COMPREHENSIVE ENERGY AUDIT REPORT

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

Gripwell Tools Industries

C 104, Focal Point Extension, Jalandhar

26-05-2015

Submitted to

ENERGY IS LIFE

CONSERVE IT

BUREAU OF ENERGY EFFICIENCY

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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. Sukhdev Singh, General Manager, Gripwell Tools Industries for showing keen interest in the energy audit and also thankful to the management of M/s Gripwell Tools Industries 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

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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 Derive

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 in selected MSME clusters in India". The objective of the project is to provide impetus to energy efficiency initiatives in the small and medium enterprises (SMEs) 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[1] 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 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 Gripwell Tools Industries
Constitution	Private Limited
MSME Classification	Small
No. of years in operation	NA
Address: Registered Office:	C–104, Focal Point Extension, Jalandhar, Punjab–144012
Administrative Office	C–104, Focal Point Extension, Jalandhar, Punjab–144012
Factory :	C–104, Focal Point Extension, Jalandhar, Punjab–144012
Industry-sector	Hand Tools
Products Manufactured	Wrenches, Pliers, Pincers, Plumbing and Construction tools

[1] http://www.dcmsme.gov.in/handtools/industry/cluster.html#3

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 production process includes blanking, heating, forging, trimming, broaching, grinding, barreling, heat treatment, shot blasting, calibration, polishing, electroplating and packing.

The raw materials used are mainly MS and CRV steel. The raw material is blanked and then sent to a forging furnace for heating. The heated material (work piece) is removed from the forging furnace and forged using hammers. The forged work piece is then cut and trimmed into desired shapes, and the unnecessary burrs along the edges are removed in the trimming operation.

The trimmed work piece is then treated in the heat treatment furnace for hardening, quenching and tempering to attain desired metallurgical properties like strength, stability and durability.

Post heat treatment, in order to get the necessary surface finish and polish, the work pieces are shot blasted after which they are placed in vibrating glazing machines along with a measured quantity of ceramic material (in form of ceramic stones). Due to the vibration action of this machine, the work pieces and ceramic materials rub against each. In this process, the work piece gets further polished.

The polished work piece is then sent for electroplating, where it is dipped for a certain period of time inside hot nickel and chromium baths to attain the desired final glaze and finishing. From the electroplating section, the finished products are packed and dispatched.

The main process equipments are furnace, hammer, broaching machines, blanking machines, heat treatment furnace, vibrators, shot blasting machine.

Identified Energy Performance Improvement Actions (EPIA)

The comprehensive energy audit covered all of the equipments, which were operational during the field study. The main energy consuming equipments in the unit are the kilns, accounting for more than 86 % of the total energy used. 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						
		(FO)	Electricity	HSD	Material Savings	Monetary savings	Estimated investment	Simple payback period
		Litre/y	kWh/y	Litre/y	Rs. lakh/y	Rs. lakh/y	Rs. lakh	y
1	Installation of PID controller for excess air control on forging-2	9659.4	787.8		1.1	5.0	7.00	1.4
2	Installation of PID controller for excess air control on forging-3	2451	787.8		0.8	1.8	7.00	3.9
3	Installation of VFD on broaching machine		2125.9			0.1	0.79	5.7
4	Installation of energy efficient pump motor instead of old and inefficient pump motor		106577.1			6.9	9.05	1.3
5	Installation of energy efficient fan instead of conventional fan		19899.0			1.3	4.02	3.1
6	Retrofitt of CFL 40 watt to led tube light of 16 watt		20554.6			1.3	2.61	2.0
7	Replacement of CFL 65 watt ,36 watt ,23 watt, 18 watt and MV lamp of 400 watt, 250 watt, 100 watt and 40 watt lamp to LED 25 watt, LED 15 watt, LED 10 watt, LED 7 watt, LED 130 watt, LED 80 watt , LED 40 watt and LED 4 watt		75601.0			4.9	13.55	2.8
8	Installation of energy monitoring system on sectional energy consuming area	5699.6	42512	195		5.0	0.75	0.2
9	Skin loss reduction from furnace surface	364.3				0.15	0.05	0.4
10	Temperature control for heaters in electroplating bath		63428			4.10	0.70	0.2
11	Replacement of present burner with energy efficient burner in forging furnace	1921.5				0.77	0.49	0.6
12	Installation of SWH for electroplating plant		228000			14.75	66.58	4.5
	Total	20096	560272.9	194.9	1.9	46.1	112.6	2.4

The projects proposed may result in energy cost savings of up to Rs. 46.1 lakhs on implementation.

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 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	Jalandhar, 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 for 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 for the period April-2014 to March-2015 (quantity and cost)
  - Data on production for the 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 and products manufactured
  - Existing manpower and levels of expertise
  - List of major equipments and specifications

- 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.
- 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 5.7 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.
- Assess the scope of application of renewable energy. In Gripwell industries, the electroplating plant was using hot water generated by fossil fuel fired hot water generator. The audit team explored the possibility of using solar based hot water system for replacing the present fossil fuel fired system.
- 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 operationalduring 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:

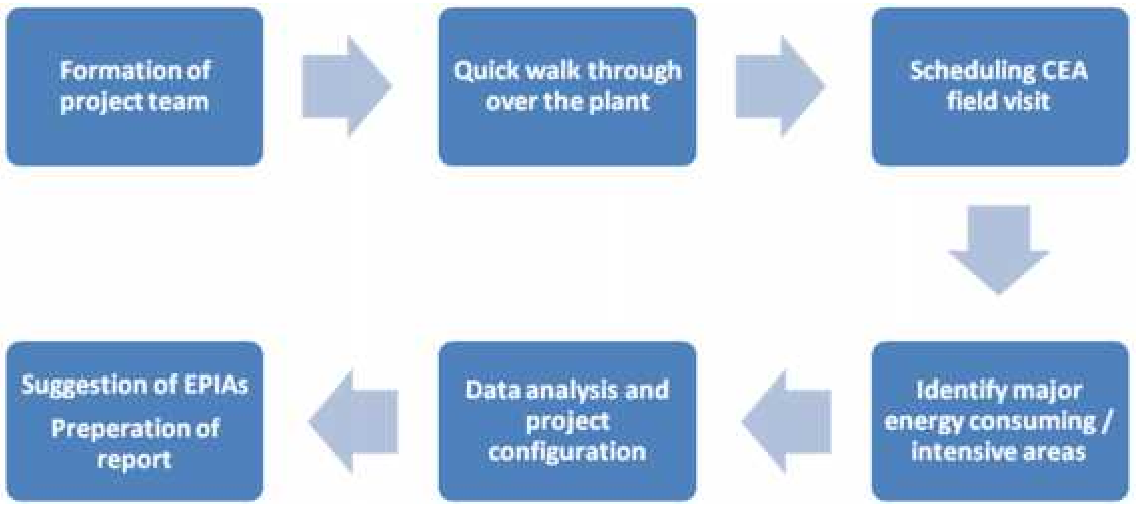

Figure 1: General methodology

The study was conducted in 3 stages:

- **Stage 1:** Walk through energy audit of the plant to understand 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 savings potential, technology assessment and understanding of project constraints
- **Stage 3**: Data analysis, initial configuration of projects, savings quantification, vendor consultation, interaction with 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 unit's 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 the process
- Fans and lighting loads

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 during the energy audit are:

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 And AVM-03	Air velocity
09	Vane Type Anemometer	Testo	410	Air velocity

Sl. No.	Instruments	Make	Model	Parameters Measured
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:

- Re-validation 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 audit report

2 ABOUT THE MSME UNIT

2.1 Particulars of the unit

Table 4: General particulars of the unit

Sl. No.	Particulars	Details
1	Name of the unit	M/s Gripwell Tools Industries
2	Constitution	Private
3	Date of incorporation / commencement of business	NA
4	Name of the contact person Mobile/Phone No. E-mail ID	Maj. Sukhdev Singh (Owner) +91-181 – 2600511,2600511,2600811,6570311 office@gripwell.co.in, gripwelltools@gmail.com
5	Address of the unit	C-104, Focal Point Extension, Jalandhar, Punjab – 144012
6	Industry / sector	Hand Tools
7	Products manufactured	Wrenches, Pliers, Pincers, Plumbing and Construction tools
8	No. of operational hours/day	8
9	No. of days of operation / year	305
10	Whether the unit is exporting its products (yes / no)	Yes

3 DETAILED TECHNICAL FEASIBILITY ASSESSMENT OF THE UNIT

3.1 Description of manufacturing process

3.1.1 Process and Energy flow diagram

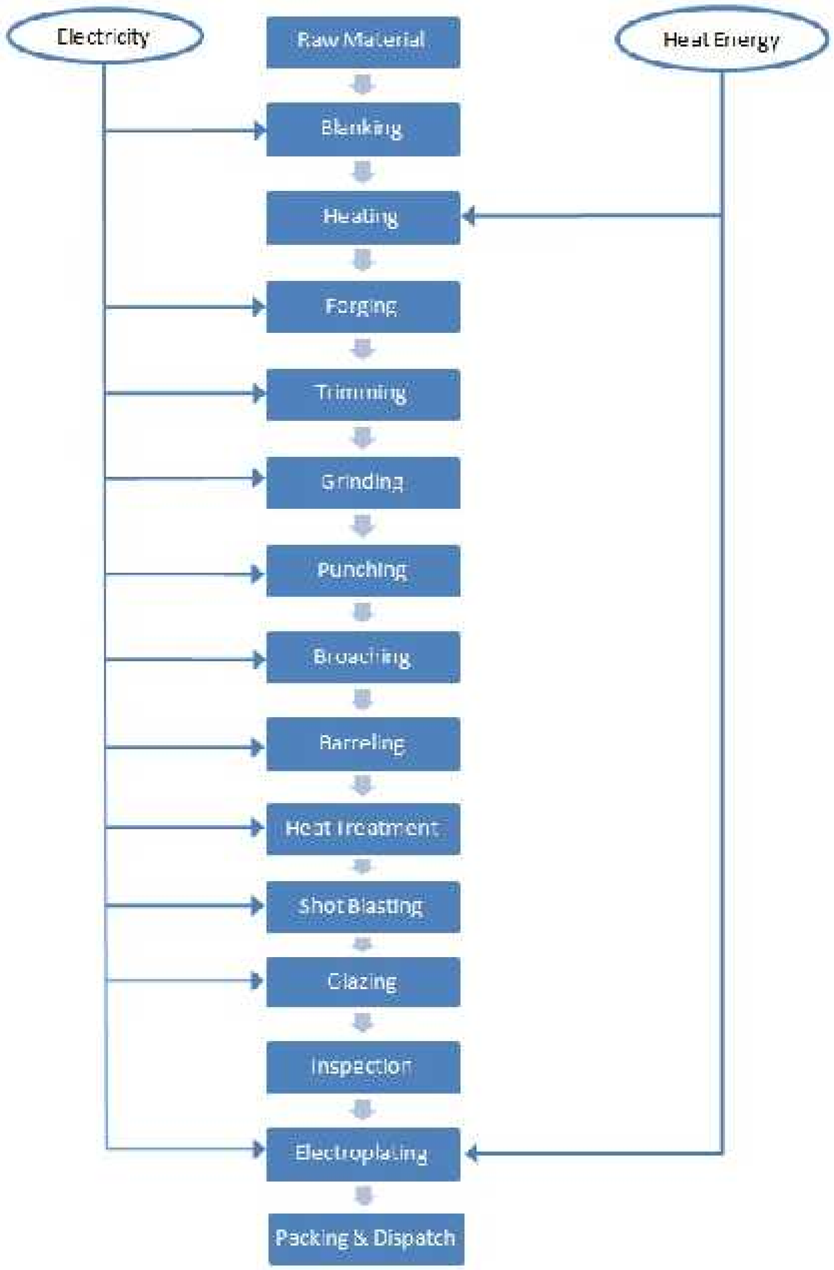

Figure 2: Process flow diagram

3.1.2 Process description

M/s Gripwell Tools Industries is a manufacturer of Wrenches, Pliers, Pincers, Plumbing and Construction tools. etc.

The process description is as follows:

Raw Material

The main raw materials used are round and flat Mild Steel and Chromium Vanadium Steel.

Blanking

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

Heating

The unit has 3 oil fired forging furnaces for heating the work pieces. The temperature maintained is around 1150-1200^{0}C.

Forging

The red hot work pieces taken out from the forging furnace are placed on the lower fixed die above the anvil. A ram moves downwards with gravity action. Below the ram is placed the upper die which is fixed to it. After several strokes of the upper die on the work piece, the work piece takes the desired shape.

Trimming

In Trimming process, the forged material is pressed to give it a uniform shape by removing the unnecessary burrs along the edges. The speed of the presses is controlled and it travels at a low speed when it comes down and exerts maximum pressure just before pressing.

Grinding

This is a process where-by a sand paper is used to do the side grinding of the “trimmed work-piece”.

Broaching

It is similar to trimming in which a toothed tool called broach is used to remove materials from the ground work piece. Two types of broaches are used, i.e. linear for open sections and rotary for circular sections.

Barreling

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

Heat Treatment

Heat treatment is done to impart the required metallurgical properties to the work piece that will improve the working life of manufactured equipments (hand-tool). The main processes involved are hardening, quenching and tempering. Electrical heat treatment furnaces are used for this purpose.

Shot Blasting

It is done to clean and polish the work piece.

Calibration and inspection

The finished product is calibrated to check the dimensions, size, shape, etc before the final finishing process.

