COMPREHENSIVE ENERGY AUDIT REPORT

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

Victor Forgings

A-4, Focal Point, Jalandhar

22-05-2015

Submitted to

ENERGY IS LIFE
BEE
CONSERVE IT

BUREAU OF ENERGY EFFICIENCY

4th Floor, Sewa Bhawan, R K Puram, Sector-I, New Delhi -110066

Submitted by

DESL

DEVELOPMENT ENVIRONERGY SERVICES LTD

819, Antriksh Bhawan, 22 Kasturba Gandhi Marg, New Delhi -110001
Tel.: +91 11 4079 1100 Fax : +91 11 4079 1101; www.deslenergy.com

DISCLAIMER

This report (including any enclosures and attachments) has been prepared for the exclusive use and benefit of the addressee(s) and solely for the purpose for which it is provided. Unless we provide express prior written consent, no part of this report should be reproduced, distributed or communicated to any third party. We do not accept any liability if this report is used for an alternative purpose from which it is intended, nor to any third party in respect of this report.

ACKNOWLEDGEMENT

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 Hand tools 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. Sukh Dev Raj, MD & CEO for showing keen interest in the energy audit and also thankful to the management of M/s Victor 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
Team member(s)	**Mr. Mithlesh Priya** Analyst
	Mr. Tanmay Varshney Project Analyst
	Mr. Prabhat Sharma Project Analyst
	Mr. Vishnu P Project Associate
	Mr. Oisik Mishra Project Associate

CONTENTS

List of figures

List of Tables

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[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 Victor Forgings
Constitution	Private Limited
MSME Classification	Small
No. of years in operation	NA
Address: Registered Office	A-4, Focal Point, Jalandhar- 144 012
Administrative Office	A-4, Focal Point, Jalandhar- 144 012
Factory	A-4, Focal Point, Jalandhar- 144 012
Industry-sector	Hand Tool
Products Manufactured	Spanners, Pliers
Name(s) of the Promoters / Directors	Mr. Sukh Dev Raj

Comprehensive Energy Audit

The study was conducted in 3 stages:

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

- **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 vibrating action of this machine, the work piece and the ceramic materials rubs against each other and 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 the equipments which were operational during the field study. Thermal energy constitutes 46% (FO, HSD and LPG) and grid electricity constitutes 54% of 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							
		Furnace Oil	Electricity	LPG	HSD	Material savings	Monetary savings	Estimated investment	Simple payback period
		Litre/y	kWh/y	kg/year	Litre/y	Rs. lakh/y	Rs. lakh/y	Rs. lakh	y
1	Installation of PID controller for excess air control on forging-3	3883.2	1478.4			0.8	2.4	7.00	2.9
2	Installation of PID controller for excess air control on forging-5	13060	984.7			1.5	6.8	7.00	1.04
3	Installation of PID controller for excess air control on forging-1		393.4	1765.3		0.5	1.4	7.00	5.1
4	Installation of VFD on broaching machine		29495.4				2.0	2.76	1.3
5	Installation of energy efficient pump motor instead of old and inefficient pump motor		86270.0				6.0	2.52	0.4
6	Replacement of inefficient DG to efficient DG				16019.0		8.0	16.72	2.1
7	Installation of energy efficient fan instead of conventional fan		19656.0				1.4	3.12	2.3
8	Retrofit of CFL 40 watt to led tube light of 16 watt		27054				1.9	1.73	0.9
9	Replacement of CFL 45 watt ,23 watt and 250 watt to LED 18 watt, Led 10 watt and LED 80 watt		55844				3.9	4.21	1.1
10	Installation of energy monitoring system on sectional energy consuming area	5529.2	119606		2712		11.7	0.75	0.1
11	Skin loss reduction from furnace surface	4807.2					1.9	0.40	0.2

12	Efficiency improvement in transformer of rating 750 kVA		2744				0.2	0.10	0.5
13	Installation of servo stabilizer with separate feeder of lighting and fan load		12732				0.9	0.80	0.9
14	Replacement of conventional man cooler fan to energy efficient fan		97954				6.8	0.60	0.1
15	Replacement of present burner with energy efficient burner	5480.0					2.2	0.73	0.3
16	Installation of Solar water heater for Electroplating				22422		11.9	61.50	5.2
	Total	32759.8	454212.3	1765.3	41152.2	2.7	69.3	116.9	1.7

The projects proposed may result in energy savings of approximately 18.70% and energy cost savings of Rs. 69.3 lakh 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 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 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, 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, and 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 5.2 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 Victor tools, 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 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

