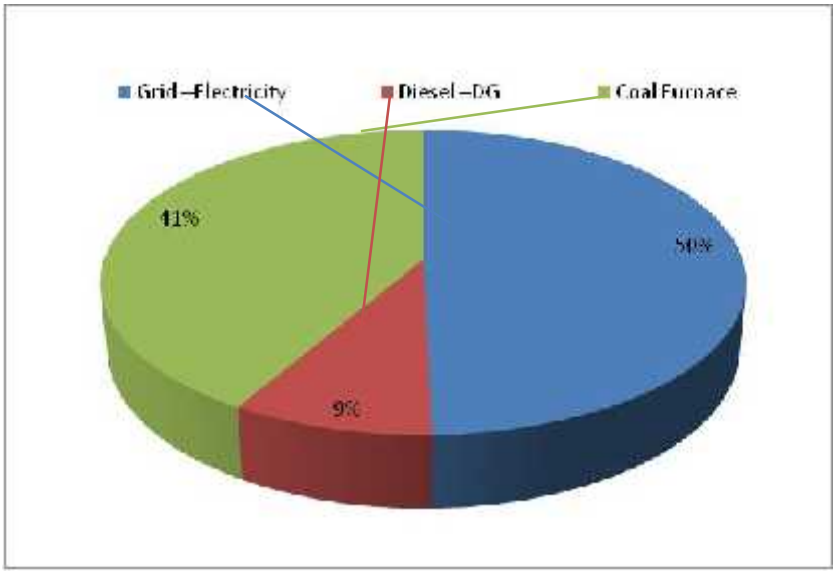

Figure 3: Energy cost share

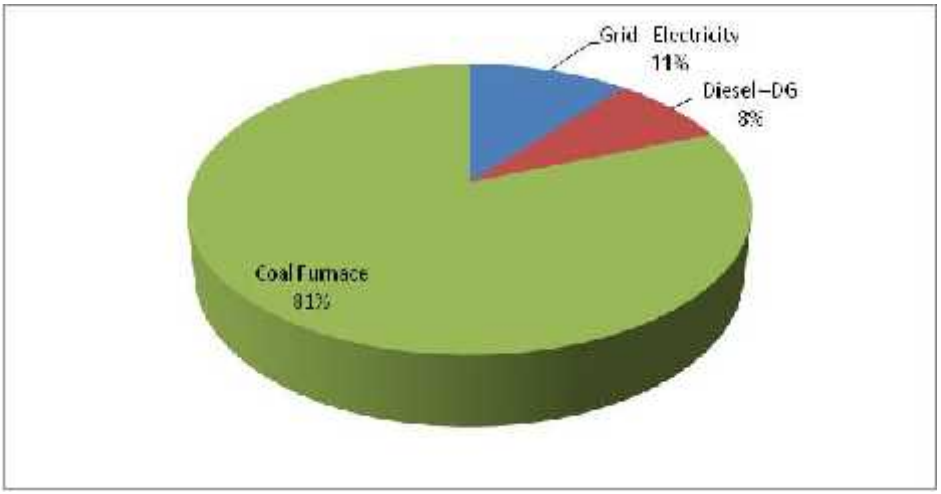

Figure 4: Energy use share

Major observations are as under:

- The unit uses both thermal and electrical energy for manufacturing operations. Electricity is sourced from the grid and also self generated by DG sets when the grid power is not available. Thermal energy consumption is in the form of coal, which is used for furnace heating.
- Coal used in furnace accounts for 41% of the total energy cost and 81% of overall energy consumption.
- Electricity used in the process accounts for 50% of the energy cost and diesel used for self generation is 9% of the overall cost.

3.3 Analysis of electricity consumption by the unit

3.3.1 Electricity load profile

Following observations have been made from the utility inventory:

- The plant and machinery load is 22.01 kW
- The utility load is about 5.98 kW including the single phase load
- The plant total connected load is 27.99 kW

A pie chart of the entire connected load is shown in the figure below:

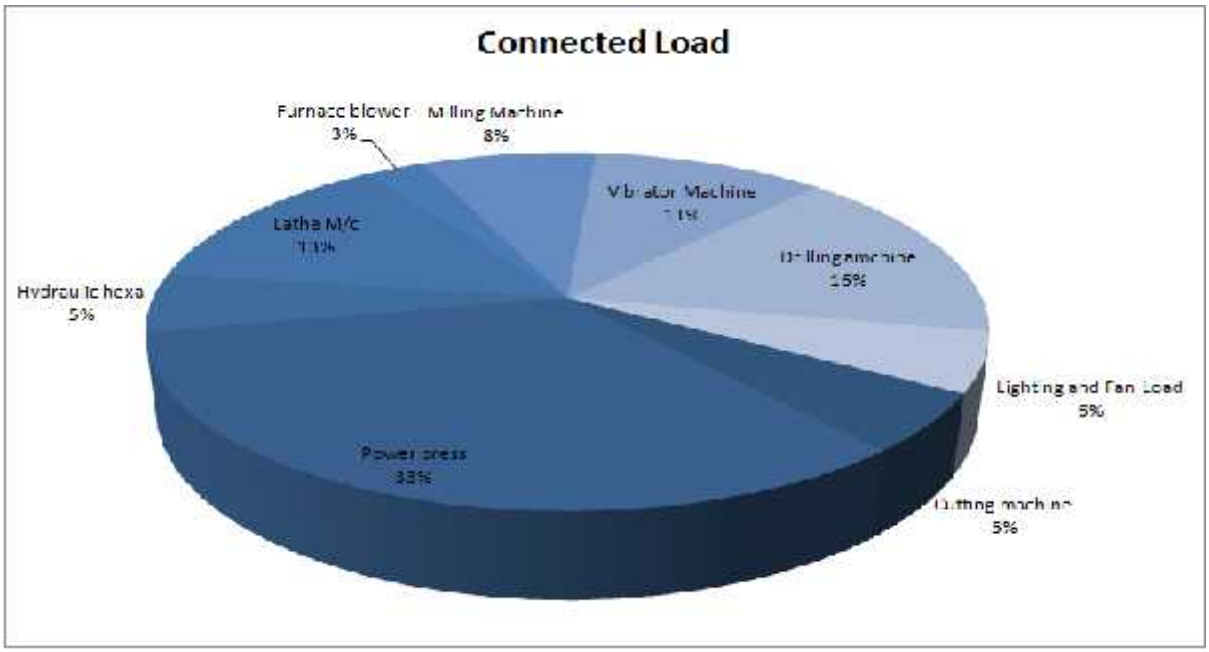

Figure 5: Details of connected load

As shown in the pie chart of connected load, the connected load is divided between power press – 33%, drilling machines – 16%, lathe machines – 13%, vibrator machines – 11%, milling machines – 8%, hydraulic hexa and cutting machines - each 5%, furnace blower – 3%. Lighting and fan load together contribute around 6 % of the connected load.