Glazing

The final polishing and smoothening is done using a vibrating machine in which the finished product is placed in a bath of ceramic medium and continuously vibrated. Due to the vibrating action of this machine, the work piece and the ceramic materials (in the form of solid stones) rub against each other by which the work piece gets polished.

Electro plating

The final shining and glazing of the product is done using electroplating. In this process, a blower is used to circulate air inside the nickel tank (bath). The final product is dipped inside the nickel tank and kept in that condition for a certain period of time and then taken out and cleaned in hot water tanks to get the final coating.

3.2 Inventory of process machines / equipments and utilities

The major energy consuming equipments in the plant are:

- **Blanking Machine:** Here, the raw material is cut into required shape before it is heated in a forging furnace.
- **Forging furnace:** FO fired furnaces are used for heating the material for forging. The operating temperature in the FO fired furnace is around 1,100^{0}C. Out of the 3 furnaces only two were operating at the time of audit.
- **Hammer:** The hammers are used for forging process in which material is pressed against a die using a drop hammer. Three hammers of 0.75 ton, 1 ton and 1.5 tons are used in the plant.
- **Broaching machine:** This machine is used to remove materials from edges so as to give a better edge finish.
- **Heat treatment:** Heat treatment furnace consists of electrical heaters for hardening and tempering process.
- **Electroplating:** Electroplating is the process of plating one metal onto another by hydrolysis, most commonly for decorative purpose and / or to prevent corrosion of the metal. This is done by placing the metal in a bath and heating the bath to required temperatures. For nickel and chromium plating: bath temperature is maintained at 55-60^{0}C and then the coated metal is cleaned in a hot water bath. The water bath is maintained at a temperature of about 55-60^{0}C. A boiler was previously used to generate steam to heat the bath by indirect heating (steam in coils), but this boiler was shut down and presently 15 electrical heaters are being used to maintain the requisite bath temperatures.

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 being sought 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 5: Energy cost distribution

Particulars	Energy cost distribution		Energy use distribution	
	Rs. Lakhs	% of Total	MTOE	% of Total
Grid –Electricity	102.13	54%	121.9	39
Diesel –DG	3.14	2%	6.2	2
Thermal – FO	82.53	44%	186.3	59
Total	187.80	100%	314.3	100.00

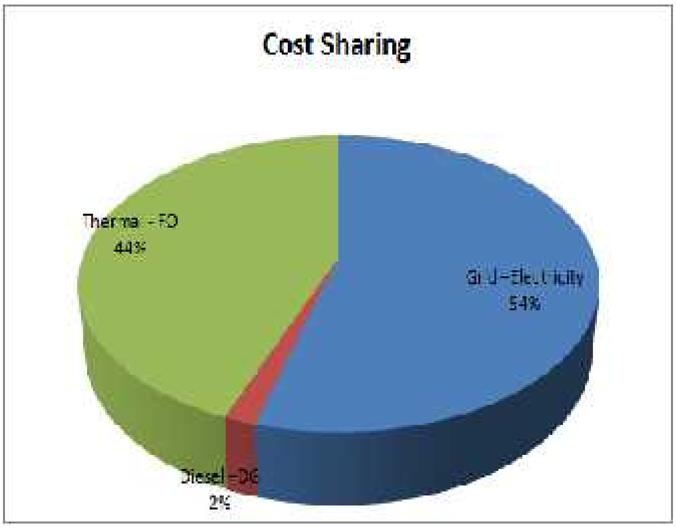

Figure 3: Energy cost share

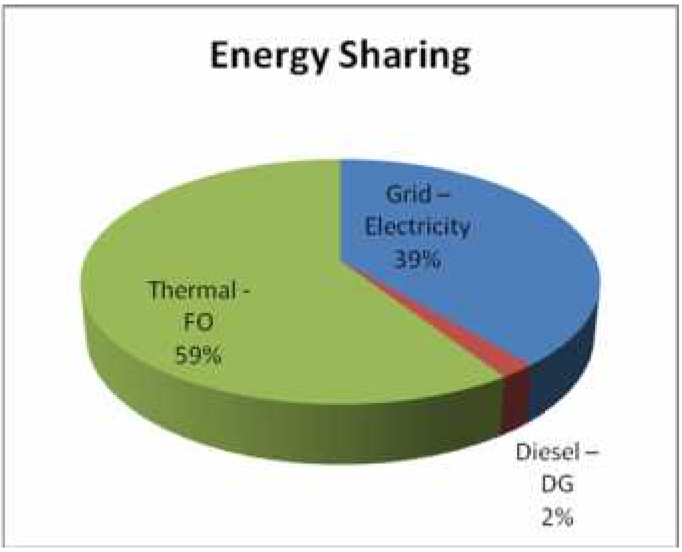

Figure 4: Energy use share

The major observations are as under

- The unit uses both thermal and electrical energy for the manufacturing operations. Electricity is sourced from the grid and self generated through DG sets when the grid power is not available. Thermal energy consumption is in the form of FO, which is used for furnace heating.
- FO used in forging furnace accounts for 44% of the total energy cost and 59% of overall energy consumption.
- Electricity (DG and Grid) used in the process accounts for the remaining 56% of the energy cost; of which diesel used for self generation is 41% of the overall cost.

3.3 Analysis of electricity consumption by the unit

3.3.1 Baseline parameters

Following are the general base line 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 costs shown are the landed costs.

Table 6: Baseline parameters

Electricity Rate (excluding Rs./kVA)	6.33	Rs. / kVAh inclusive of taxes
Weighted average electricity cost	6.47	Rs. / kWh for 2012-13
Percentage of total DG based generation	1.3%	
Average cost of HSD	50	Rs. / Litre for April 2015
Average cost of FO	40	Rs. / Litre for April 2015
Annual operating days per year	305	Days/yr
Annual operating hours per day	8	Hr/day
Production	761	MT

3.3.2 Electricity load profile

Following observations have been made from the utility inventory:

- The plant and machinery load is 1,099.3 kW
- The utility load (lighting and fans) is about 49.7 kW including the single phase load
- The plant total connected load is 1,149 kW

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

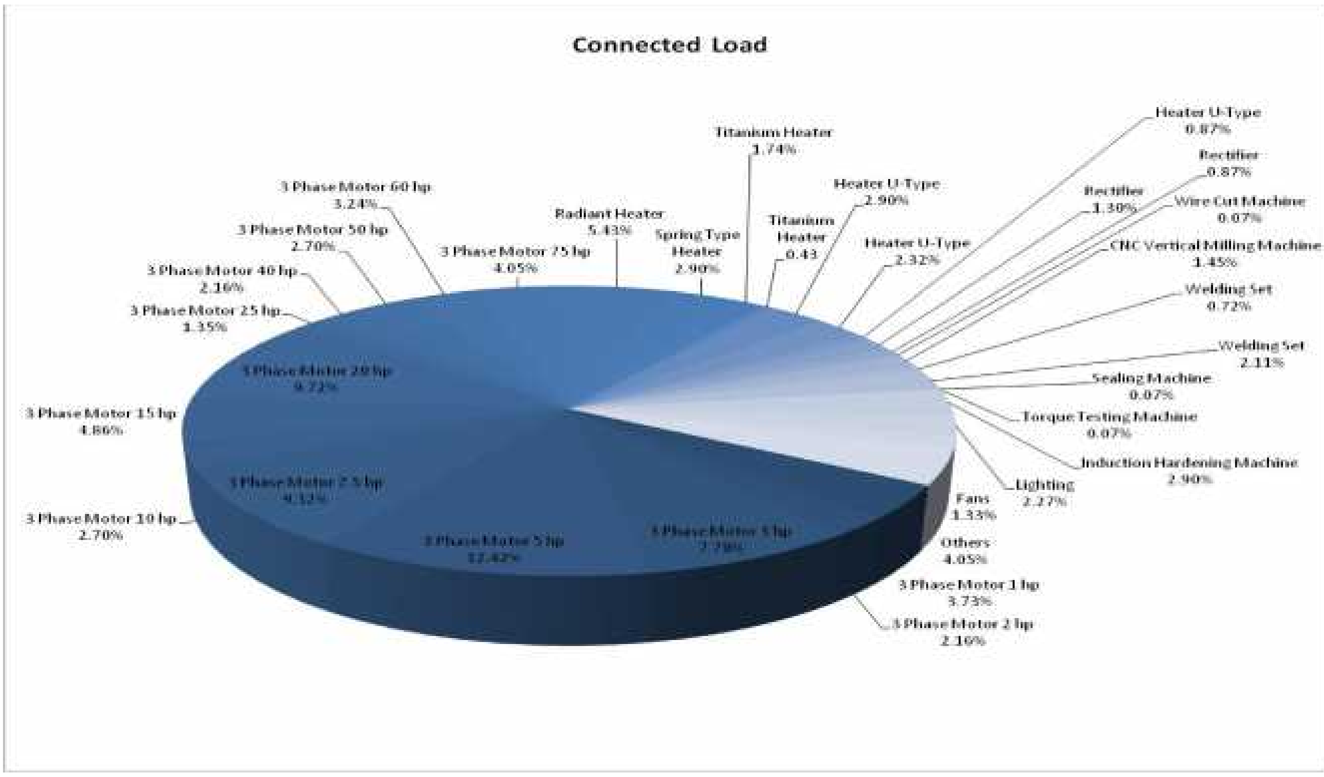

Figure 5: Details of connected load

As shown in the pie chart of connected electrical loads, the major share is for the motors used in different processes (66.2%), heaters and rectifiers in electroplating section (19%), induction hardening machine (2.90%), lighting and fan load contributes around 2.27% and 1.33% each of 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: Machinery wise electricity consumption (estimated)

Sl. No.	Consumption	kW	kWh/year	% of Total
1	3 Phase Motor 1 hp	30.9	60286.35	4.2%
2	3 Phase Motor 2 hp	17.9	34948.61	2.4%
3	3 Phase Motor 3 hp	64.5	125814.99	8.8%
4	3 Phase Motor 5 hp	102.9	200954.50	14.1%

Sl. No.	Consumption	kW	kWh/year	% of Total
5	3 Phase Motor 7.5 hp	77.2	150715.87	10.5%
6	3 Phase Motor 10 hp	18.7	36404.80	2.5%
7	3 Phase Motor 15 hp	33.6	65528.64	4.6%
8	3 Phase Motor 20 hp	67.1	131057.28	9.2%
9	3 Phase Motor 25 hp	9.3	18202.40	1.3%
10	3 Phase Motor 40 hp	14.9	21842.88	1.5%
11	3 Phase Motor 50 hp	18.7	27303.60	1.9%
12	3 Phase Motor 60 hp	22.4	32764.32	2.3%
13	3 Phase Motor 75 hp	28.0	40955.40	2.9%
14	Radiant Heater	45.0	65915.14	4.6%
15	Spring Type Heater	24.0	35136.00	2.5%
16	Titanium Heater	14.4	21081.60	1.5%
17	Titanium Heater	3.6	5270.40	0.4%
18	Heater U-Type	24.0	35136.00	2.5%
19	Heater U-Type	19.2	28108.80	2.0%
20	Heater U-Type	7.2	10540.80	0.7%
21	Rectifier	10.8	15811.20	1.1%
22	Rectifier	7.2	10540.80	0.7%
23	Wire Cut Machine	0.6	878.40	0.1%
24	CNC Vertical Milling Machine	12.0	17568.00	1.2%
25	Welding Set	6.0	8784.00	0.6%
26	Welding Set	17.5	25649.28	1.8%
27	Sealing Machine	0.6	878.40	0.1%
28	Torque Testing Machine	0.6	878.40	0.1%
29	Induction Hardening Machine	24.0	35136.00	2.5%
30	Lighting	31.4	76596.48	5.4%
31	Fans	18.3	44749.60	3.1%
32	Others	22.4	43724.80	3.1%

This is represented graphically in the figure below:

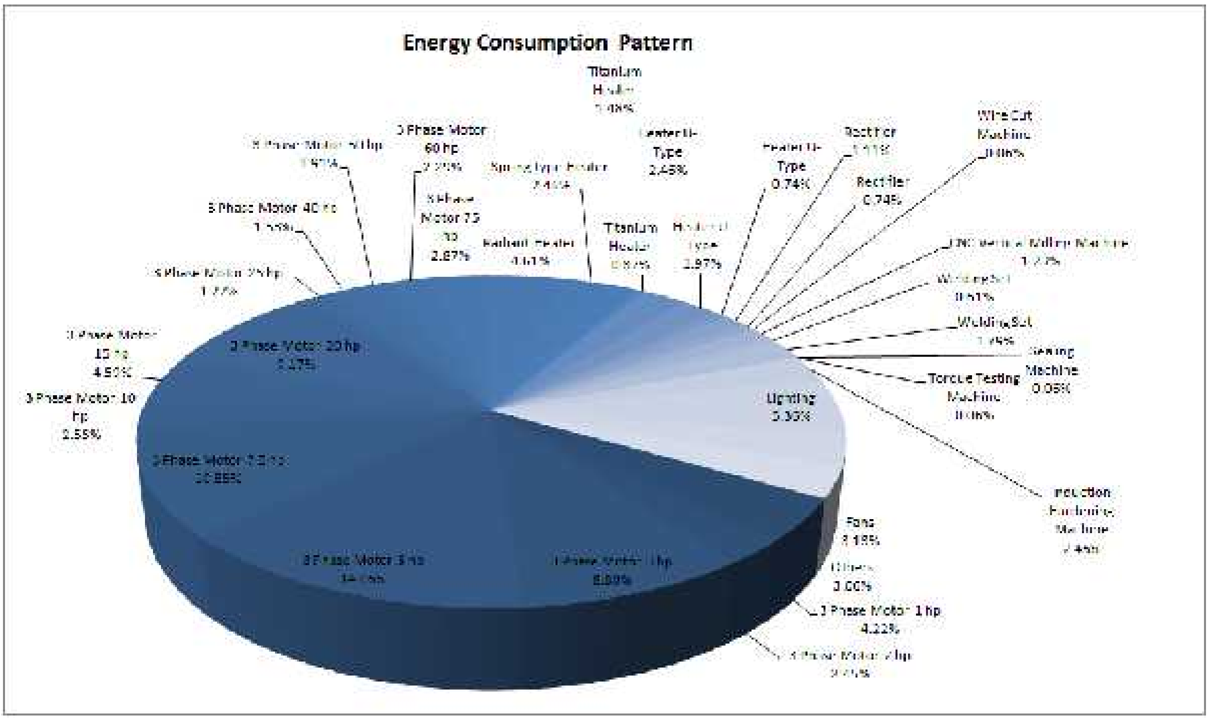

Figure 6: Area wise electricity consumption

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).