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

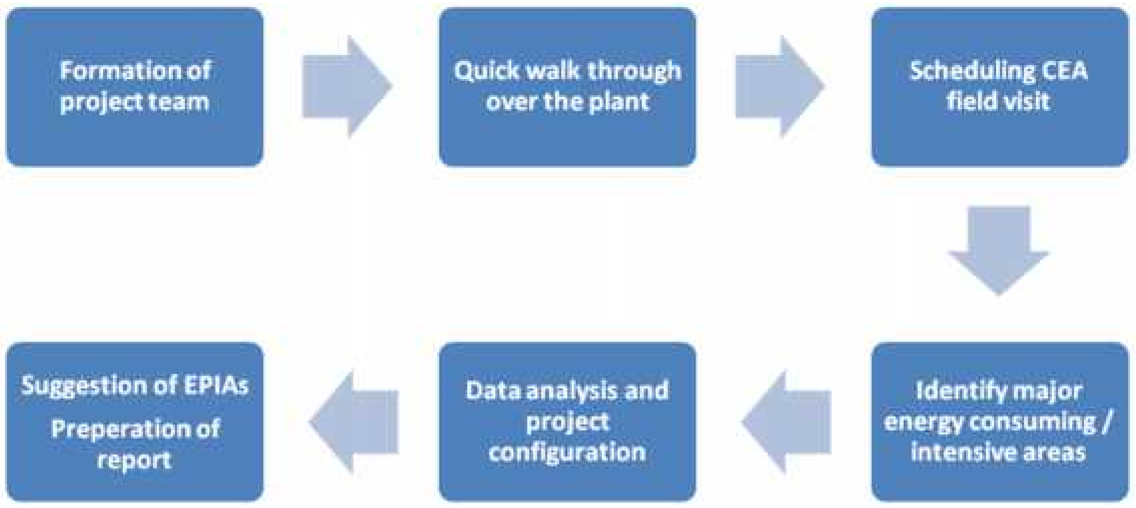


Figure 1: General methodology

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 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 units financial performance
- Assess the energy conservation potential at macro level
- Finalize the schedule of equipment's 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

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

Sl. No.	Instruments	Make	Model	Parameters Measured
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:

- Re-validation of all the calculations for arriving at the savings potential
- Quick costing based on DESL 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 4: General particulars of the unit

S. No	Particulars	Details
1	Name of the unit	M/s Victor Forgings
2	Constitution	Private
3	Date of incorporation / commencement of business	NA
4	Name of the contact person Mobile/Phone No. E-mail ID	Mr. Sukhdev Singh Raj 0181-5030200 victor@jla.vsnl.net.in
5	Address of the unit	A-4, Focal Point, Jalandhar – 144012
6	Industry / sector	Hand tools
7	Products manufactured	Spanners, Pliers
8	No. of operational hours	24
9	No. of days of operation / year	300
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 & Energy flow diagram