An analysis of area wise electricity consumption has been computed to quantify the electricity consumption in the individual processes. The area wise energy consumption details are shown as under:

Table 7: Area wise electricity consumption (estimated)

Consumption	kW	kWh/year	% of Total
Cutting machine	0.2	326	2.9%
Power press	3.1	1407	12.4%
Hydraulic hexa machine	0.9	1074	9.5%

Lathe machine	0.5	703	6.2%
Furnace blower	0.4	591	5.2%
Milling machine	0.9	1342	11.8%
Vibrator machine	1.8	1343	11.8%
Drilling machine	2.7	2417	21.3%
Lighting and Fan load	0.9	2164	19.0%
Total	**28**	**11,367**	**100%**

This is represented graphically in the figure below:

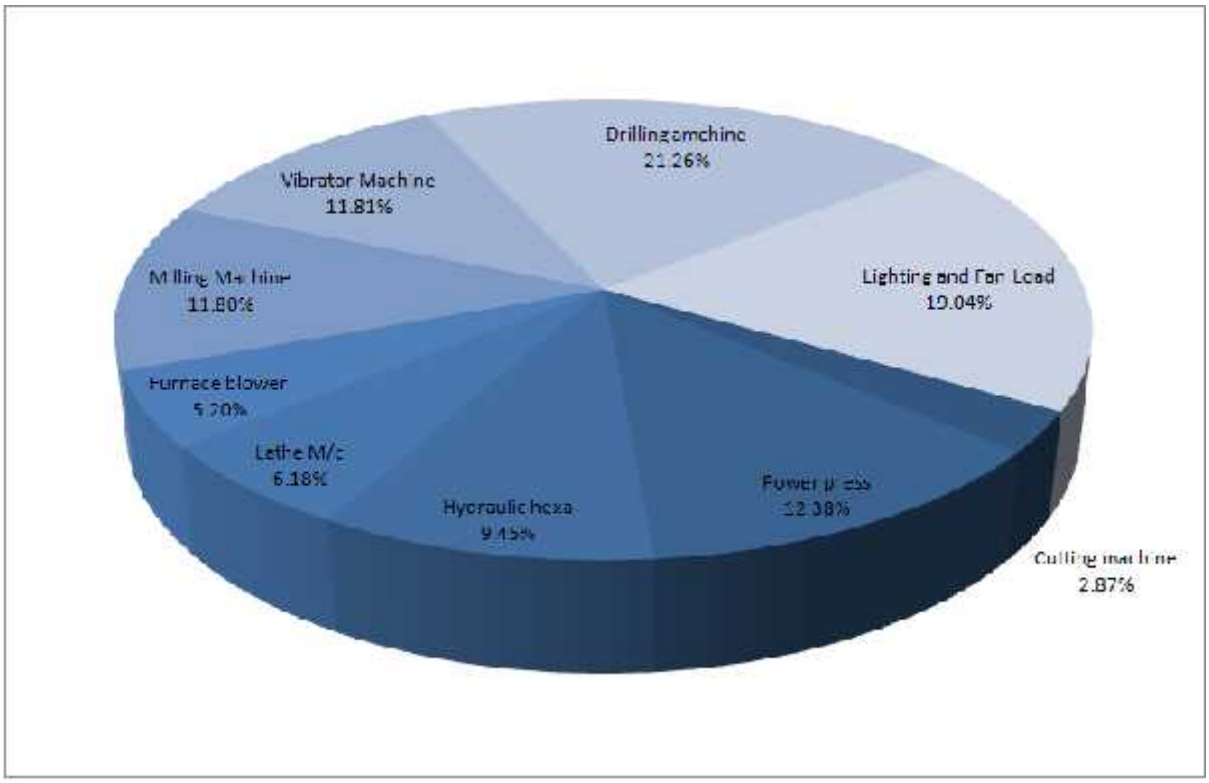

Figure 6: Area wise electricity consumption

There is a small difference between the estimated energy consumption and actual consumption recorded (<1%). This is attributed to assumptions made on operating load (based on measurement), diversity factor and hours of operation (based on discussion with plant maintenance).

3.3.2 Sourcing of electricity

The unit is drawing electricity from two different sources:

- Utility (PSPCL) through regulated tariff
- Captive DG set which is used as a backup source and supplies electricity in case of grid power failure

The share of utility power and DG power is shown in the table and figure below:

Table 8: Electricity share from grid and DG

	Consumption (kWh)	%	Cost (Lakh Rs.)	%
Grid Electricity	10,230	90	1.8	85
Self Generation	1,151	10	0.3	15
Total	**11,381**	**100**	**2.2**	**100**

This is graphically depicted as follows:

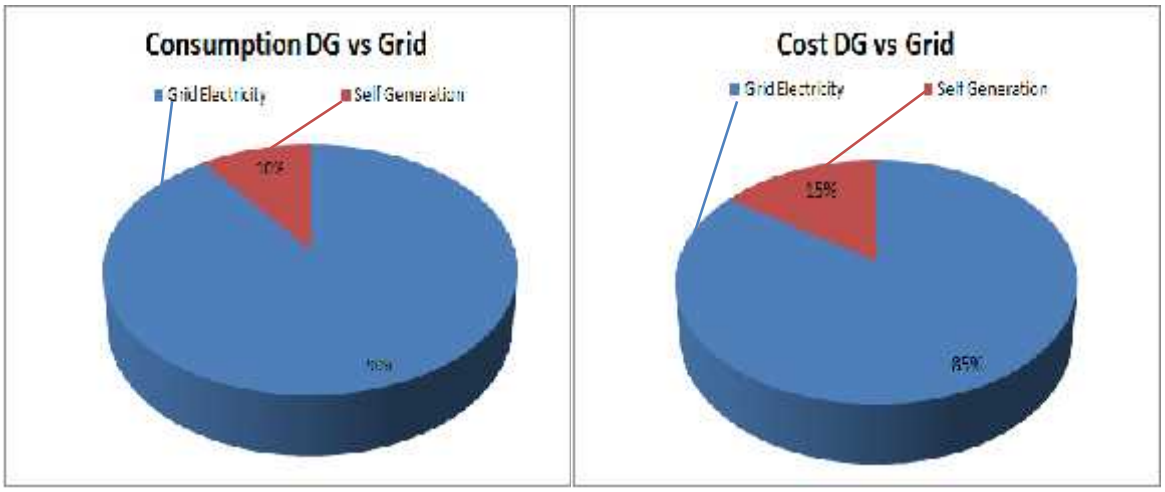

Figure 7: Share of electricity by source and cost

The share of electrical power as shown in the above chart indicates the condition of power supply from the utility. The requirement of power supply from backup source, i.e. DG set is about 10% of the total power which is not very high. Although the share of DG power in terms of kWh is just 10% of the total electrical power, it accounts for about 15% in terms of total cost of electrical power. This indicates the high cost of DG power due to rise in the price of diesel. For economical operation of the plant, the utilization of DG set needs to be minimized, but it will depend upon the supply condition of the grid, as well as the power requirement of the plant.

3.3.3 Supply from utility

Electricity is supplied by PSPCL. The unit has one HT energy meter provided by the distribution company within its premises. Details of the supply are as follows:

a)	Power Supply	:	430 V line
b)	Contract Demand	:	77.1 kVA
c)	Sanctioned Load	:	69.6 kW
d)	Nature of Industry	:	LT – G

The tariff structure is as follows:

Table 9: Tariff structure

Particulars	Tariff Structure	
Present energy charge	5.00	Rs./kVAh
Regulatory charges	0.76	Rs./kVA
Fuel surcharge	0.10	Rs./kVAh
Municipality tax	0.00	Rs./kVAh
Electricity duty	0.00	Rs./kVah

(As per bill)

Note: The meter was out of order for the last one year. The electricity board has charged the minimum electricity charge from the unit, but they haven't provided any value for the unit consumed. From the data of the last two years, the power factor was very poor and unit charge was very high. Unit owner was also not aware about this.