3.3.3 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 electrical power 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	1,417,050	99	102.1	97
Self Generation	17,957	1	3.1	3
Total	1,435,007	100	82.3	100

This is graphically depicted as follows:

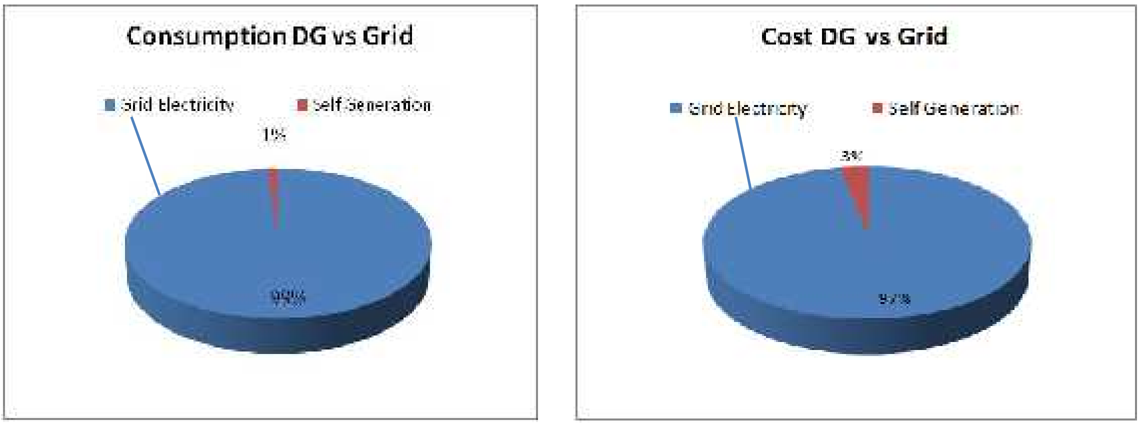

Figure 7: Share of electricity by source and cost

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 sets is about 1% of the total power which is not very high. Although the share of DG power in terms of kWh is just 1% of the total electrical power, but it is about 3% in terms of total cost of electrical power. For economical operation, the utilization of DG sets needs to be minimized, but it will depend upon the supply condition of grid as well as power requirement of the plant.

3.3.4 Supply from utility

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

a) Power Supply : 11 kV line
b) Contract Demand : 799 kVA
c) Sanctioned Load : 1,198.925 kW
d) Nature of Industry : HT – G

The tariff structure is as follows:

Table 9: Tariff structure

Particulars	Tariff structure	
Energy Charges	6.33	Rs./kVAh
Fuel Surcharge	0.10	Rs./kVAh
ED Charges	0.82	Rs./kVAh
Municipality tax	0.00	Rs./kVAh
Other surcharges	0.00	Rs./kVAh

(As per bill for February – 2015)

Table 10: Electricity Bill Analysis

Month	Sanctioned Load	Contract Demand	Peak load allowed	Recorded Maximum Demand	PF	Electricity Consumption		Energy Charges	Energy Charge	Energy Charge	Fuel Cost Adjustment Charge	Total Rentals	Octroi Charges	ED Charges	Total Charge
	kW	kVA	kW	kVA		kVAH	kWH	Rs.	Rs./ kWh	Rs./ kVAh	Rs.	Rs.	Rs.	Rs.	Rs.
Apr-14	1198.925	799	465	475	1	111630	111470	689999	6.19		2780	469	11163	90061	794473
May-14	1198.925	799	465	403	1	117450	117280	725963	6.19		2780	469	11745	94737	835694
Jun-14	1198.925	799	465	445	1	126840	126610	783716	6.19		2780	469	12684	102244	901893
Jul-14	1198.925	799	465	478	1	123320	123100	761989	6.19		2780	469	12332	99420	876990
Aug-14	1198.925	799	465	504	1	130450	130200	805938	6.19		2780	469	13045	105133	927365
Sep-14	1198.925	799	465	455	1	111500	111310	689009	6.19		2780	469	11150	89933	793340
Oct-14	1198.925	799	465	481	1	134370	133910	847650	6.33		2780	469	13437	110556	974892
Nov-14	1198.925	799	465	479	1	133810	133640	847017		6.33	2780	469	13381	110474	974121
Dec-14	1198.925	799	465	494	1	138940	138740	879490		6.33	2780	469	13894	114695	1011328
Jan-15	1198.925	799	465	461	1	126320	126140	799606		6.33	2780	469	12632	104310	919797
Feb-15	1198.925	799	465	418	1	59610	59480	377331		6.33	2780	469	5961	49414	435956
Mar-15	1198.925	799	465	443	1	105340	105170	666802		6.33	2780	469	10534	87046	767631

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

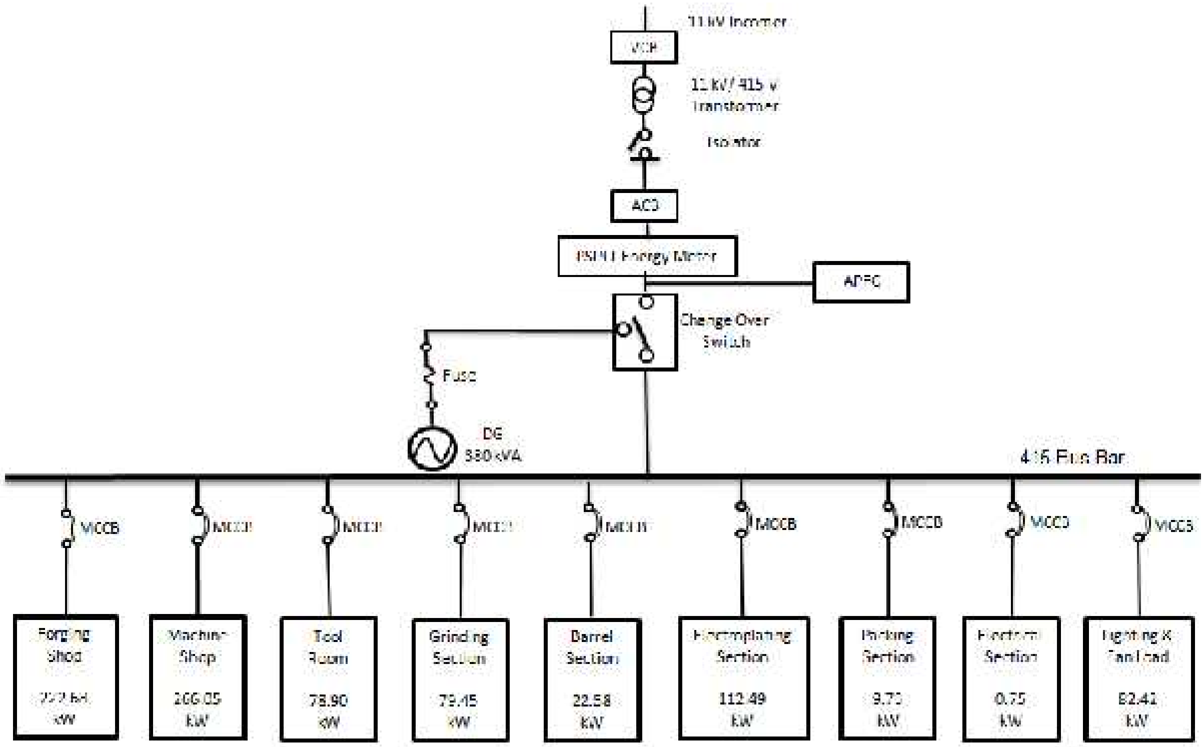

Figure 8: SLD of electrical load

Power factor

The utility bills of the unit reflect a good power factor. A study was conducted by logging of the electrical parameters of the main incomer. The average power factor was found to be 1.00.

Maximum demand

Average Maximum demand as reflected in the utility bill is 462.25 kVA from the bill analysis.

3.3.5 Self – generation

The unit has 2 DG sets of 320 kVA and 250 kVA respectively. The unit does not have a system for monitoring the energy consumption and fuel usage in DG. Diesel purchase records are, however, maintained by the unit. The DG performance test was conducted during the audit and specific energy consumption of DGs are given below:

- DG set-1 with rating of 320 kVA – 2.55 kWh/litre
- DG set-2 with rating of 250 kVA – 3.20 kWh/litre

Table 11: Diesel used for self generation

Month	Diesel Consumption in DG Sets	Power Generation	Cost of Diesel
	Litre	kWh	Rs.

Month	Diesel Consumption in DG Sets	Power Generation	Cost of Diesel
Apr-14	182	518	9,075
May-14	409	1,235	20,450
Jun-14	337	944	16,825
Jul-14	938	2,817	46,875
Aug-14	52	159	2,600
Sep-14	1,336	3,802	66,800
Oct-14	268	683	13,400
Nov-14	195	546	9,750
Dec-14	1,212	3,366	60,600
Jan-15	421	1,133	21,050
Feb-15	570	1,615	28,500
Mar-15	366	1,140	18,300
Total	**6,285**	**17,957**	**314,225**

3.3.6 Month wise electricity consumption

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

Table 12: Electricity consumption and cost

Months	Electricity Used (kWh)			Electricity Cost (Rs.)		
	Grid	DG	Total	Grid	DG	Total
	kWh	kWh	kWh	Rs.	Rs.	Rs.
Apr-14	111,470	518	111,988	794,473	9,075	803,548
May-14	117,280	1,235	118,515	835,694	20,450	856,144
Jun-14	126,610	944	127,554	901,893	16,825	918,718
Jul-14	123,100	2,817	125,917	876,990	46,875	923,865
Aug-14	130,200	159	130,359	927,365	2,600	929,965
Sep-14	111,310	3,802	115,112	793,340	66,800	860,140
Oct-14	133,910	683	134,593	974,892	13,400	988,292
Nov-14	133,640	546	134,186	974,121	9,750	983,871
Dec-14	138,740	3,366	142,106	1,011,328	60,600	1,071,928
Jan-15	126,140	1,133	127,273	919,797	21,050	940,847
Feb-15	59,480	1,615	61,095	435,956	28,500	464,456

Months	Electricity Used (kWh)			Electricity Cost (Rs.)		
	Grid	DG	Total	Grid	DG	Total
	kWh	kWh	kWh	Rs.	Rs.	Rs.
Mar-15	105,170	1,140	106,310	767,631	18,300	785,931
Total	**1,417,050**	**17,957**	**1,435,007**	10,213,480	314,225	10,527,705

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

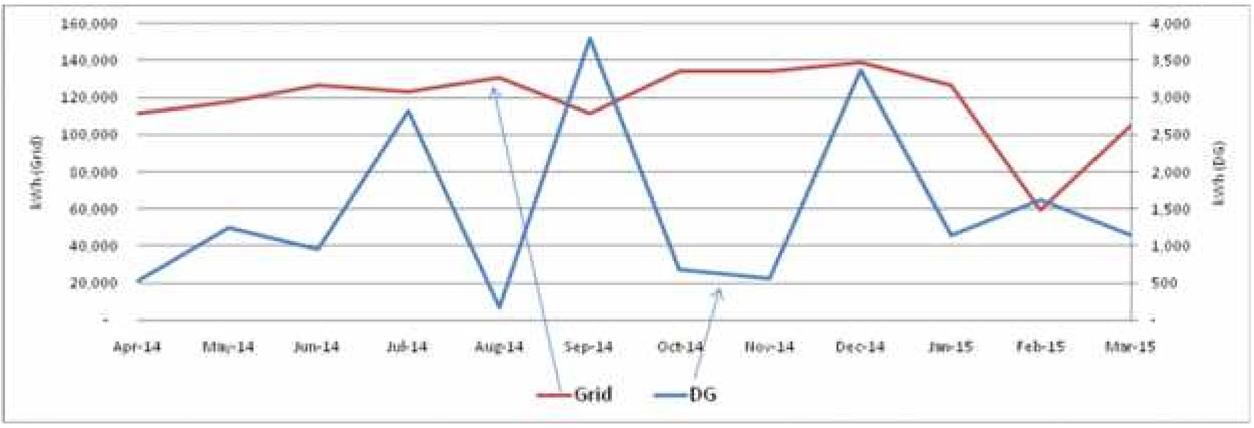

Figure 9: Month wise variation in electricity consumption from different sources

As shown in the figure above, the consumption of electrical energy was on higher side during the months of October and December 2014, and was fluctuating over the remaining period. It was noticed that the electricity consumption during February 2015 was very low because the production during that month might have been low. The corresponding month wise variation in electricity cost is shown in the figure below:

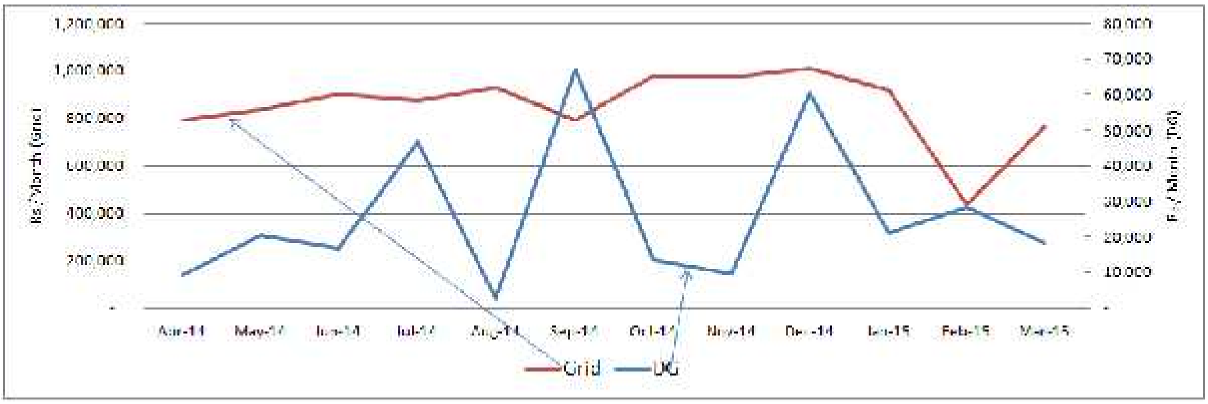

Figure 10: Month wise variation in electricity cost from different sources

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

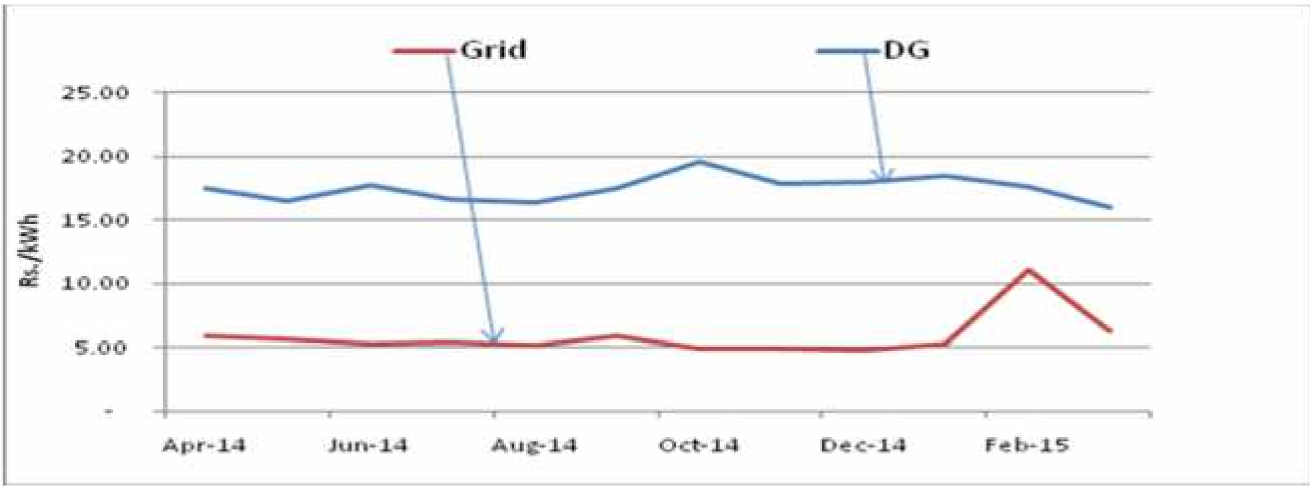

Figure 11: Average cost of power (Rs./kWh) from different sources

From the above graph, it is seen that the cost of electrical energy from DG sets is very high, nearly 1.5 times the cost of utility electricity.

3.4 Analysis of thermal consumption by the unit

The fuel used for forging furnace is FO whose average cost is Rs. 43.38 / liter. There is no meter installed for measuring the fuel consumption by the furnace. The FO consumption by the forging furnaces and its cost is given below:

Table 13: FO used as fuel

Month	Fuel Consumption (Kilo-litre)*	Rs./Month
Apr-14	15.40	743,050
May-14	15.83	686,705
Jun-14	15.73	769,197
Jul-14	15.61	763,085
Aug-14	15.56	727,430
Sep-14	15.44	717,960
Oct-14	19.14	846,150
Nov-14	15.83	686,705
Dec-14	15.93	759,623
Jan-15	14.90	644,425
Feb-15	15.50	435,550
Mar-15	15.13	472,813
Total	**189.99**	**8,252,692**

*The fuel consumption in furnace is calculated based on average value given by the unit personnel.

3.5 Specific energy consumption

Annual Production data was available from the unit in metric tons (MT). 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 14: Overall specific energy consumption

Parameters	UOM	Value
Annual grid electricity consumption	kWh	1,417,050
Annual DG generation units	kWh	17,957
Annual total electricity consumption	kWh	1,435,007
Diesel consumption for electricity generation	Litres	6,285
Annual fuel consumption in furnace (FO)	Litres	189985
Annual energy consumption	MTOE	314
Annual energy cost	Lakhs Rs.	187.80
Annual Production	MT	761
SEC; Electricity from grid and generator	kWh / MT	1885
SEC; Thermal	Litre / MT	250
SEC; Overall	MTOE / MT	0.413
SEC; Cost based	Rs. / MT	24665

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
  - 1 kg of oil equivalent : 10,000 kCal
- GCV of diesel : 11,840 kCal/ kg
- Density of HSD : 0.8263 kg/liter
- GCV of FO : 10,500 Kcal/kg
- Density of FO : 0.9337 kg/liter
- CO_2 conversion factor
  - Grid : 0.89 kg/kWh
  - Diesel : 3.07 tons/ ton
  - FO : 3.1 tons/liter

3.6 Identified energy conservation measures in the plant

Diagnostic Study

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

3.6.1 Electricity Supply from Grid

The electrical parameters at the main incomer from PSPCL were recorded for 5 hours using the portable power analyzer. Following are the graphs obtained by data from power analyzer:

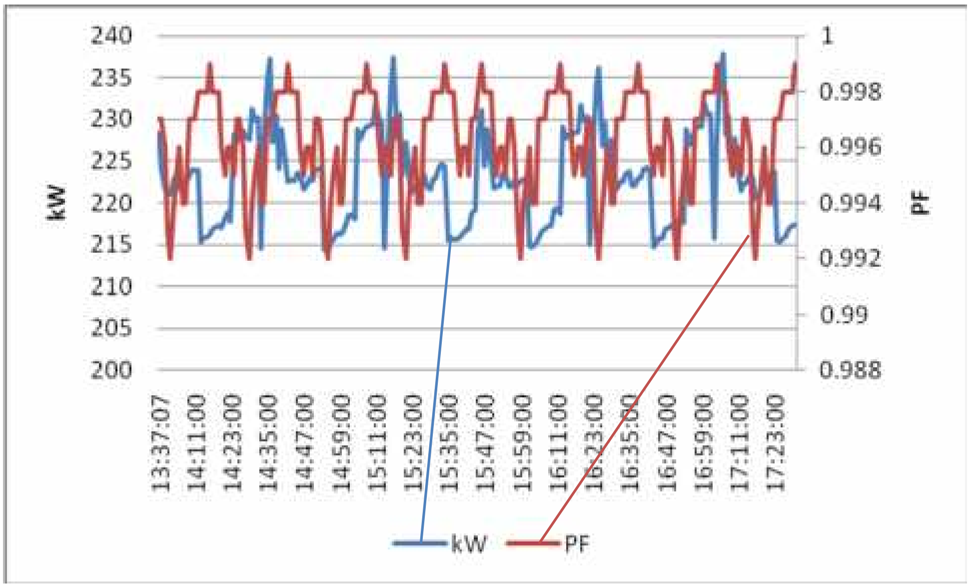

Figure 12: Power factor and load profile

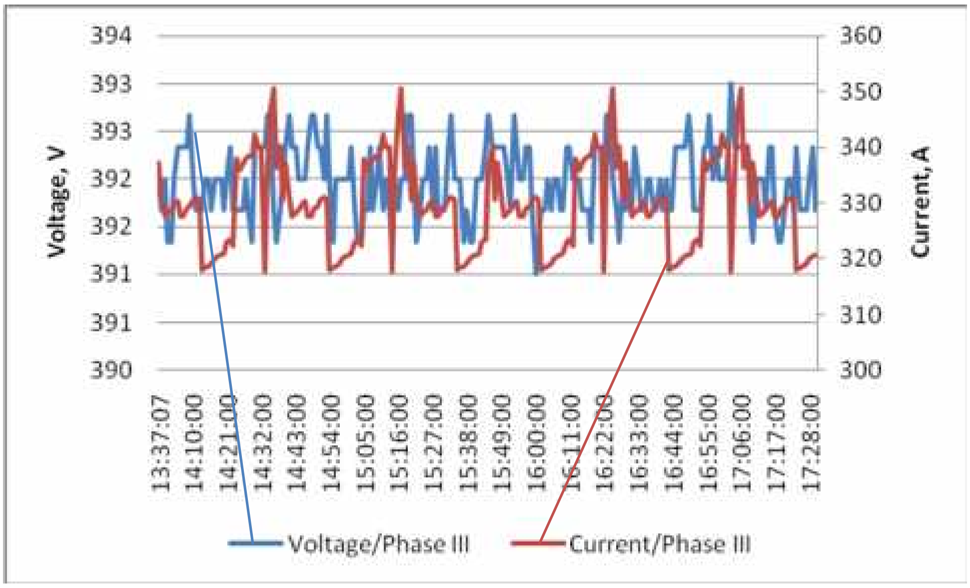

Figure 13: Current and voltage profile

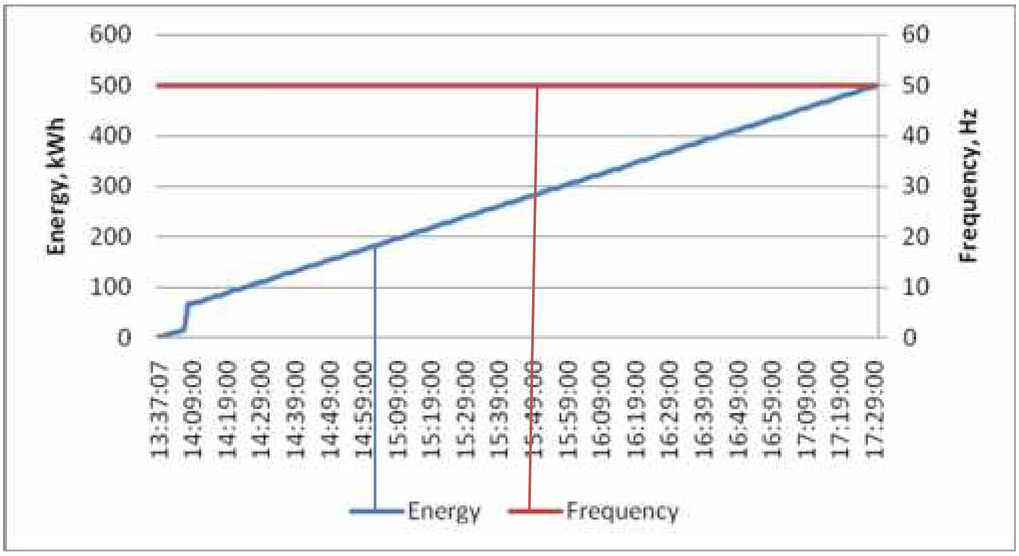

Figure 14: Energy and frequency profile

Following observations have been made:

Table 15: Diagnosis of electric supply

Name of Area	Present Set-up	Observations during field Study and measurements	Ideas for energy performance improvement actions
Electricity Demand	Power is supplied to this unit from PSPCL through a separate transformer. The unit has a HT connection. The contract demand of the unit is 799 kVA.	The maximum kVA recorded as per the utility bill was 504 kVA (from Apr-2014 to March-2015) which is well below the contract demand.	No EPIAs were suggested.
Power Factor	Unit has HT connection and billing is in kVAh. The utility bills reflect the PF of the unit. The unit has an APFC panel installed to control the power factor.	The plant was maintaining good PF of 1.	No EPIAs were suggested.
Voltage Profile	The unit has no separate lighting feeder for lighting loads.	The voltage profile of the unit was not satisfactory and average voltage measured at main incomer was 392 V with a maximum of 393 V. All the other equipments were operating at low voltage rather than their rated operating voltage. Although an EE measure for improvement of voltage was developed, the same was not recommended due to poor	No EPIAs were recommended.

Name of Area	Present Set-up	Observations during field Study and measurements	Ideas for energy performance improvement actions
		financial viability.	