The single line diagram of electrical distribution system is shown in the figure below:

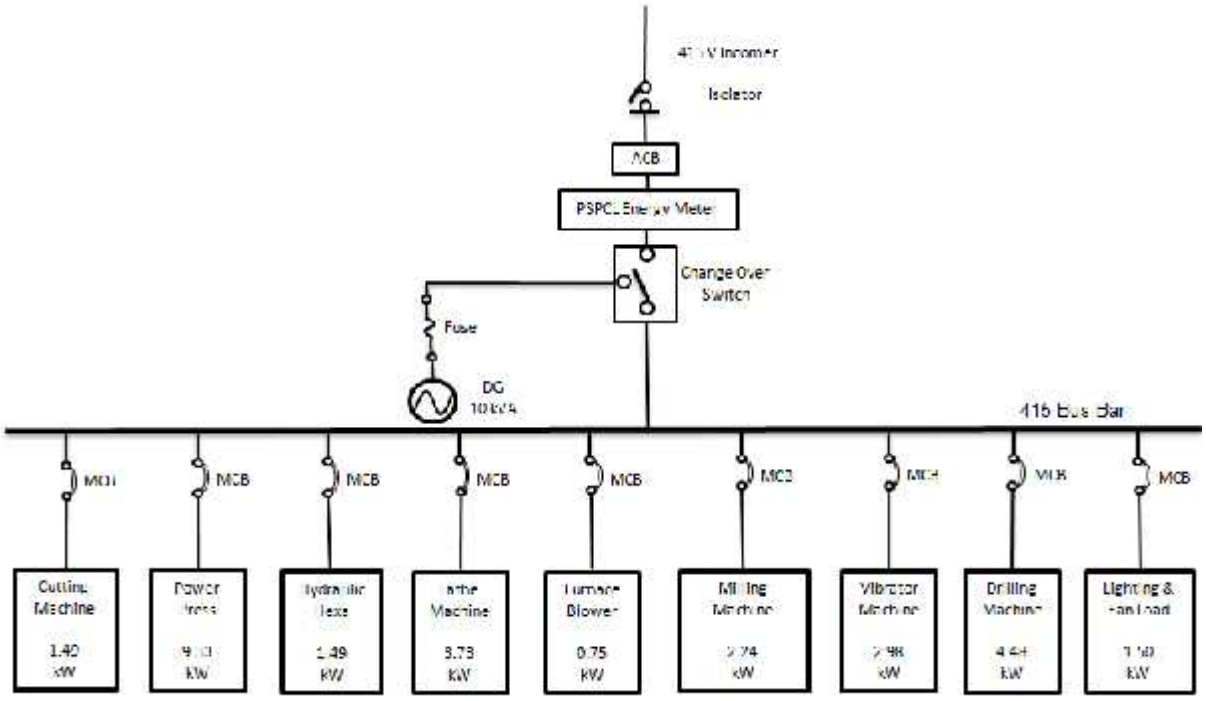

Figure 8: SLD of electrical load

Power factor

The utility bills of the unit reflect very poor power factor. However, during the energy audit study, measurement of the power factor was done by logging the main incomer. The average power factor measured was found to be 0.996 with the maximum being 1.

3.3.4 Self – generation

The unit has 1 DG set of 10 kVA. The unit does not have a system for monitoring the energy generation and fuel usage in the DG set. Diesel purchase records are, however, maintained by the unit. The DG performance testing was conducted during the audit and specific fuel consumption was calculated as 1.74 kWh / litre. Annual Diesel consumption by the DG set is 662 litres generating 1151 kWh at a cost of Rs. 33,080.

Note: Month wise total Ddesel consumption by the DG set was not provided by the unit, hence the average value is computed for the month.

3.3.5 Month wise electricity consumption

Month wise total electrical energy consumption from different sources is shown as under:

Table 10: Electricity consumption & cost

Months	Electricity Used (kWh)			Electricity Cost (Rs.)		
	Grid	DG	Total	Grid	DG	Total
	kWh	kWh	kWh	Rs	Rs.	Rs.
May-14	853	96	948	15,523	2,757	18,279
Jun-14	853	96	948	15,523	2,757	18,279
Jul-14	853	96	948	15,523	2,757	18,279
Aug-14	853	96	948	15,523	2,757	18,279
Sep-14	853	96	948	15,523	2,757	18,279
Oct-14	853	96	948	15,523	2,757	18,279
Nov-14	853	96	948	15,593	2,757	18,350
Dec-14	853	96	948	15,360	2,757	18,117
Jan-15	1,027	96	1,123	15,737	2,757	18,494
Feb-15	678	96	774	15,400	2,757	18,157
Mar-15	853	96	948	15,523	2,757	18,279
Apr-15	853	96	948	15,523	2,757	18,279
Total	**10,230**	**1,151**	**11,381**	**186,270**	**33,080**	**219,350**

The month wise variation in electricity consumption is shown graphically in the figure below:

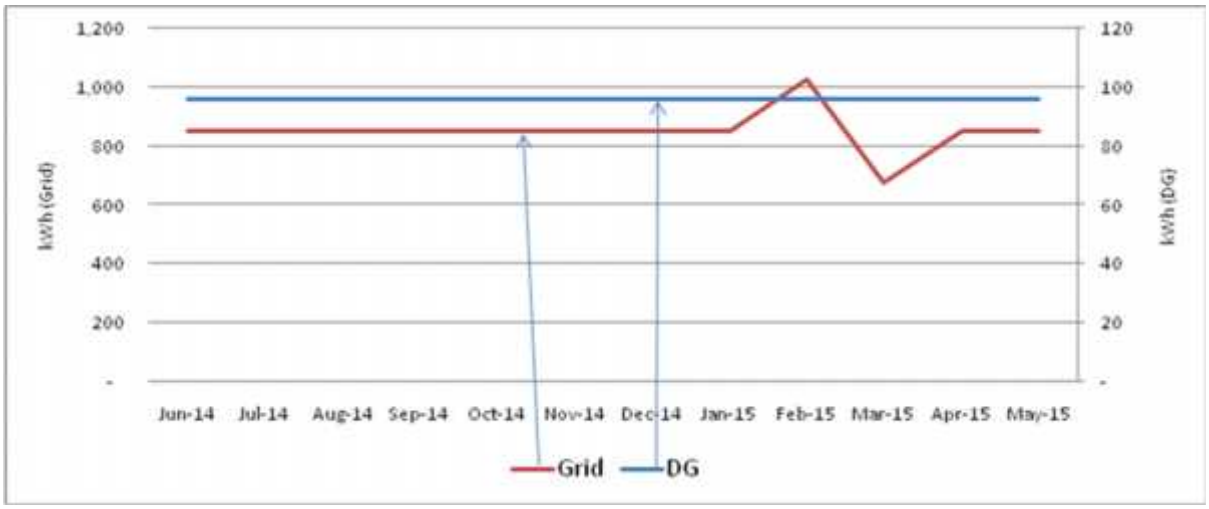

Figure 9: Month wise variation in electricity consumption from different sources

As shown in figure above, the consumption of electrical energy is on the higher side during the months of August 2014 and December 2014. However, the electricity consumption during the month of November 2014 was less, maybe because the production during that month might have been low. The corresponding month wise variation in electricity cost is shown graphically in the figure below:

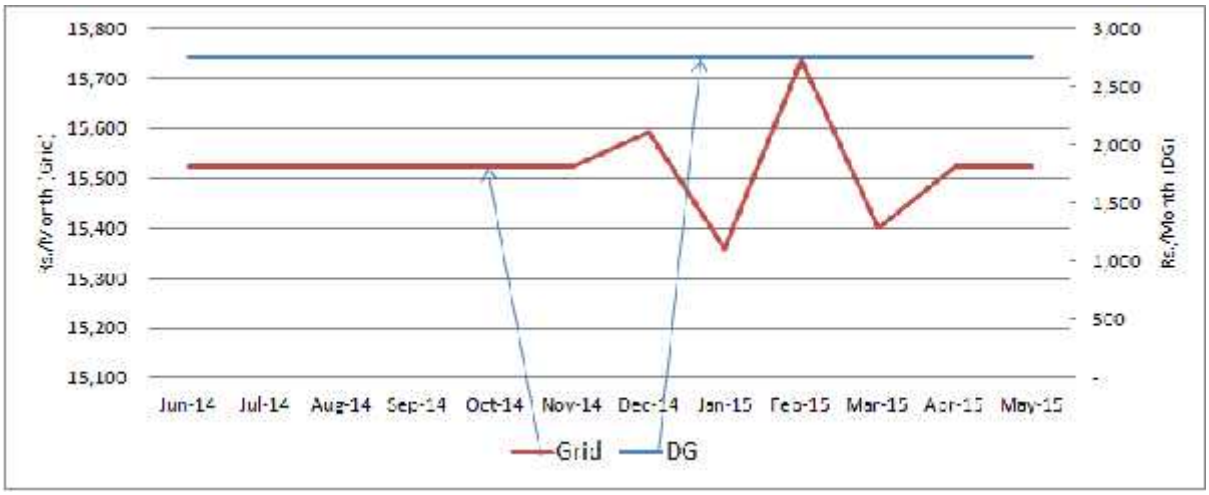

Figure 10: Month wise variation in electricity cost from different sources

The annual variation in cost of energy from utility as well as DG set is shown in the figure below:

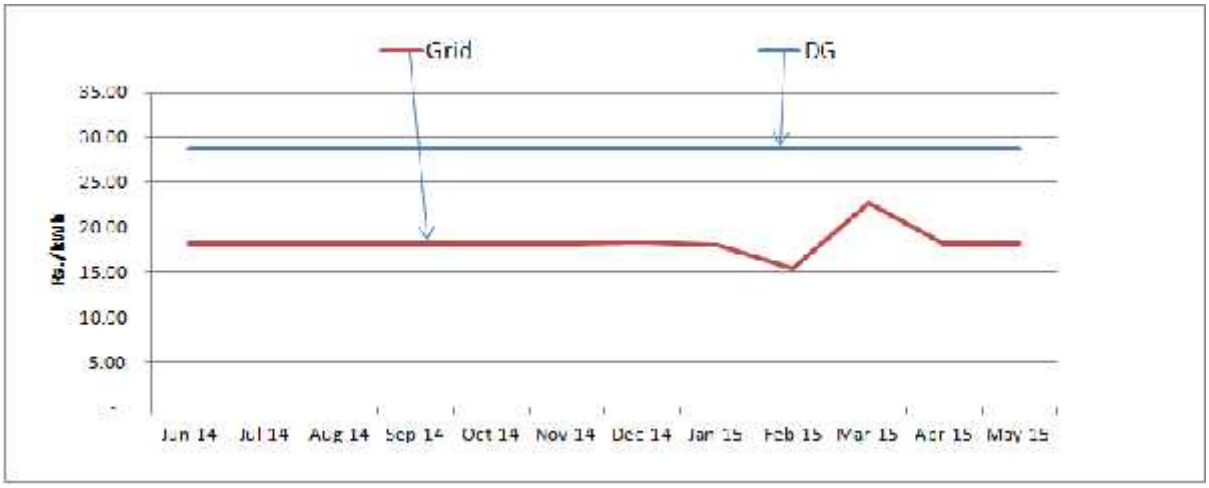

Figure 11: Average cost of power (Rs. /kWh) from different sources

From the above graph, it could be seen that the cost of electrical energy from DG set is very high, nearly twice the cost of utility power.

3.4 Analysis of thermal consumption by the unit

Fuel used for furnace is coal which is bought at the rate of Rs. 13/kg. There is no provision for measurement of coal consumption in the furnace. The plant management provided coal bill for only one month to the audit team. The consumption for other months has been assumed to be same as for all the remaining month for which the coal bill was provided. Annual coal consumption is 12000 kg costing Rs. 156000.

Note: The coal consumption in furnace is considered constant, as no data was recorded and it is based on average values given by the unit personnel.

3.5 Specific energy consumption

Annual production data was provided by the unit. Based on the available information, various specific energy consumption parameters have been estimated as shown in the following table. ***It is to be noted here that though annual production value was provided, the monthly data for the same was not provided by the unit.***

Table 11: Overall specific energy consumption

Parameters	Value	UoM
Annual Grid Electricity Consumption	10,230	kWh
Annual DG Generation Unit	1,151	kWh
Annual Total Electricity Consumption	11,381	kWh
Diesel Consumption for Electricity Generation	662	Litres
Annual Coal Consumption	12,000	Kg
Annual Energy Consumption; MTOE	8	MTOE
Annual Energy Cost	3.75	Lakhs Rs.

Annual Production	42	MT
SEC; Electricity from Grid	272	kWh/MT
SEC; Thermal	289	kg/MT
SEC; Overall	0.193	MTOE/MT
SEC; Cost Based	9032	Rs./MT

Basis for estimation of energy consumption in terms of tons of oil equivalent are as follows:

- Conversion Factors
  - Electricity from the Grid : 860 kCal/KWh
  - 1koe : 10,000 kCal
- GCV of Diesel : 11,840 kCal/ kg
- Density of HSD : 0.8263 kg/litre
- GCV of Coal : 4,500 Kcal/kg
- CO_2 Conversion factor
  - Grid : 0.89 kg/kWh
  - Diesel : 3.07 tons/ ton
  - Coal : 2.62 tons/ton

3.6 Baseline parameters

Following are the general baseline parameters, which have been considered for the techno-economic evaluation of various identified energy cost reduction projects, as well as for the purpose of comparison after implementation of the projects. The rates shown are the landed rates.

Table 12: Baseline parameters

Electricity Rate (Excluding Rs./kVA)	5.00	Rs. / kVAh inclusive of taxes
Weighted Average Electricity Cost	7.90	Rs. / kWh for 2012-13
Percentage of total DG based Generation	10%	
Average Cost of HSD	54	Rs. / Litre for April 2015
Average Cost of Coal	13	Rs. / Litre for April 2015
Annual Operating Days per year	330	Days/yr
Annual Operating Hours per day	10	Hr/day
Production	42	MT

3.7 Identified energy conservation measures in the plant

Diagnostic Study

A detailed study was conducted during CEA in the unit. Observations regarding energy performance of various processes / equipments were recorded, and a few ideas of EPIAs were developed. Summary of key observations is as follows:

3.7.1 Electricity Supply from Grid

The electrical parameters at the main electrical incomer feeder from PSPCL supply of the unit was recorded for 5 hours using the portable power analyzer instrument.