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

1.6.2 DG Performance

The unit has 2 DG sets of 320 kVA and 250 kVA. The unit does not have a system for monitoring the energy generation and fuel usage in the DG sets. Diesel purchase records are maintained by the unit. As part of the performance testing, measurements were conducted on the DG sets by keeping track of the diesel consumed (by measuring the top up to the diesel tank) and recording of kWh generated by the DG sets during the same period. The key performance indicators of the DG sets were evaluated and Specific Fuel Consumption (SFC) of 2 DGs are as follows:

Table 16: Analysis of DG set

Particulars	Rated kVA	Specific Energy Generation Ratio (kWh/Litre)
DG – 1	320	2.55
DG - 2	250	3.20

The observations made are as under:

- The SFC of DG 1 was low but since the average operating hours of this DG was less, replacement with a new EE DG set was not recommended.
- The SFC of DG 2 was good.

For DG – 1, the total testing time was 15 minutes 51 seconds in which total kWh generated was 23.26. Load profile and power consumption during the test for DG – 1 is given below:

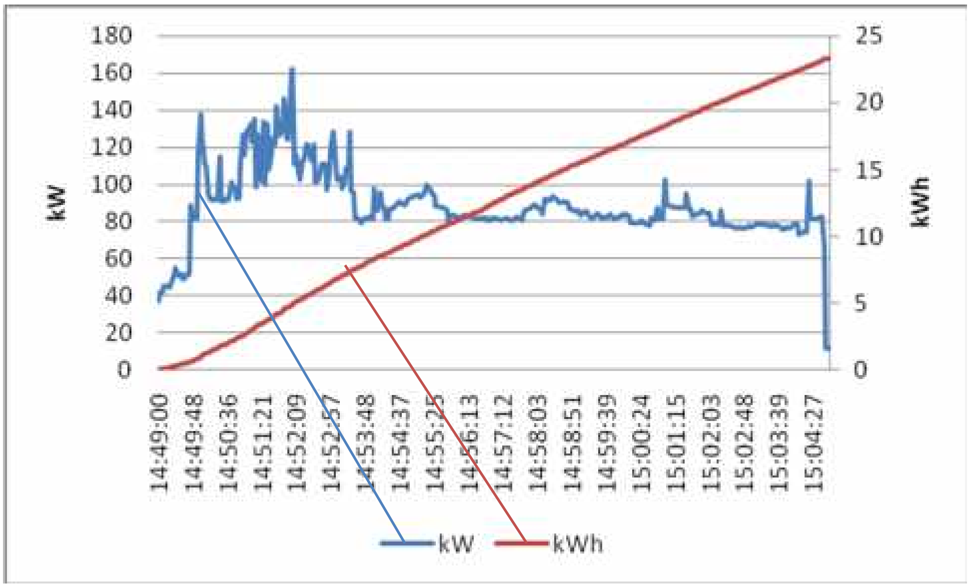

Figure 15: DG – 1 (320 kVA) test graph

For DG – 2, the total testing time qwas14 minutes 33 seconds in which total kWh generated was 30.58. Load profile and power consumption during the test for DG – 2 is given below:

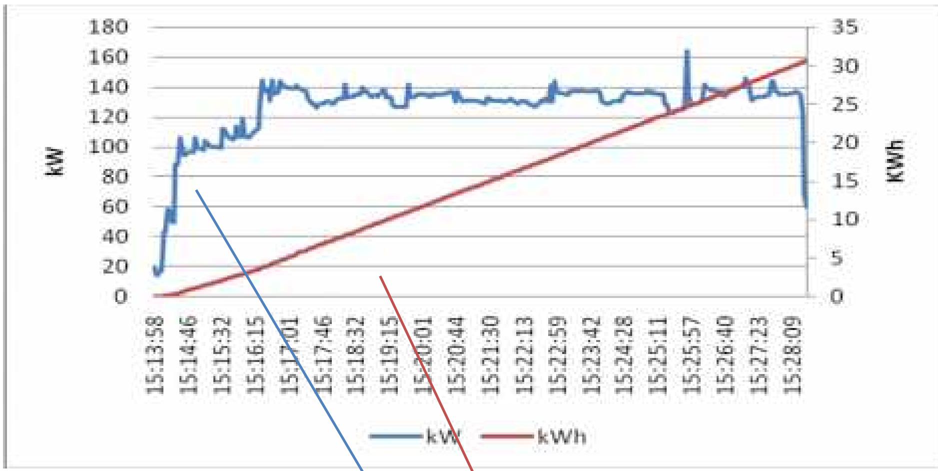

Figure 16: DG – 2 (250 kVA) test graph

1.6.3 Electrical consumption areas

The section-wise consumption of electrical energy is indicated in Table 6. Over 96.2% of energy consumption is in manufacturing operations and about 3.6% is in the utilities.

The details of the observations, measurements conducted and energy conservation measures are as follows:

Name of Area	Present Set-up	Observations during field Study and measurements	Proposed Energy performance improvement actions
Forging	There are 2 blanking machines of 7.5 Hp and 20 Hp respectively. There are three hammer motors, out of which two were working whose capacities were 75 Hp and 60 Hp respectively.	Study was conducted on a blanking machine and hammer motor No. 3 The results of the study are as below: Machine / Avg. kW / Avg. PF Blanking M/c 10 / 2.13 / 0.52 Blanking M/c 11 / 4.22 / 0.52 Hammer Motor 2 / 18.42 / 0.82 Hammer Motor 3 / 26.2 / 0.73	No EPIAs were suggested for blanking machines and hammers.
Broaching	There are 5 broaching machines whose capacities are in the range of 20 - 25 Hp	It was found that during the unloading time, power is consumed by motor which contributes to the total energy consumed The results of the study are as below: Machine / Avg. kW / Avg. PF Broaching S 35 / 6.6 / 0.43 Broaching S 37 / 2.5 / 0.64	It is recommended to install a VFD on broaching machine S 35 to reduce power consumption during unloading time.

<table>
<tr><th>Name of Area</th><th>Present Set-up</th><th>Observations during field Study and measurements</th><th>Proposed Energy performance improvement actions</th></tr>
<tr><td></td><td></td><td><table><tr><td>Broaching S 75</td><td>3.3</td><td>0.50</td></tr><tr><td>Broaching S 32</td><td>1.7</td><td>0.44</td></tr><tr><td>Broaching S 34</td><td>3.2</td><td>0.50</td></tr></table></td><td></td></tr>
<tr><td>Air Compressor</td><td>There are 4 air compressors in the plant and study was conducted on 3 compressors as the fourth compressor was not running.</td><td>3 compressors were studied and their free air delivery test was conducted to calculate the specific power consumption
The results of the study are as below:<table><tr><th>Machine</th><th>Avg. kW</th><th>SPC (kW/CFM)</th></tr><tr><td>Compressor T 17</td><td>4.32</td><td>0.13</td></tr><tr><td>Compressor S 79</td><td>3.42</td><td>0.27</td></tr><tr><td>Compressor S 80</td><td>4.13</td><td>0.20</td></tr></table></td><td>No EPIAs were suggested for the compressors.</td></tr>
</table>

1.6.4 Thermal consumption areas

As discussed in the earlier section, about 50 % of energy cost and 58% of the energy use is in forging furnace. The details of present set-up, key observations made and potential areas for energy cost reduction have been mentioned in the table below:

<table>
<tr><th>Name of Area</th><th>Present Set-up</th><th>Observations during field Study and measurements</th><th>Proposed Energy performance improvement actions</th></tr>
<tr><td>Forging furnace</td><td>Fuel used for heating in furnace is FO.

The required air for burning of fuel is supplied by electrical driven fan.

The insulation provided on furnace walls is poor.</td><td>There was no metering system available for measuring fuel consumption.

The O_2 level in flue gas of furnace 2 and 3 were 15.78 % and 16.60 % respectively.

The temperature of furnace surfaces, especially side walls, was high which clearly indicates that insulation is poor.</td><td>Installation of flow meters are recommended.

Installation of PID for excess air control is recommended.
It is recommended to reduce skin losses by improving furnace refractory and insulation.</td></tr>
</table>

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 already been discussed in earlier section of this report.

Based on the analysis, Energy Performance Improvement Actions (EPIAs) have been identified as below:

4.1 EPIA 1 and 2: Installation of PID controller for excess air control in forging furnace

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. On the other hand, 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 the 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 the burning losses.

A PID controller, if installed, will measure the oxygen levels in the flue gases at the exit of the furnace, and based on that the combustion air flow from FD fan (blower) can be regulated. Subsequently, proper temperature and optimum excess air will be attained in the furnace.

Study and investigation

At the time of CEA, it was found that there was no proper automation and control system installed in the forging furnaces 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 furnace 2 and furnace 3 were 15.78% and 16.60% respectively, which indicates very high excess air levels. This results in high heat loss due to dry flue gas from the furnace.

Recommended action

It is recommended to install PID control system to regulate the supply of excess air for maintaining optimum excess air levels and ensuring 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 the energy conservation measure is given below:

Table 17: Cost benefit analysis for forging furnace-2(EPIA 1)

Parameters	UOM	Present	Proposed
Oxygen level in flue gas	%	15.78	4.00
Excess air control	%	302.30	23.53
Dry flue gas loss	%	19.87	
Production of material	Tph	0.17	
Specific fuel consumption	kg/t	72.43	52.24
Savings in specific fuel consumption	kg/h		3.42
Operating hours of forging furnace	hr/y	2,640	2,640
Saving in fuel consumption per year	kg/y		9018.95
Savings in fuel cost	Rs. Lakhs / y		3.86
Installed capacity of blower	kW	3.73	3.73
Running load of blower	kW	2.98	2.69
Operating hours	hr/y	2,640	2,640
Electrical energy consumed	kWh/y	7,878	7,090
Savings in terms of power consumption	kWh/y		788
Savings in terms of cost of electrical energy	Lakhs Rs. / y		0.05
Reduction in the burning loss inside the furnace	%		0.50
Total material savings	Tpy		2.23
Cost of saved material	Lakhs Rs / y		1.12
Monetary savings	Lakhs Rs / y		5.03
Estimated investment	Lakhs Rs		7.00
Simple payback	Years		1.39

Table 18: Cost benefit analysis for forging furnace-3 (EPIA 2)

Parameters	UOM	Present	Proposed
Oxygen level in flue gas	%	16.60	4.00
Excess air levels	%	377.27	23.53
Dry flue gas loss	%	42.76	
Production of material	tph	0.07	
Specific fuel consumption	kg/t	33.54	21.67
Saving in specific fuel consumption	kg/h		0.87
Operating hrs of forging furnace	hr/y	2,640	2,640
Saving in fuel consumption per year	kg/y		2288.91
Savings in fuel cost	Lakhs Rs. / y		0.98
Installed capacity of blower	kW	3.73	3.73
Running load of blower	kW	2.98	2.69
Operating hours	hr/y	2,640	2,640
Electrical energy consumed	kWh/y	7,878	7,090
Savings in terms of power consumption	kWh/y		788

Parameters	UOM	Present	Proposed
Savings in terms of cost of electrical energy	Lakhs Rs. / y		0.05
Reduction in the burning loss inside the furnace	%		0.80
Total material savings	Tpy		1.54
Cost of saved material	Lakhs Rs. / y		0.77
MonetarysSavings	Lakhs Rs. / y		1.80
Estimated investment	Lakhs Rs.		7.00
Simple payback	Years		3.88

4.2 EPIA 3: Installation of VFD on broaching machine

Technology description

For fluctuating loads, it is always recommended to install a variable frequency drive (VFD) to control the speed of the motor. A VFD will reduce the power consumption according to the load variation in the broaching machine. During loading periods, the current drawn by the broaching machine will be very high, as an external force is also applied for the process to take place. During no load / unloading periods, the broaching machine will draw some current which is 1/3rd of the total current. Hence, installation of a VFD will help in regulating the speed of the broaching machine's motor, thereby resulting in lower current drawn and reduction in power consumption.

Study and investigation

During measurements, it was found that the existing broaching machine no. 35 draws high current even during unloading periods.

Recommended action

It is recommended to install VFD with the broaching machine no. 35. This will ensure that the machine draws minimal current during unloading by sensing the required power. The cost benefit analysis of the energy conservation measure is given below:

Table 19: Cost benefit analysis (EPIA 3)

Sl. No.	VFD on broaching machine		Broaching M/c-35	
	Parameters	Unit	As Is	To Be
1	Installed capacity of motor	kW	14.92	14.92
2	Estimated energy savings by installing VFD on compressor	%		20
3	Average power consumption	kW	4.4	3.0
4	Percentage load	%	29.2	23.4
4	No of operating hours per day	Hr	8	8
5	Operating days per Year	days	305	305
6	Average electricity consumption per year	kWh	10630	8504
7	Savings in terms of power consumption	kWh/y		2126

Sl. No.	VFD on broaching machine		Broaching M/c-35	
	Parameters	Unit	As Is	To Be
8	Average weighted cost	Rs / kWh		6.47
9	Monetary savings	Lakhs Rs.		0.14
10	Estimated investment	Lakhs Rs.		0.8
11	Simple Payback	Years		5.7

4.3 EPIA 4: Replacement of old, inefficient motors with energy efficient motors

Technology description

Replacing old, inefficient (and several times re-wounded) existing motors of the forging hammers (3 numbers), simplicity machines (3 numbers), Die blower (1 number), face grinding (1 number) and one motor in tool room with energy efficient motors which will reduce power consumption of those motors 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 a large number of motors which are re-wounded and are having efficiency below 60%. The motors selected for replacement are given below in a tabular form:

Table 20: List of Motors for replacement

Location	Motor ID	Rated kW
Forging Room	Hammer Motor 50 hp	37.3
Forging Room	Hammer Motor 60 hp	44.76
Forging Room	Hammer Motor 75 hp	55.95
Simplicity	Grinding motor 7.5 hp	5.595
Simplicity	Grinding motor 5 hp	3.73
Simplicity	Grinding motor 3 hp	3.73
Die Blower	-	3.73
Tool Room	-	1.492
Face grinding	-	7.46

Recommended action

It is recommended to replace the present motors of the forging hammers and simplicity machines (as in table below) with energy efficient motors.