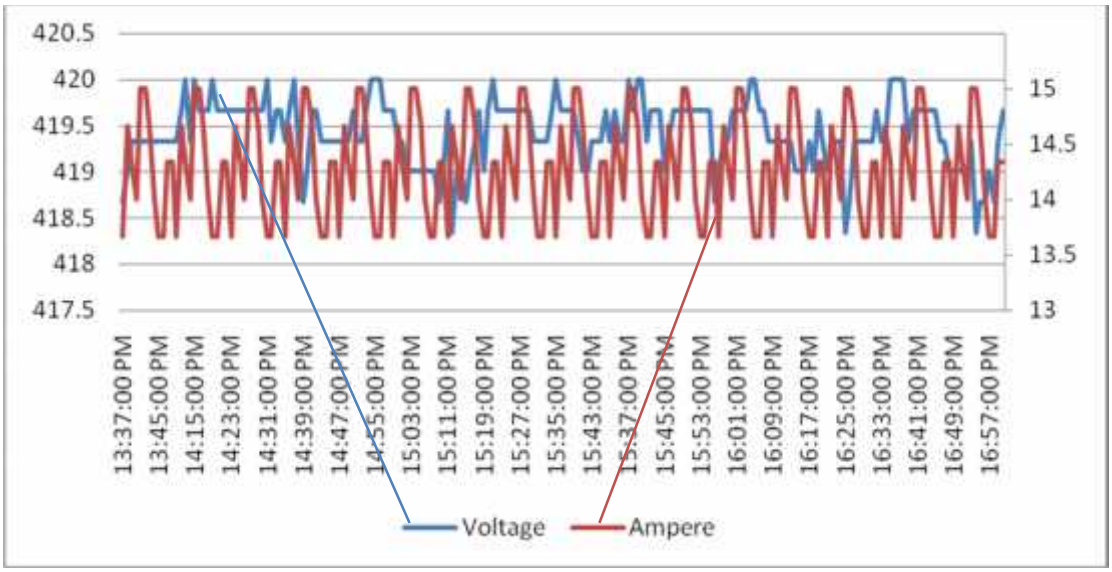

Figure 12: Voltage and Current profile

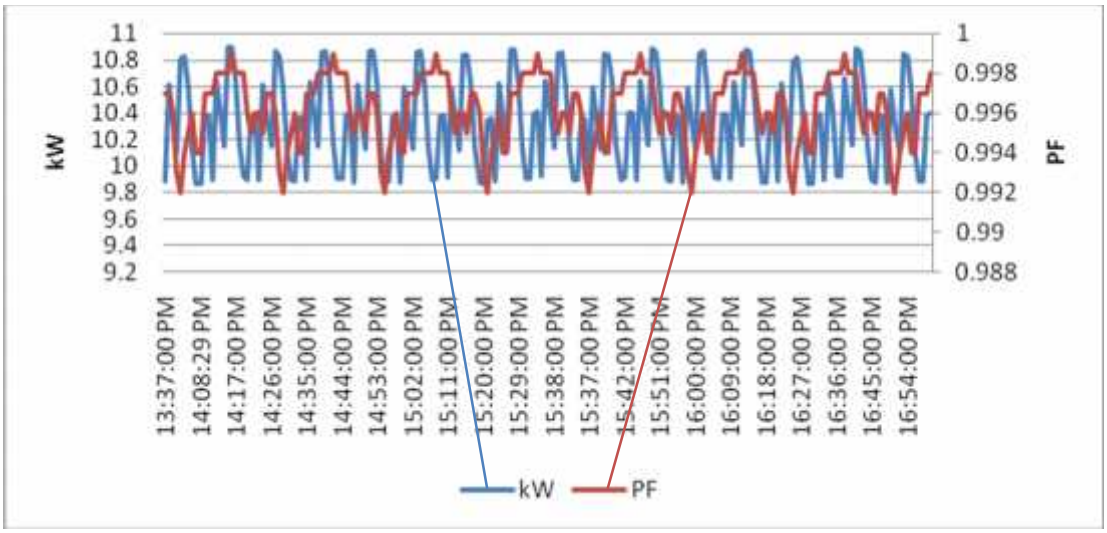

Figure 13: Load and power factor profile

Following observations have been made:

Table 13: Diagnosis of electric supply

Name of Area	Present Set-up	Observations during field Study & measurements	Ideas for energy performance improvement actions
Electricity Demand	PSPCL supplies the required power to the unit through a transformer. The unit has a HT connection. The contract demand of the unit is 77.1 kVA and sanctioned load is 69.6 kW.	The energy meter of this plant was out of order (not working) for the last one year. As per the electricity bill analysis, it was found that the unit was paying electricity at a tariff of Rs. 16.40 / kVAh and the PF according to the electricity bill was about 0.90. ***Also, it should be noted that as per the PSPCL tariff order the unit tariff rate (approx.) for this unit should be Rs. 5.85 / kWh.***	No EPIAs were suggested.
Power Factor	Unit has an HT connection and billing is in kVAh. PF paid by the unit is as per the utility bill.	The average PF found during the measurement was 0.996 and maximum was measured as 1. But as per the electricity bill, it was around 0.90 due to faulty meter. It is recommended that the unit should contact the utility authorities and get their energy meter repaired or replaced.	No EPIAs were suggested.
Voltage variation	The unit has no separate lighting feeder and no servo stabilizer for the same.	The voltage profile of the unit was satisfactory and it is recommended to install a separate lighting feeder and a servo stabilizer for lighting and fan load to reduce the voltage from 419.42 V (current voltage) to 390 V.	Although it is recommended to install a servo stabilizer, but the pay-back period for this measure worked out to be very high. Hence, no EPIAs were suggested.

In order to monitor the overall energy performance, the installation of a basic energy monitoring system has been proposed for this unit.

3.7.2 DG Performance

The unit has 1 DG set of 10 kVA rating. The unit does not have a system for monitoring the energy consumption and fuel usage in DG. Diesel purchase records are maintained by the unit. As part of the performance testing, measurements were conducted on the DG set by keeping track of the diesel consumption (by measuring the top up to the diesel tank) and recording the kWh generated during the same period. The key performance indicators of the DG set were evaluated and specific fuel consumption (SFC) of the DG is as follows:

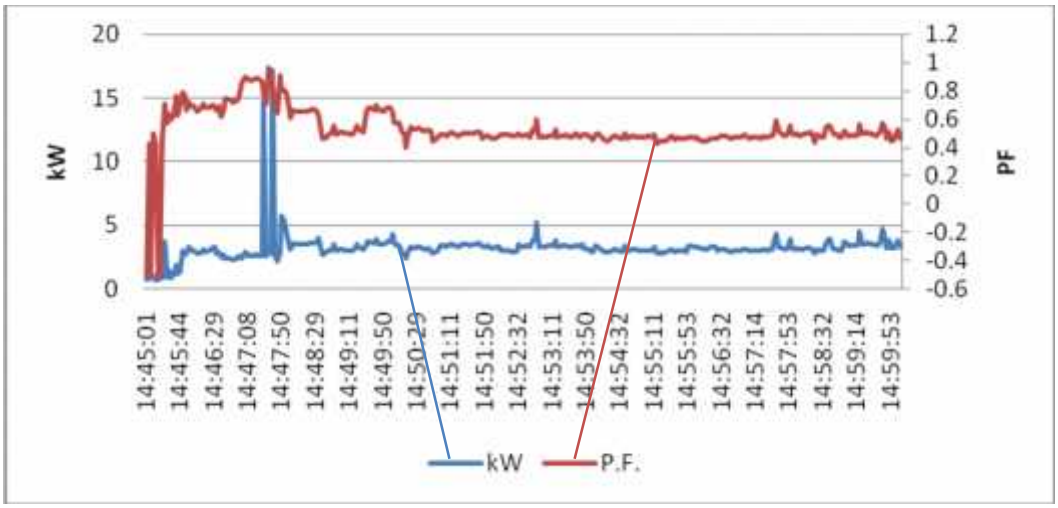

Figure 14: Load and power factor profile of DG Set

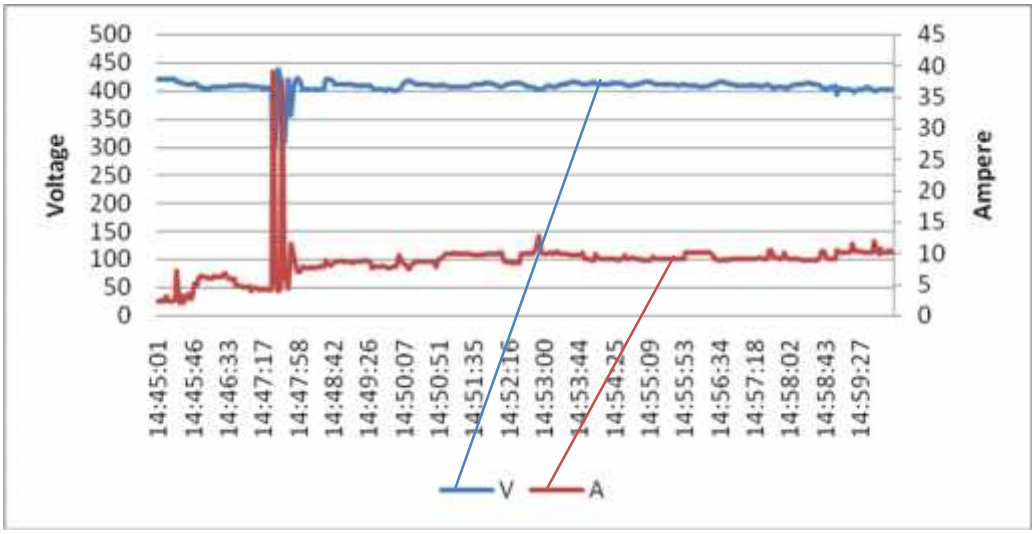

Figure 15: Voltage and Current profile

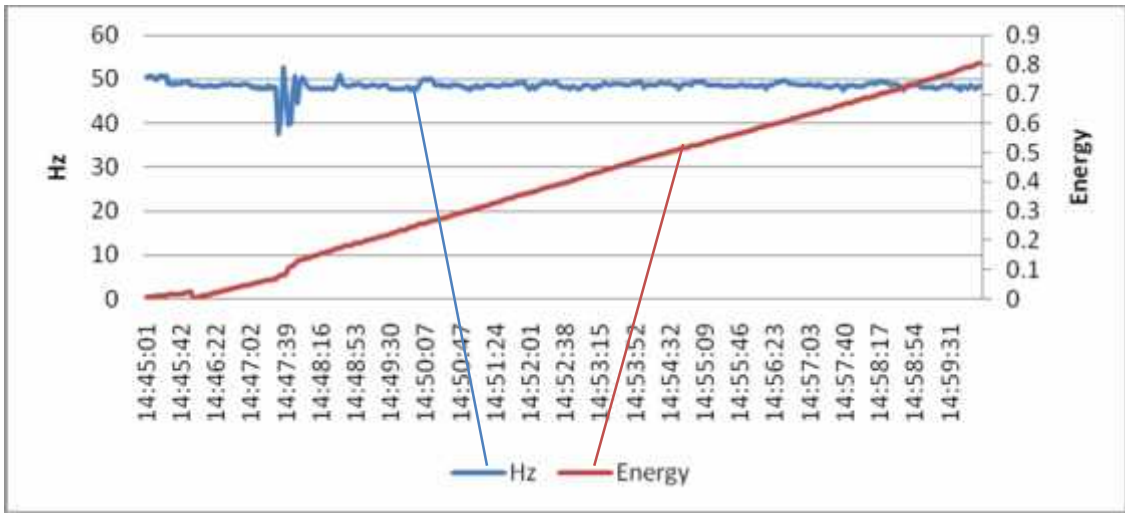

Figure 16: Energy and Harmonics profile

Table 14: Analysis of DG set

Particulars	DG
Rated KVA	10
Specific Fuel Consumption (kWh/Litre)	1.74

The observations made are as under:

- The SFC of DG set worked out to be 1.74 kWh / litre
- The power factor measured was 0.55
- The present average frequency of the DG set was 48.42 Hz

3.7.3 Electrical consumption areas

The equipment-wise consumption of electrical energy was measured in consultation with the unit. This is indicated in Table 6 of this report. Around 93.38% of energy consumption is for carrying out manufacturing operations and about 6.62 % is for the utilities.

Details of the observations, measurements conducted and ideas generated for energy conservation measures are as follows:

<table>
<tr><th>Name of Area</th><th>Present Set-up</th><th>Observations during field Study & measurements</th><th>Proposed Energy performance improvement actions</th></tr>
<tr><td>Power Press</td><td>There are 2 power presses of 7.5 HP and 5 HP respectively. Power press constitutes 32.88% of total energy consumption.</td><td>Study was conducted on both of the power presses

The results of the study are as below:
<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Power press #1</td><td>1.60</td><td>0.62</td></tr><tr><td>Power press #2</td><td>1.53</td><td>0.55</td></tr></table></td><td>Replacement of existing motors in power press with energy efficient motors has been recommended.</td></tr>
<tr><td>Lathe Machines</td><td>There are 10 lathe machines. Out of which 6 are driven by motors of 1 HP and 4 by motors of 2 HP.

Lathe machines constitute 13.15% of total energy consumption.</td><td>The study was conducted on all 3 lathes.

The results of the study are as below:
<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Lathe m/c #1</td><td>0.47</td><td>0.998</td></tr><tr><td>Lathe m/c #2</td><td>0.46</td><td>0.975</td></tr><tr><td>Lathe m/c #3</td><td>0.43</td><td>0.758</td></tr></table></td><td>No EPIAs were suggested for lathe machines.</td></tr>
</table>

3.7.4 Thermal consumption areas

As discussed in earlier sections, about 60% of total energy cost of the plant and 85% of the total energy usage was in the furnace. The details of present set-up, key observations made and potential areas for energy cost reduction have been mentioned in the table below:

Name of Area	Present Set-up	Observations during field Study & measurements	Proposed Energy performance improvement actions
Furnace	The fuel used for heating in furnace is coal.	There was no metering system available for measuring coal consumption.	Installation of flow meter is recommended.
	The combustion air required for burning of coal is supplied by	The O_2 level in flue gases coming out of the furnace was above 10%. This reflects high amount of excess air supplied than required	Operation of manual excess air control system

	electrical driven blower (FD fan).	for efficient combustion. This also results in high heat loss due to dry flue gases.	(dampers).
		A feasibility study was also done for replacing the existing coal fired furnace with electrical induction furnace. The recommendation to replace the present coal fired furnace with electrical induction furnace was not feasible because the operational cost of using electricity was much higher when compared to present coal based system due to low running hours of the furnace and high tariff rate of electricity.	EPIA for replacing the present coal fired furnace with an electrical induction furnace is not recommended.

4 EE TECHNOLOGY OPTIONS AND TECHNO – ECONOMIC FEASIBILTY

During CEA of the plant, all energy consuming equipments and processes were studied. The analysis of all major energy consuming equipments and appliances were carried out, which have been already discussed in earlier section of this report.

Based on the analysis, Energy Performance Improvement Actions (EPIA) has been identified below:

4.1 EPIA 1: Manual Excess air control

Technology description

It is necessary to maintain optimum excess air levels in combustion air supplied for complete combustion of the fuel. The excess air levels are calculated based on oxygen content in the flue gases. The theoretical air required for combustion of any fuel can be known from the ultimate analysis of the fuel. All combustion processes require a certain amount of excess air in addition to the theoretical air supplied. Excess air supplied needs to be maintained at optimum levels, as too much of excess air results in excessive heat loss through the flue gases. Similarly, too little excess air results in incomplete combustion of fuel and formation of black coloured smoke in flue gases.

Generally, in most of the furnaces, fuel is fired with too much of excess air. This results in formation of excess flue gases, taking away the heat produced from the combustion and increasing fuel consumption. This also results in formation of excess GHG emissions. The excess air effects the formation of ferrous oxide resulting in increase in burning losses.

The unit is using conventional furnace (chullah) for forging. It is suggested to control the combustion air being supplied by the blower (FD fan) by manual operation of the damper on the supply air duct.

Study and investigation

At the time of CEA, it was found that there was no proper automation and control system installed to maintain the optimum excess air levels. Fuel was fired from the existing burner and no air flow control mechanism was in place for maintaining proper combustion of the fuel. It was found that the oxygen level in the furnace was 11.88 % which indicates very high excess air levels resulting in high heat loss due to dry flue gas from the furnace.

Recommended action

Since the unit is using conventional furnace (chullah) for forging, manual operation of the damper on the supply air duct is suggested to regulate the supply of excess air for complete combustion. As a thumb rule, reduction in every 10% of excess air will save 1% in specific fuel consumption.

The cost benefit analysis of energy conservation measure is given below:

Table 15: Cost benefit analysis (EPIA 1)

Parameters	UOM	Present	Proposed
Production of material	tph	0.31	0.31
Oxygen level in flue gas	%	11.88	2.00
Excess air	%	130.14	10.53
Dry flue gas loss	%	54.56	
Specific fuel consumption	kg/t	198.53	177.36
Saving in specific fuel consumption	kg/h		0.89
Operating hrs of forging furnace	hr/y	900.00	900.00
Saving in fuel consumption per year	kg/y		799.56
Savings in fuel cost	Rs. Lakhs/y		0.10
Installed capacity of blower	kW	0.75	0.75
Running load of blower	kW	0.39	0.35
Operating hours	hr/y	900.00	900.00
Electrical energy consumed	kWh/y	354.57	319.11
Savings in terms of power consumption	kWh/y		35.46
Savings in terms of cost of electrical energy	Lakhs Rs./y		0.003
Reduction in burning loss inside furnace	%		0.50
Total material savings	tpy		0.19
Cost of saved material	Lakhs Rs./y		0.09
Monetary savings	Lakhs Rs./y		0.20
Estimated investment	Lakhs Rs.		5.00
Simple payback	Years		24.85

4.2 EPIA 2: Replacing existing conventional ceiling fans with energy efficient fans

Technology description

Replacing old fans of conventional types installed in various sections of the plant with energy efficient fans will help in reducing the power consumption by approximately 50%. The energy efficient fans have a noiseless operation and are controlled by electronic drives which on speed reduction automatically sense the rpm and reduce power consumption.