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

Table 21: Cost benefit analysis (EPIA 4)

Parameters	UOM	Forging Room						Simplicity Section					
		AS IS	TO BE	AS IS	TO BE	AS IS	TO BE	AS IS	TO BE	AS IS	TO BE	AS IS	TO BE
Motor ID		Hammer No. 1		Hammer No. 4		Hammer No. 3		Machine No. 2		Machine No. 3		Machine No. 4	
Rated Power	kW	37.3	37.3	44.76	44.76	55.95	55.95	5.59	5.59	3.73	3.73	2.24	2.24
Efficiency of motor	%	45%	90%	58%	90%	58%	90%	58%	90%	56%	90%	56%	90%
Average Load	kW	26.11	13.06	31.33	20.19	39.17	25.24	3.92	2.52	2.61	1.62	1.57	0.97
Net Power Savings	kW	13.06		11.14		13.93		1.39		0.99		0.59	
Running Hours	hr/y	2440		2440		2440		2440		2440		2440	
Savings in terms of power consumption	kWh/y	31854		27182		33978		3398		2407		1444	
Average weighted cost	Rs. / kWh	6.47		6.47		6.47		6.47		6.47		6.47	
Investment	Lakhs Rs.	1.92		2.33		3.20		0.35		0.25		0.20	
Monetary Savings	Lakhs Rs.	2.06		1.76		2.20		0.22		0.16		0.09	
Simple Payback	Years	0.93		1.32		1.46		1.58		1.62		2.10	

Parameters	UOM	Die Blower		Tool Room		Face Grinding	
		AS IS	TO BE	AS IS	TO BE	AS IS	TO BE
Rated Power	kW	3.73	3.73	1.49	1.49	7.46	7.46
Efficiency of motor	%	56%	90%	32%	90%	74%	90%
Average Load	kW	2.61	1.62	1.04	0.37	5.22	4.29

Parameters	UOM	Die Blower		Tool Room		Face Grinding	
		AS IS	TO BE	AS IS	TO BE	AS IS	TO BE
Net Power Savings	kW		0.99		0.67		0.93
Running Hours	hr/y		2440		2440		2440
Savings in terms of power consumption	kWh/y		2407		1642		2265
Average weighted cost	Rs / kWh		6.47		6.47		6.47
Investment	Lakhs Rs.		0.25		0.15		0.40
Monetary Savings	Lakhs Rs.		0.16		0.11		0.15
Simple Payback	Years		1.62		1.39		2.74

4.4 EPIA 5: Installation of energy efficient fan instead of conventional fan

Technology description

Replacing old fans of conventional types installed in various sections of the plant with energy efficient fans will reduce power consumption by almost half. 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 134 old conventional type fans which can 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 22: Cost benefit analysis (EPIA 5)

Data and Assumptions	UOM	Ordinary fan	Super fan
Number of fans in the facility	Nos.	134	134
Run hours per day	hrs / day	10	10
Power consumption at maximum speed	Watts	75	35
Number of working days/year	days	330	330
Average weighted cost	Rs. / kWh	6.47	6.47
Fan unit price	Rs. / pc	1,500	3,000
Electricity consumption:			
Electricity demand	kW	10.72	4.69
Power consumption by fans in a year	kWh/y	35,376	15,477
Savings in terms of power consumption	kWh/y		19,899
Monetary savings	Rs. (Lakhs) / y		1.29
Estimated investment	Rs. (Lakhs)		4.02
Payback period	Years		3.12

4.5 EPIA 6 and 7: Energy efficient light fixture

Technology description

Replacing conventional lights like T-12s, T-8s, CFLs, etc with LED lights will help in reducing power consumption, and also result in higher illumination (lux) levels for the same power consumption.

Study and investigation

The unit is having 156 nos. T-12 tube lights, 84 nos. 65 W CFLs, 30 nos. 36 W CFLs, 74 nos. 23 W CFLs, 90 nos. 18 W CFLs, 14 nos. 400 W Mercury vapor (MV) lamps, 9 nos. 250 W MV lamps, 60 nos. 100 W MV lamps and 36 nos. 40 W Incandescent lamps.

Recommended action

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

Table 23: Cost benefit analysis (EPIA 6)

Particulars	UOM	Existing	Proposed
		T-12	**16 Watt LED tube light**
Power consumed	W	40	16
Power consumed in ballast/ choke	W	12	0
Total power consumption	W	52	16
Operating hours/day	Hr	12	12
Annual days of operation	Day	305	305
Energy used per year/fixture	kWh	190	59
Average weighted cost	Rs. / kWh	6.47	6.47
No. of fixtures	Nos.	156	156
Power consumption per year	kWh /y	29690	9135
Operating cost per year	Rs. Lakhs / y	1.92	0.59
Saving in terms of power consumption	kWh / y		20555
Monetary savings	Rs. Lakhs / y		1.33
Investment per fixture of LED	Rs.		0.01675
Investment of project	Rs. Lakhs		2.613
Payback period	Years		1.96

Table 24: Cost benefit analysis (EPIA 7)

Particulars Fixture	Unit UOM	Existing 65 W CFL	Proposed 25 Watt LED Bay light	Existing 36 W CFL	Proposed 15 Watt LED AC Street light	Existing 23 W CFL	Proposed 10 Watt LED Star Bulb	Existing 18 W CFL	Proposed 7 Watt AC LED Star Bulb
Power consumed	W	65	25	36	15	23	10	18	7
Power consumed	W	13	0	8	0	7	0	4	0
Total power consumption	W	78	25	44	15	30	10	22	7
Operating hours/day	Hr	10	10	12	12	12	12	12	12
Annual days of operation	Day	305	305	305	305	305	305	305	305
Energy used per year/fixture	kWh	238	76	161	55	110	37	81	26
Average weighted cost	Rs./kWh	6.47	6.47	6.47	6.47	6.47	6.47	6.47	6.47
No. of fixtures	Unit	84	84	30	30	74	74	90	90
Power consumption per year	kWh/y	19984	6405	4831	1647	8125	2708	7247	2306
Operating cost per year	Rs. Lakh/Y	1.29	0.41	0.31	0.11	0.53	0.18	0.47	0.15
Saving in terms of power consumption	kWh/Y		13579		3184		5417		4941
Monetary savings	Rs. Lakh/Y		0.88		0.21		0.35		0.32
Investment per fixture of LED	Rs. Lakh		0.04		0.022		0.008		0.0064
Investment of project	Rs. Lakh		3.36		0.66		0.592		0.576
Payback period	Years		3.82		3.20		1.69		1.80

Particulars	Unit	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed
		400 W MV lamp	130 Watt LED Bay light	250 W MV lamp	80 Watt LED Bay light	100 W MV lamp	40 Watt LED Bay light	40 W lamp	4 Watt AC LED Bulb
Power consumed	W	400	130	250	80	100	40	40	4
Power consumed in ballast/choke	W	80	0	40	0	20	0	10	0
Total power consumption	W	480	130	290	80	120	40	50	4
Operating Hours/day	Hr	12	12	12	12	12	12	12	12
Annual days of operation	Day	305	305	305	305	305	305	305	305
Energy used per year/fixture	kWh	1,757	476	1,061	293	439	146	183	15
Average weighted cost	Rs. / kWh	6.47	6.47	6.47	6.47	6.47	6.47	6.47	6.47
No. of Fixtures	Nos.	14	14	9	9	60	60	36	36
Power consumption per year	kWh / y	24595	6661	9553	2635	26352	8784	6588	527
Operating cost per year	Lakhs Rs. / y	1.59	0.43	0.62	0.17	1.70	0.57	0.43	0.03
Savings in terms of power consumption	kWh / y		17934		6917		17568		6061
Monetary savings	Lakhs Rs. / y		1.16		0.45		1.14		0.39
Investment per fixture of LED	Rs		0.18		0.123		0.0755		0.00575
Investment of project	Rs. Lakhs		2.52		1.107		4.53		0.207
Payback period	years		2.17		2.47		3.99		0.53

4.6 EPIA 8: Installation of energy monitoring system on sectional energy consuming area

Technology description

Installation of energy monitoring systems in a unit will monitor energy consumed by various machines. This will help in setting the benchmark energy consumption with respect to production for the machines. If an increase in energy consumption is noticed for any machine, then the reasons for the increased consumption can be diagnosed and proper remedial actions can be taken.

Study and investigation

As per the analysis, online data measurement was not being done on the main incomer as well as at various electrical panels for energy consumption. It was also noticed that there were no proper fuel monitoring systems installed in the DG sets and in forging furnaces, like online flow-meters.

Recommended action

It is recommended to install online electrical energy monitoring systems (smart energy meters) on the main incomer and on the various electricity distribution panels. It is also recommended to install online flow-meters on the individual DG sets and forging furnaces to measure the oil (HSD, FO, etc) flow. This measure will help in reduction in energy consumption by approximately 3%. from its present levels. The cost benefit analysis for this project is given below:

Table 25: Cost benefit analysis (EPIA 8)

Parameters	Unit	As Is	To Be
Energy monitoring savings (Electrical)	%	0	3
Energy consumption of major machines per year	kWh/y	1,417,050	1,374,539
Annual electricity savings per year	kWh/y		42,512
Average weighted cost	Rs./kWh		6.47
Annual monetary savings	Lakhs Rs./y		2.75
Estimate of investment	Lakhs Rs.		0.35
Simple payback	Months		1.53
Energy monitoring savings (FO in furnace)	%	0	3
Current fuel consumption	kg/y	177,389	172,067
Annual fuel savings per year	kg/y		5,322
Unit cost	Rs./kg		40
Annual monetary savings	Lakhs Rs./y		2.13
Estimate of investment	Lakhs Rs.		0.20
Simple payback	Months		1.13
Energy monitoring (Diesel in DG)	%	0	3

Parameters	Unit	As Is	To Be
Current fuel consumption	litres/y	6,497	6,302
Annual fuel savings per year	litres/y		195
Diesel cost per unit	Rs./litres		50
Monetary savings	Rs. Lakhs		0.10
Investment for the DG fuel consumption meter	Rs. Lakhs		0.20
Simple payback	Months		24.63

4.7 EPIA 9: Reduction in radiation and convection losses from surface of forging furnace

Technology description

A significant portion of the losses in a forging furnace occurs as radiation and convection loss from the furnace walls and the roof. These losses are substantially higher in areas of openings or in case of infiltration of cold air in the furnace. Ideally, optimum amount of refractory and insulation should be provided in the furnace walls and the roof to maintain the outer surface temperature of the furnace at around 10°C above ambient temperature, so as to minimize the heat loss due to radiation and convection from the surfaces. Refractories are heat-resistant materials that constitute the linings for high-temperature furnaces. In addition to being resistant to thermal stress and other physical phenomena induced by heat, refractories must also withstand physical wear and corrosion by chemical agents.

Thermal insulations are used to achieve reduction in heat transfer between objects in thermal contact or in range of radiative influence.

A furnace wall is designed in combination of refractories and insulation layers, with the objective of retaining maximum heat inside the furnace and avoiding losses from furnace roof and walls.

Study and investigation

The average measured temperature of the side walls of the forging furnace no. 2 and no. 3 were 90.22°C and 89°C. It was diagnosed that the high temperature of furnace walls were due to poor insulation, and the temperature of furnace surfaces should be in the range of 47-52°C.

Recommended action

It is recommended to maintain the surface temperature of the furnace walls and roof to within 47-52°C in order to minimize the heat loss due to radiation and convection. The savings assessment has been given in the table below:

Table 26: Losses calculation

Parameters	UOM	Forging-2	Forging-3
Natural convection heat transfer rate from sidewall surfaces	kCal/m^2 deg C	2.2	2.2
External temperature of side walls	deg C	90	89
Sidewall surface area	m^2	1.62	1.92
Room temperature	deg C	44	44

Parameters	UOM	Forging-2	Forging-3
Recommended temperature	deg C	50	50
Present heat loss due to poor insulation	kCal/hr	723	828
Proposed heat loss (after insulation)	kCal/hr	67	80
Temperature at current condition	deg C	90	89
Operating hours	hr/y	2,640	2,640

Table 27: Cost benefit analysis (EPIA 9)

			Forging-2		Forging-3
Parameters	**UOM**	**Present**	**Proposed**	**Present**	**Proposed**
Temperature of side walls	deg C	90	50	89	50
Total wall area	m^2	1.62	1.62	1.92	1.92
Heat loss from surface	kCal/h	723.46	67.28	827.95	79.57
Reduction in heat loss	kCal/h		656.17		748.38
Savings in fuel	kg/h		0.06		0.07
Operating hours of furnace	hr/y	2,640	2,640	2,640	2,640
Savings in fuel per year	kg/y		159		181
Monetary savings	Lakhs Rs.		0.07		0.08
Estimated investment	Rs.		2,000		3,000
Simple payback period	Years		0.36		0.37

4.8 EPIA 10: Temperature control for heaters in electroplating bath

Technology description

Electrical heaters (immersion type) are used for heating the electro-plating baths. Here, resistive heating is used where-by the heaters are immersed in different baths for a certain period of time until the desired temperature is reached.