Study and investigation

The unit is having about 10 fans which are very old and are recommended to be replaced with energy efficient fans.

Recommended action

It is recommended to replace the existing fans with energy efficient fans. The cost benefit analysis of the same is given in the table below:

Table 16: Cost benefit analysis (EPIA 2)

Data & Assumptions	UOM	Ordinary fan	Super fan
Number of fans in the facility	Nos.	10	10
Run hours per day	hr/days	10	10
Power consumption at Maximum speed	Watts	75	35
Number of working days/year	days	300	300
Electricity tariff rate	Rs. / kWh	7.90	7.90
Fan unit price	Rs. / pc	1,500	3,000
Electricity consumption:			
Electricity demand	kW	0.75	0.35
Power consumption by fans in a year	kWh/y	2250	1050
Savings in terms of power consumption	kWh/y		1200
Monetary Savings	Lakhs Rs./y		0.0948
Estimated investment	Lakhs Rs./y		0.30
Payback period	Years		3.16

4.3 EPIA 3: Replacing present conventional lighting system with energy efficient lighting fixtures

Technology description

Replacing conventional lights like T-12, T-8 etc with LED lights helps reduce power consumption and also results in higher illumination (lux) levels for the same power consumption.

Study and investigation

The unit is having 7 nos. T12 and 5 nos.T8 tube lights.

Recommended action

It is recommended to replace the above mentioned lighting fixtures with energy efficient LED lamps which will help in reducing present lighting energy consumption. The cost benefit analysis for the EPIA is given below:

Table 17: Cost benefit analysis (EPIA 3)

Particulars	Unit	Existing	Proposed
Fixture	**UOM**		**16 Watt LED tube light**
Power consumed by T12 lighting	W	40	16
Power consumed by magnetic choke	W	12	0

Total nos. of T12 lighting	Nos.	7	7
Power consumed by T8 lighting	W	36	16
Power consumed by magnetic choke	W	12	0
Total nos. of T8 lighting	Nos.	5	5
Total power consumption	W	604	192
Operating hours/day	hr	10	10
Annual days of operation	day	300	300
Energy used per year/fixture	kWh	1,812	576
Average Weighted cost	Rs. / kWh	7.90	7.90
Operating cost per year	Lakhs Rs. / y	0.14	0.05
Saving in terms of power consumption	kWh / y		1236
Monetary savings	Lakhs Rs. / y		0.10
Investment per fixture of LED	Rs.		0.0075
Investment of project	Lakhs Rs.		0.09
Payback period	Years		0.92

4.4 EPIA 4: Replacement of old, inefficient (and several times re-wounded) motors with energy efficient motors

Technology description

Replacing old and inefficient motors of the power press machines (2 numbers) with energy efficient motors will reduce power consumption by approximately 50%. The energy efficient motors have minimum losses and are capable of delivering power at efficiency of over 90%. These motors have class F insulation level and are made of high grade materials.

Study and investigation

The unit is having two motors for power press machines which are re-wounded several times and are having efficiency below 60%.

Recommended action

It is recommended to replace the present motors of power press machines (as in table below) with energy efficient motors.

The cost benefit analysis for this energy conservation measure is given below:

Table 18: Cost benefit analysis (EPIA 4)

Parameters	UOM	Press Mc-1		Press Mc-2	
		AS IS	TO BE	AS IS	TO BE

Rated Power	kW	5.60	5.595	3.73	3.73
Efficiency of motor	%	60%	90%	70%	90%
Average Load	kW	4.48	2.98	2.61	2.03
Net Power Savings	kW		1.49		0.58
Running hours per day	hrs / day		7		7
Running Hours	hrs / y		2,100		2,100
Savings in terms of power consumption	kWh/y		3133		1218
Average. weighted cost	Rs / kWh		7.90		7.90
Investment	Lakhs Rs.		0.32		0.23
Monetary Savings	Lakhs Rs.		0.25		0.10
Simple Payback	Years		1.29		2.39

5 ANNEXURE

Furnace efficiency calculations

Input parameters

Input Data Sheet		
Type of Fuel		**Coal**
Source of fuel	**Local vendor**	
	Value	**Units**
Furnace operating temperature (Heating Zone)	1063	*Deg C*
Final temperature of material (at outlet of Heating zone)	986	*Deg C*
Initial temperature of material	33	*Deg C*
Average fuel Consumption	20	*kg/hr*
Flue Gas Details		
Flue gas temperature after	474	*deg C*
Preheated air temperature	33	*deg C*
O2 in flue gas	12	*%*
CO2 in flue gas	8.1	*%*
CO in flue gas	68.9	*Ppm*
Atmospheric Air		
Ambient Temperature	33	*Deg C*
Relative Humidity	45.6	*%*
Humidity in ambient air	0.03	*kg/kg dry air*
Fuel Analysis		
C	*80.36*	%
H	*5.46*	%
N	*1.26*	%
O	*7.62*	%
S	*1.53*	%
Moisture	*1.17*	%
Ash	*2.48*	%
GCV of Fuel	*5400*	kCal/kg
Ash Analysis		
Unburnt in bottom ash	*2.00*	%
Unburnt in fly ash	*3.85*	%
GCV of bottom ash	*215*	kCal/kg
GCV of fly ash	*333*	kCal/kg
Material and flue gas data		
Weight of material (Raw material) being heated in furnace	315	*kg/hr*
Weight of Stock	315	*kg/hr*
Specific heat of material	0.12	kCal/kg *degC*

Average specific heat of fuel	0.5	kCal/kg *degC*
fuel temp	33	*deg C*
Specific heat of flue gas	0.26	kCal/kg *degC*
Specific heat of superheated vapour	0.45	kCal/kg *degC*
Heat loss from surfaces of various zone		
For Ceiling		
Natural convection heat transfer rate from ceiling	2.8	kCal */m2 degC*
External temperature of ceiling	321	*deg K*
Room Temperature	306	*deg K*
Ceiling surface area	0.23	*m2*
Emissivity of furnace body surface	0.75	
For side walls		
Natural convection heat transfer rate from sidewall surfaces	2.2	*kCal/m2 degC*
External temperature of side walls	370	*deg K*
Sidewall surface area	1.5498	*m2*
For Hearth		
Natural convection heat transfer rate from flue gas duct surfaces	1.5	*kCal/m2 degC*
External temp. of side walls	339	*deg K*
External surface area	0.027	*m2*
Outside dia of flue gas duct	*0.15*	*m*
For radiation loss in furnace(through charging and discharging door)		
Time duration for which the material enters through preheating zone and exits through Furnace	1	*hr*
Area of opening in m2	0.2	*m2*
Coefficient based on profile of furnace opening	0.7	
Maximum temperature of air at furnace door	393	*deg K*

Efficiency calculations

Calculations	Values	Unit
Theoretical Air Required	10.96	*kg/kg of fuel*
Excess Air supplied	130.14	*%*
Actual Mass of Supplied Air	25.22	*kg/kg of fuel*
Mass of dry flue gas	25.69	*kg/kg of fuel*
Amount of Wet flue gas	26.22	*kg of flue gas/kg of fuel*
Amount of water vapor in flue gas	0.50	*kg of H2O/kg of fuel*
Amount of dry flue gas	25.71	*kg/kg of fuel*
Specific Fuel consumption	63.53	*kg of fuel/ton of material*
Heat Input Calculations		
Combustion heat of fuel	343,053	*kCal/ton of material*
Sensible heat of fuel	-	*kCal/ton of material*
Total heat input	343,053	*kCal/ton of material*
Heat Output Calculation		