Study and investigation

Currently, the switching ON and OFF of heaters is done manually and the heaters remain ON for a certain period of time even after the desired bath temperature is reached. Also, the temperature of the bath is measured manually using thermometer.

Recommended action

It is recommended to install microcontroller based automatic ON / OFF electric heaters. The cost benefit analysis for the same is given in the table below:

Table 28: Cost benefit analysis (EPIA 10)

Parameters	UOM	Nickel Tank 1 – 7000 l		Nickel Tank 2 – 4000 l		Chrome Tank 1 -1200 l		Chrome Tank 2 -1200 l		Cleaner Tank -1000 l		Water Washing 1 -300 l		Water Washing 2 -300 l	
		AS IS	TO BE	AS IS	TO BE	AS IS	TO BE	AS IS	TO BE	AS IS	TO BE	AS IS	TO BE	AS IS	TO BE
Ambient Temperature	deg C	32	32	32	32	32	32	32	32	32	32	32	32	32	32
Operating Temperature	deg C	57	57	57	57	57	57	57	57	57	57	57	57	57	57
Surface Area	m^2	7.51	7.51	4.16	4.16	2.49	2.49	2.49	2.49	1.10	1.10	0.37	0.37	0.37	0.37
Tank Capacity	Litres	7,000	7,000	4,000	4,000	1,200	1,200	1,200	1,200	1,000	1,000	300	300	300	300
Specific Heat of water	KJ/kg K	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20
Energy Consumed for heating water from ambient to 57°C	MJ	1,231	735	821	420	137	126	137	126	137	105	137	31.5	137	31.5
Energy Consumed for heating water from ambient to 57°C	kWh	342	204	228	117	38	35	38	35	38	29	38	9	38	9
Heater rated capacity	kW	3		3		2		2		2		2		2	
U Value	W/m^2K	26		26		26		26		26		26		26	
X Factor	Sec	0.00000673		0.00000652		0.00001301		0.00001301		0.00000690		0.00000773		0.00000773	
Cool Down Temperature	deg C	56		56		56		56		56		56		56	
No of heaters	Nos.	6		4		1		1		1		1		1	
Time required for heating	hr	19	11	19	10	19	18	19	18	19	15	19	4	19	4

Parameters	UOM	Nickel Tank 1 – 7000 l		Nickel Tank 2 – 4000 l		Chrome Tank 1 -1200 l		Chrome Tank 2 -1200 l		Cleaner Tank -1000 l		Water Washing 1 -300 l		Water Washing 2 -300 l	
		AS IS	TO BE	AS IS	TO BE	AS IS	TO BE	AS IS	TO BE	AS IS	TO BE	AS IS	TO BE	AS IS	TO BE
from ambient to 57 deg C															
Time required for drop in 1 deg C	hr		0.73		0.76		0.38		0.38		0.71		0.64		0.64
Time required for heating from 56 to 57°C	hr		0.45		0.39		0.70		0.70		0.58		0.18		0.18
Energy required for heating from 56 to 57°C	kWh		8.17		4.67		1.40		1.40		1.17		0.35		0.35
No. of cycles for the heaters to be switched on			6		8		1		1		3		18		18
Total Energy required for heating	kWh	342	257	228	155	38	36.95	38	36.95	38	33.14	38	15.1	38	15.1
Savings in Energy	kWh		85.09		73.48		1.05		1.05		4.86		22.94		22.94
Operating Days			300		300		300		300		300		300		300
Annual Energy Savings	kWh		25,527		22,045		316		316		1,458		6,883		6,883
Average weighted cost	Rs./kWh		6.47		6.47		6.47		6.47		6.47		6.47		6.47
Total Monetary Savings	Lakhs Rs.		1.65		1.43		0.02		0.02		0.09		0.45		0.45
Investment	Rs.		10,000		10,000		10,000		10,000		10,000		10,000		10,000
Payback	Years		0.06		0.07		4.89		4.89		1.06		0.22		0.22

4.9 EPIA 11: Replacement of present inefficient burners with new EE burners

Technology description

The EE burners are decided on the basis of furnace temperature, dimensions and the production. They have a film technology, where each droplet of oil is surrounded by the air increasing the surface area exposed to air resulting in efficient burning. Hence, the fuel consumption is reduced.

Study and investigation

The present fuel firing for the given production was high. It was monitored during the CEA that production of most of the furnaces was much lower than the standard capacity.

Table 29: Furnace specifications for the EE burners

Parameters	UoM	Forging furnace-2	Forging furnace-3
Fuel Firing rate	Liters/hr	13.13	2.63
Production	kg/hr	97	73
Area of the furnace	m2	2.3276	2.304

Recommended action

It is recommended to replace the inefficient burners with new EE burners. The cost benefit analysis f the burner's replacement is given in the table below:

Table 30: Cost benefit analysis (EPIA 11)

Parameters	Unit	As Is	To Be	As Is	To Be
Production rate of the forging furnace	kg/hr	169	169	73	73
Total numbers of burners	Nos.	1.0	1.0	1.0	1.0
Total numbers of energy efficient burner required	Nos.	1.0	1.0	1.0	1.0
Estimated saving by energy efficient burner	%		5.0		5.0
Current fuel firing in forging furnace	kg/hr	12	12	2	2
Savings in fuel per hours	kg/hr		0.61		0.12
Number of operating days	days	305	305	305	305
Number of operating hours per day	hrs	8	8	8	8
Total savings per year into fuel firing	kg/yr		1495		299
Unit cost of fuel	Rs./kg		42.84		42.84
Monetary savings	Lakh Rs./yr		0.64		0.13
Estimated investment for all burners	Lakh Rs.		0.2		0.2
Payback period	Yr		0.4		1.9

4.10 EPIA 12: Installation of Solar Water Heater for Electroplating

Technology description

The electroplating industry requires hot water at a temperature of about 90°C for maintaining the bath temperate within a range of 60 – 70°C. Heat pipe technology which is provided through solar water heater is, therefore, considered to be best suited for this purpose. Hence, this will lead to reduction in fuel consumption.

The proposed project envisages to reduce the existing fuel consumption of oil fired boiler, i.e. diesel by feeding the boiler with pre–heated water from the solar thermal system. This would raise the temperature of ambient / return line hot water to a temperature as near as possible to the required temperature of 90°C for circulation in the heat exchangers to maintain the temperature of electroplating process at the desired temperature level depending upon the available solar irradiation. The system will substantially reduce the consumption of fossil fuel (diesel) and result in reduction of GHG & global warming.

Study and investigation

The existing fuel consumption was very high in the boiler for the electroplating plant of around 36000 litres/day. It was monitored during the CEA that the consumption of diesel by the boiler was very high which could be replaced by the solar water heater.

Recommended action

It is recommended to install solar water heater with heat pipe technology. The cost benefit analysis for the solar water heater in the electroplating plant is given in the table below:

Table 31: Cost benefit analysis (EPIA 12)

Parameters	UoM	AS IS	To Be	AS IS	To Be	AS IS	To Be
Process Water Required Per Day	Lt	100	100	100	100	100	100
Inlet Water Temp	Deg C	45	45	45	45	35	35
Temperature required	^{o}C	55	55	55	55	40	40
Initial Change in Enthalpy for water	kCal	1000	1000	1000	1000	500	500
Fuel required	kCal/day	364120	364120	236080	236080	38680	38680
Energy supplied by SWH	kCal/day	-	364120	-	236080	-	38680
Present power consumption: EH	kWh/day	342	0	228	0	38	0
No of Working Days	Day/year	300	300	300	300	300	300
Average weighted cost	Rs./kWh	6.5	6.5	6.5	6.5	6.5	6.5
Savings in terms of power consumption	kWh/year		102,600		68,400		11,400
Monetary savings	Rs. Lakhs/y		6.64		4.43		0.74
Investment required	Rs. Lakhs		30.63		19.86		3.25
Payback Period	years		4.6		4.5		4.4

Parameters	AS IS	To Be	AS IS	To Be	AS IS	To Be	AS IS	To Be
Process Water Required Per Day	100	100	100	100	100	100	100	100
Inlet Water Temp	35	35	45	45	45	45	45	45
Temperature required	40	40	55	55	55	55	55	55
Initial Change in Enthalpy for water	500	500	1000	1000	1000	1000	1000	1000
Fuel required	38680	38680	42680	42680	35680	35680	35680	35680
Energy supplied by SWH	-	38680	-	42680	-	35680	-	35680
Present power consumption: EH	38	0	38	0	38	0	38	0
No of working ddays	300	300	300	300	300	300	300	300
Average weighted cost	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Savings in terms of power consumption		11,400		11,400		11,400		11,400
Monetary savings		0.74		0.74		0.74		0.74
Investment required		3.25		3.59		3.00		3.00
Payback Period		4.4		4.9		4.1		4.1

5 ANNEXURE

Forging furnace 2 efficiency calculations

Input parameters

Input Data Sheet		
Type of Fuel		Furnace Oil
Source of fuel	Local vendor	
	Value	Units
Furnace Operating temperature (Heating Zone)	876	Deg C
Final temperature of material (at outlet of Heating zone)	826	Deg C
Initial temperature of material	44	Deg C
Average fuel Consumption	12.3	Kg/hr
Flue Gas Details		
Flue gas temperature after APH B12	187	Deg C
Preheated air temp.	110	Deg C
O_2 in flue gas	15.78	%
CO_2 in flue gas	3.9	%
CO in flue gas	66.5	ppm
Atmospheric Air		
Ambient Temperature	44	Deg C
Relative Humidity	45.6	%
Humidity in ambient air	0.03	kg/kg dry air
Fuel Analysis		
C	84.00	%
H	12.00	%
N	0.00	%
O	1.00	%
S	3.00	%
Moisture	0.00	%
Ash	0.00	%
Weighted Average GCV of Fuel	10500	kcal/kg
Material and flue gas data		
Weight of material (Raw material) being heated in furnace	169	kg/hr
Weight of Stock	169	kg/hr
Specific heat of material	0.12	kCal/kgdegC
Average specific heat of fuel	0.417	kCal/kgdegC
fuel temperature	70	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/m^{2}degC
External temp. of ceiling	376	deg K
Room Temperature	317	deg K
Ceiling surface area	3.60	m^2
Emissivity of furnace body surface	0.75	
For side walls		
Natural convection heat transfer rate from sidewall surfaces	2.2	kCal/m^{2}degC
External temperature of side walls	363	deg K
Sidewall surface area	1.6236	m^2
For Hearth		
Natural convection heat transfer rate from flue gas duct surfaces	1.5	kCal/m^{2}degC
External temperature of side walls	366.84	deg K
External surface area	2.3276	m^2
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 pre-heating zone and exits through Furnace	1	Hr
Area of opening in m^2	0.56	m^2
Coefficient based on profile of furnace opening	0.7	
Maximum temperature of air at furnace door	476	deg K

Efficiency calculations

Calculations	Values	Unit
Theoretical Air Required	14.01	kg/kg of fuel
Excess Air supplied	302.30	%
Actual Mass of Supplied Air	56.35	kg/kg of fuel
Mass of dry flue gas	56.27	kg/kg of fuel
Amount of Wet flue gas	57.35	kg of flue gas/kg of fuel
Amount of water vapour in flue gas	1.08	kg of H2O/kg of fuel
Amount of dry flue gas	56.27	kg/kg of fuel
Specific Fuel consumption	72.43	kg of fuel/ton of material
Heat Input Calculations		
Combustion heat of fuel	760,494	kCal/ton of material
Sensible heat of fuel	792	kCal/ton of material
Total heat input	761,285	kCal/ton of material
Heat Output Calculation		
Heat carried away by 1 ton of material (useful heat)	93,821	kCal/ton of material
Heat loss in dry flue gas per ton of material	151,286	kCal/ton of material
Loss due to H_2 in fuel	50,707	kCal/ton of material
Loss due to moisture in combustion air	109	kCal/ton of material
Loss due to partial conversion of C to CO	586	kCal/ton of material
Loss due to convection and radiation (openings in furnace - inlet and outlet door of furnace)	4,239	kCal/ton of material
Loss Due to Evaporation of Moisture Present in Fuel	-	kCal/ton of material

Total heat loss from furnace body	26,718	kCal/ton of material
Heat loss due to unburnts in Fly ash	-	kCal/ton of material
Heat loss due to unburnts in bottom ash	-	kCal/ton of material
Unaccounted heat losses	433,820	kCal/ton of material
Heat loss from furnace body and ceilings		
Heat loss from furnace body ceiling surface	2,984	kCal/hr
Heat loss from furnace body side walls surfaces	723	kCal/hr
Heat loss from hearth	813	kCal/hr
Total heat loss from furnace body	26,718	kCal/tons
Furnace Efficiency	**12.34**	**%**

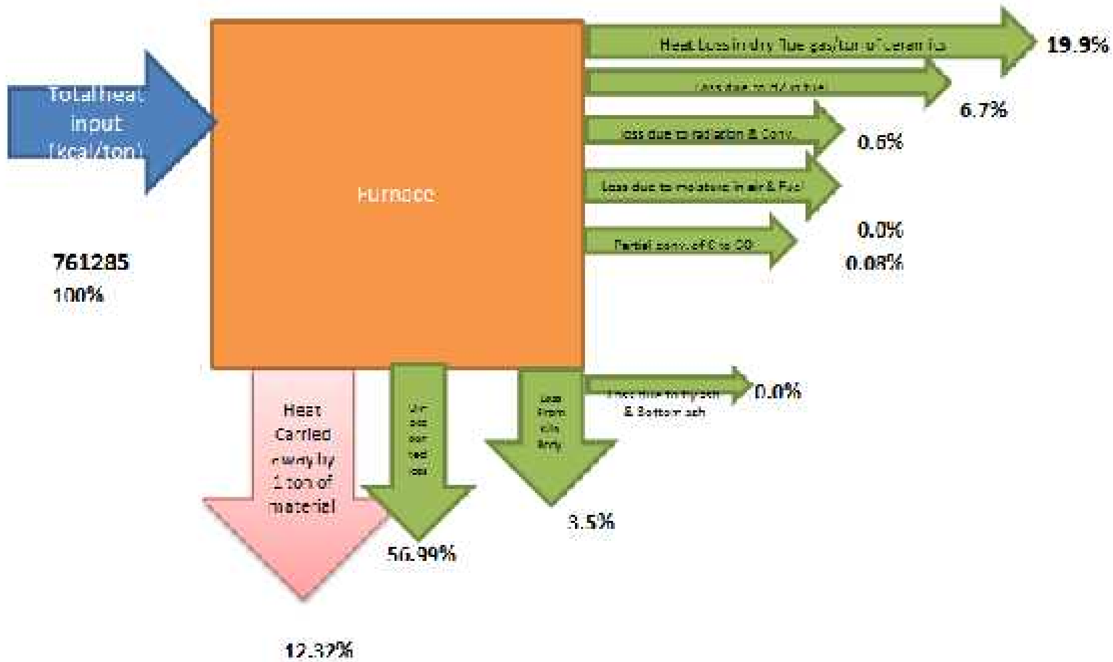

Figure 17: Sankey Diagram of furnace-2

Forging furnace 3 efficiency calculations

Input parameters

Input Data Sheet

Type of Fuel		Furnace Oil
Source of fuel	Local vendor	
	Value	Units
Furnace Operating temperature (Heating Zone)	878	Deg C
Final temperature of material (at outlet of Heating zone)	824	Deg C
Initial temperature of material	59	Deg C
Average fuel Consumption	2.5	Kg/hr
Flue Gas Details		
Flue gas temperature after APH	317	Deg C
Preheated air temperature	110	Deg C
O2 in flue gas	17	%
CO2 in flue gas	3.4	%
CO in flue gas	13.2	ppm
Atmospheric Air		
Ambient Temperature	59	Deg C
Relative Humidity	45.6	%
Humidity in ambient air	0.03	kg/kg dry air
Fuel Analysis		
C	84.00	%
H	12.00	%
N	0.00	%
O	1.00	%
S	3.00	%
Moisture	0.00	%
Ash	0.00	%
Weighted Average GCV of Fuel	10,500	kCal/kg
Material and flue gas data		
Weight of material (Raw material) being heated in furnace	73	kg/Hr
Weight of Stock	73	kg/hr
Specific heat of material	0.12	kCal/kg degC
Average specific heat of fuel	0.417	kCal/kg degC
Fuel temperature	70	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/m^2degC
External temp. of ceiling	370	deg K
Room Temperature	332	deg K
Ceiling surface area	2.54	m^2
Emissivity of furnace body surface	0.75	
For side walls		
Natural convection heat transfer rate from sidewall surfaces	2.2	kCal/m^2 degC
External temp. eraturef side walls	362	Deg K

Sidewall surface area	1.92	m^2
For Hearth		
Natural convection heat transfer rate from flue gas duct surfaces	1.5	kCal/m^2degC
External temperature of side walls	363	deg K
External surface area	2.304	m^2
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	0.56	m^2
Coefficient based on profile of furnace opening	0.7	
Maximum temperature of air at furnace door	463	deg K

Efficiency calculations

Calculations	Values	Unit
Theoretical Air Required	14.01	kg/kg of fuel
Excess Air supplied	377.27	%
Actual Mass of Supplied Air	66.85	kg/kg of fuel
Mass of dry flue gas	66.77	kg/kg of fuel
Amount of Wet flue gas	67.85	Kg of flue gas/kg of fuel
Amount of water vapour in flue gas	1.08	Kg of H_2O/kg of fuel
Amount of dry flue gas	66.77	kg/kg of fuel
Specific Fuel consumption	33.54	kg of fuel/ton of material
Heat Input Calculations		
Combustion heat of fuel	352,150	Kcal/ton of material
Sensible heat of fuel	158	Kcal/ton of material
Total heat input	352,308	Kcal/ton of material
Heat Output Calculation		
Heat carried away by 1 ton of material (useful heat)	91,836	Kcal/ton of material
Heat loss in dry flue gas per ton of material	150,643	Kcal/ton of material
Loss due to H2 in fuel	25,370	Kcal/ton of material
Loss due to moisture in combustion air	234	Kcal/ton of material
Loss due to partial conversion of C to CO	62	Kcal/ton of material
Loss due to convection and radiation (openings in furnace - inlet and outlet door of furnace)	8,406	Kcal/ton of material
Loss Due to Evaporation of Moisture Present in Fuel	-	Kcal/ton of material
Total heat loss from furnace body	32,445	Kcal/ton of material
Heat loss due to unburnts in Fly ash	-	Kcal/ton of material
Heat loss due to unburnts in bottom ash	-	Kcal/ton of material
Unaccounted heat lossess	43,313	Kcal/ton of material
Heat loss from furnace body and ceilings		
Heat loss from furnace body ceiling surface	1316	Kcal/hr
Heat loss from furnace body side walls surfaces	538	Kcal/hr
Heat loss from hearth	517	Kcal/hr

Total heat loss from furnace body	32445	Kcal/tons
Furnace Efficiency	**26.08**	**%**

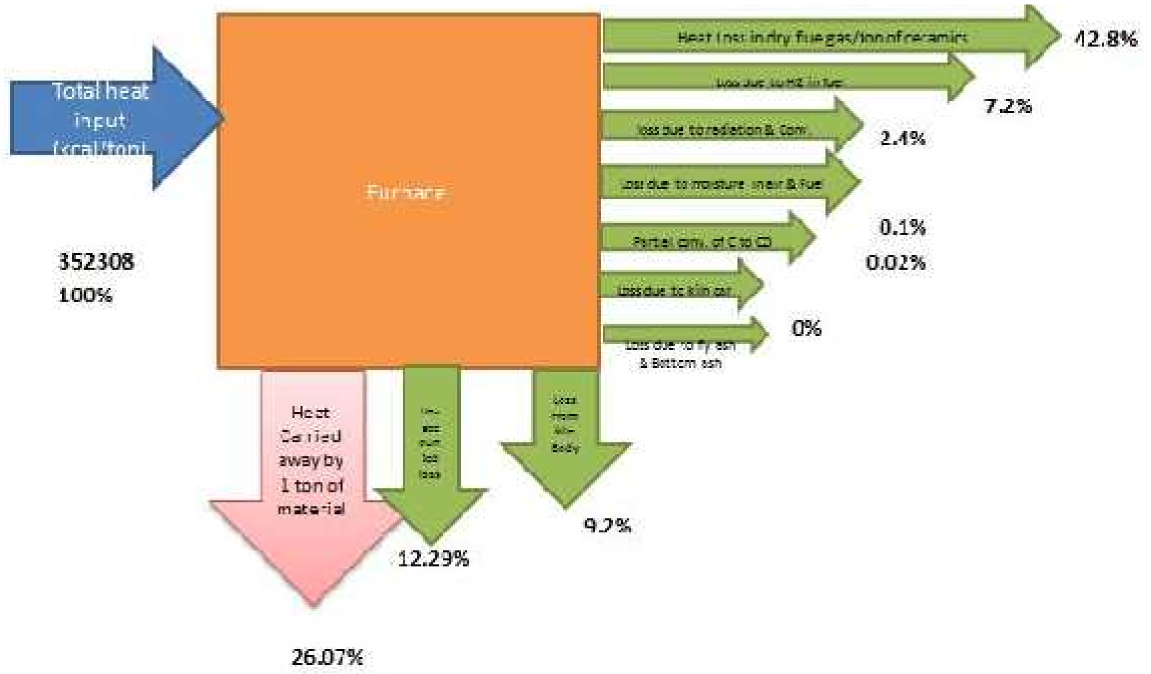

Figure 18: Sankey Diagram Furnace 3

6 LIST OF VENDORS

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

EPIA 1, 2: Excess Air Control

Sl. No.	Name of Company	Address	Phone No	E-mail /Website

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 3: VFD on broaching machines

Sl. No.	Name of Company	Address	Phone No.	E-mail

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Schneider Electric Contact Person: Mr. Amritanshu	A-29, Mohan Cooperative Industrial Estate, Mathura Road, New Delhi-110044, India.	9871555277 (Rinki), Mr.Amritanshu (9582941330), 0124-3940400	amit.chadha@schneider-electric.com
2	Larson & Toubro Contact Person: Mr. Rajesh Bhalla	Electrical business group,32,Shivaji Marg,Near Moti nagar,Delhi-15	011(41419500),9582252422(Mr.Rajesh),7838299559(Mr.Vikram-sales),(PrIthvi power-technical)-9818899637,9810028865(Mr.Ajit),8510999637(Mr.Avinash Vigh)	Email: bhallar@lntebg.com, vikram.garg@lntebg.com, prithvipowers@yahoo.com, rajesh.bhalla@lntebg.com,ajeet.singh@lntebg.com

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

EPIA 5: 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 6 & 7: 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), 9810461907(Kapil)	kushagra.kishore@bajajelectricals.com, kushagrakishore@gmail.com; sanjay.adlakha@bajajelectricals.com

EPIA 8: Energy Monitoring System

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
Automation				
1	Iadept Marketing Contact Person: Mr. Brijesh Kumar Director	S- 7, 2nd Floor, Manish Global Mall, Sector 22 Dwarka, Shahabad Mohammadpur, New Delhi, DL 110075	Tel.: 011-65151223	iadept@vsnl.net ,info@iadeptmarketing.com
2	Aimil Limited Contact Person: Mr. Manjul Pandey	Naimex House A-8, Mohan Cooperative Industrial Estate, Mathura Road, New Delhi - 110 044	Office: 011-30810229, Mobile: +91-981817181	manjulpandey@aimil.com
3	Panasonic India Contact Person: Neeraj Vashisht	Panasonic India Pvt Ltd Industrial Device Division (INDD) ABW Tower,7th Floor, Sector 25, IFFCO Chowk, MG Road,Gurgaon - 122001, Haryana,	9650015288	neeraj.vashisht@in.panasonic.com

EPIA 9: Skin loss reduction

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Morgan Advanced Materials - Thermal Ceramics	P.O. Box 1570, Dare House Complex, Old No. 234, New No. 2, NSC Bose Rd, Chennai - 600001, INDIA	T 91 44 2530 6888 F 91 44 2534 5985 M 919840334836	munuswamy.kadhirvelu@morganplc.com mmtcl.india@morganplc.com ramaswamy.pondian@morganplc.com
2	M/s LLOYD Insulations (India) Limited,	2,Kalka ji Industrial Area, New Delhi-110019	Phone: +91-11-30882874 / 75 Fax: +91-11-44-30882894 /95	Email: kk.mitra@lloydinsulation.com

Sl. No.	Name of Company	Address	Phone No.	E-mail
			Mr. Rajneesh Phone : 0161-2819388 Mobile : 9417004025	

EPIA 10: Temperature control for heaters in electroplating bath

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Larson & Toubro Contact Person: Mr. Rajesh Bhalla	Electrical business group,32,Shivaji Marg,Near Moti nagar,Delhi-15	011(41419500),9582252422(Mr.Rajesh),7838299559(Mr.Vikram-sales),(PrIthvi power-technical)-9818899637,9810028865(Mr.Ajit),8510999637(Mr.Avinash Vigh)	Email: bhallar@lntebg.com, vikram.garg@lntebg.com, prithvipowers@yahoo.com, rajesh.bhalla@lntebg.com,ajeet.singh@lntebg.com
2	Sanobar Systems Contact Person: Mr. Jayant Shinde	B-1 & B-5, Sankul Building,Near Damodar Nagar,Off Sinhagad Road,Higane Khurd,Pune	020-24351413, 9850094736, 9822306936	NA

EPIA 11: Installation of EE Burners

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
Automation				
1	ENCON Thermal Engineers (P) Ltd	297, Sector-21 B Faridabad – 121001	Tel.: +91 129 4041185	sales@encon.co.in kk@encon.co.in

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
	Contact Person: Mr V B Mahendra, Managing Director Mr. Puneet Mahendra, Director	Haryana	Fax: +91 129 4044355 Mobile: +919810063702 +919971499079	www.encon.co.in
2	TECHNOTHERMA FURNACES INDIA PVT. LTD.	206, Hallmark Commercial Complex, Near Nirmal Lifestyles, L.B.S. Marg, Mulund West, Mumbai - 400 080. India.	T: 022-25695555	Furnace@technotherma.net
3	Therm process	Mr. Sanjay Parab B/1203-O2 Commercial Complex, Minerva Estate, Opp Asha Nagar, P.K.Cross Road, Mulund (W) Mumbai-400080	T: 022-25917880/82/83 M: 9967515330	thermprocess@yahoo.com sanjay@thermprocess.com

EPIA 12: Installation of Solar heat pipe for electroplating bath heating

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
1	Mr. Manmohan Reen, Regional Manager Electrotherm Solar Limited	Plot No. 414/1, GIDC Phase-II, Vatva, Ahmedabad-382445 Gujarat	09988596639	manmohan.reen@electrotherm.com www.electrothermal.com