Heat carried away by 1 ton of material (useful heat)	123,600	*kCal/ton of material*
Heat loss in dry flue gas per ton of material	187,175	*kCal/ton of material*
Loss due to H2 in fuel	24,422	*kCal/ton of material*
Loss due to moisture in combustion air	150	*kCal/ton of material*
Loss due to partial conversion of C to CO	244	*kCal/ton of material*
Loss due to convection and radiation (openings in furnace - inlet & outlet door of furnace)	327	*kCal/ton of material*
Loss Due to Evaporation of Moisture Present in Fuel	581	*kCal/ton of material*
Total heat loss from furnace body	3,290	*kCal/ton of material*
Heat loss due to unburnts in Fly ash	32	*kCal/ton of material*
Heat loss due to unburnts in bottom ash	11	*kCal/ton of material*
Unaccounted heat losses	3,220	*kCal/ton of material*
Heat loss from furnace body and ceilings		
Heat loss from furnace body ceiling surface	35	*kCal/hr*
Heat loss from furnace body side walls surfaces	995	*kCal/hr*
Heat loss from hearth	5	*kCal/hr*
Total heat loss from furnace body	3290	*kCal/tons*
Furnace Efficiency	**36.03**	*%*

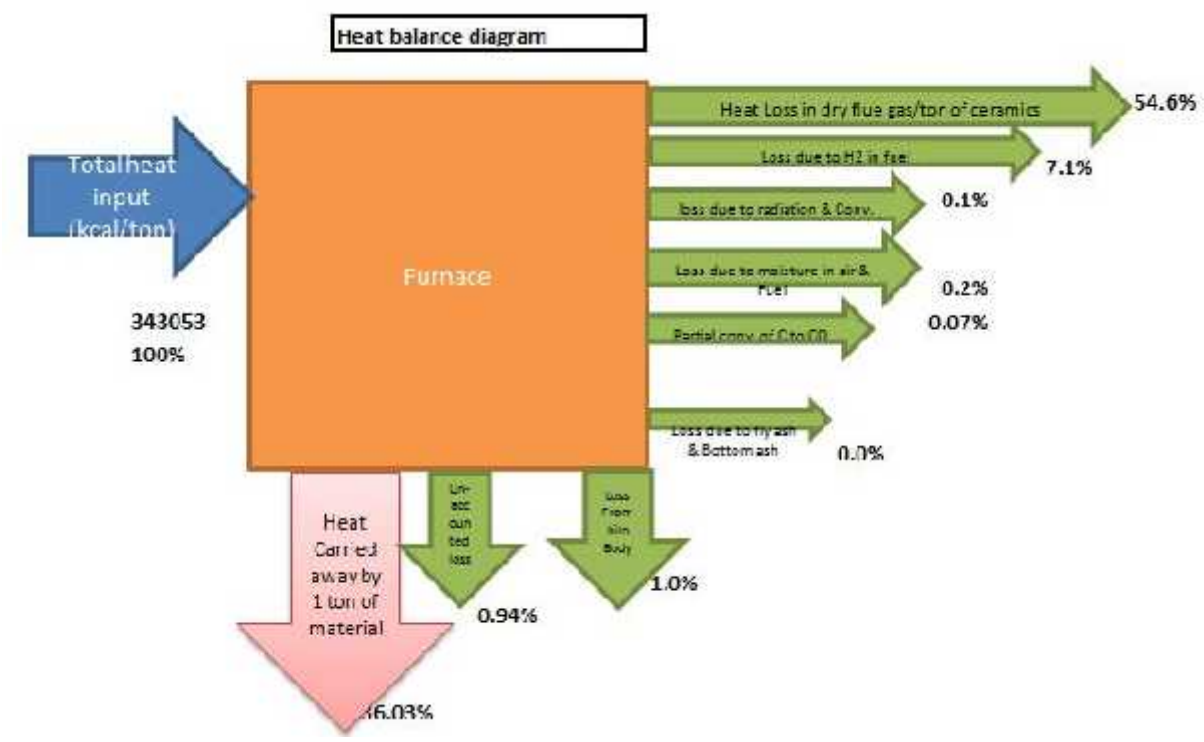

Figure 17: Sankey diagram for Furnace

6 LIST OF VENDORS

The details of some of the suppliers for energy equipments are given in the table below:

EPIA 1: Excess Air Control

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
Automation				
1	Delta Energy Nature Contact Person Gurinder Jeet Singh, Director	F-187, Indl. Area, Phase-VIII-Bm Mohali-160059	Tel.: 0172-4004213/ 3097657/ 2268197 Mobile: 9316523651 9814014144 9316523651	dengjss@yahoo.com den8353@yahoo.com
2	International Automation Inc Contact Person Sanjeev Sharma)	# 1698, First Floor, Canara Bank Building, Near Cheema Chowk, Link Road, Ludhiana	Office: +91-161-4624392, Mobile: +91-9815600392	Email: interautoinc@yahoo.com
3	Happy Instrument	Yogesh 20, Proffulit Society, Nr Navo Vas, Rakhial, Ahmedabad-380021	079-22771702 9879950702	yogesh@happyinstrument.com
4	Wonder Automation	Kulwinder Singh E-192, Sector 74, Phase 8-B, Industrial Area, SAS nagar Mohali	0172-4657597 98140 12597	info@wonderplctrg.com admn.watc@gmail.com hs@wonderplctrg.com

EPIA 2: Installation of EE fans instead of conventional fans

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Super fans	351B/2A, Uzhaipalar street, GN Mills PO, Coimbatore. INDIA 641029.	Mob: 9489078737	Email: superfan@versadrives.com
2	Usha pumps Contact Person: Mr. KB Singh	J-1/162, Rajouri Garden, Rajouri Garden New Delhi, DL 110005	011(23318114),011 2510 4999,01123235861(Mr.Manish)	Email: kb_singh@ushainternational.com

EPIA 3: Energy Efficient Lights

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Osram Electricals Contact Person: Mr. Vinay Bharti	OSRAM India Private Limited,Signature Towers, 11th Floor,Tower B, South City - 1,122001 Gurgaon, Haryana	Phone: 011-30416390 Mob: 9560215888	vinay.bharti@osram.com
2	Philips Electronics Contact Person: Mr. R. Nandakishore	1st Floor Watika Atrium, DLF Golf Course Road, Sector 53, Sector 53 Gurgaon, Haryana 122002	9810997486, 9818712322(Yogesh-Area Manager), 9810495473(Sandeep-Faridabad)	r.nandakishore@phillips.com, sandeep.raina@phillips.com
3	Bajaj Electricals Contact Person: Mr. Kushgra Kishore	Bajaj Electricals Ltd,1/10, Asaf Ali Road, New Delhi 110 002	9717100273, 011-25804644 Fax : 011-23230214 ,011-23503700, 9811801341(Mr.Rahul Khare), (9899660832)Mr.Atul Baluja, Garving Gaur(9717100273),	kushagra.kishore@bajajelectricals.com, kushagrakishore@gmail.com; sanjay.adlakha@bajajelectricals.com

Sl. No.	Name of Company	Address	Phone No.	E-mail
			9810461907(Kapil)	

EPIA 4: Replacement of old motors with Energy Efficient Motors

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Havells India Contact Person: Mr. Niranjan Sanghvi	QRG Towers,2D,Sec-126,Express way,Noida-201304,UP	Mr.Niranjan Sanghvi(9314060101),Mr.Vishwanathan(9899104105),Mr Sanjeev Nayyar(9818499726)	niranjan.singhvi@havells.com
2	Crompton Greaves- Dealer Contact Person: Mr. Ajay Gupta	New Delhi-110019	Mobile : 9811888657	Email: NA