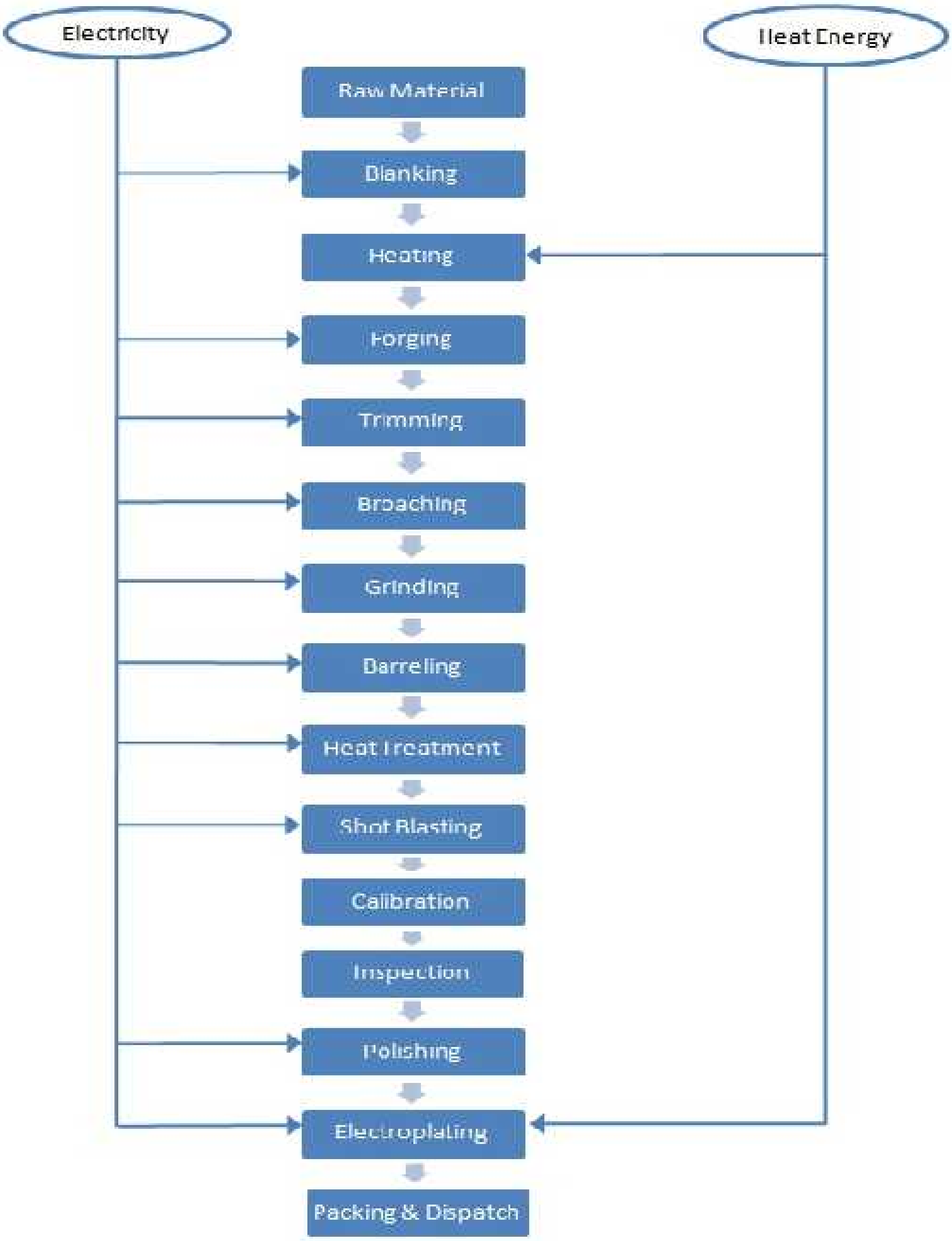


Figure 3: Process flow diagram

3.1.2 Process description

M/s Victor Forgings is a manufacturer of hand tools.

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 blank metal scrap.

Heating

The unit has 4 oil fired forging furnaces and 1 LPG fired forging furnace 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 furnaces 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 this operation, the forged material is pressed to give it a uniform shape by removing the unnecessary burrs along the edges. The speed of the press 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 in which sand paper is used for 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

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

Heat Treatment

Heat treatment is done to impart required metallurgical properties to the work piece that will benefit the working life of manufactured equipment (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 and is 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. The ceramic material and the work pieces are placed together on the vibrating glazing machines. 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 and during this process the work piece gets polished.

Electro plating

The final shining and glazing of the product is attained by electroplating, where a blower is used to circulate air inside a nickel tank. 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 touch.

3.1.3 Types of energy used and description of usage pattern

Both electricity and thermal energy are used for carrying out various 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	Rs.(Lakhs)	% of Total	Consumption (MTOE)	Energy sharing (%)
Grid –Electricity	292.04	69%	342.9	54.17
Diesel –DG	45.19	11%	88.4	13.97
FO	73.72	18%	180.7	28.55
LPG	9.57	2%	21.0	3.31
Total	420.53	100%	632.9	100.00

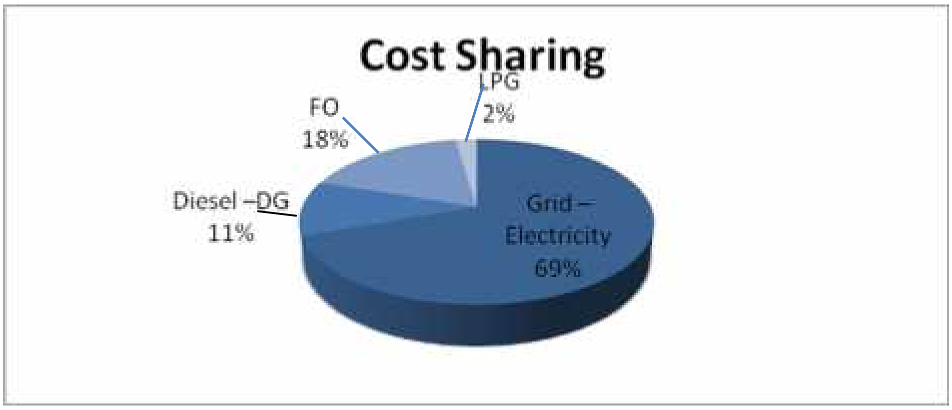


Figure 4: Energy cost share

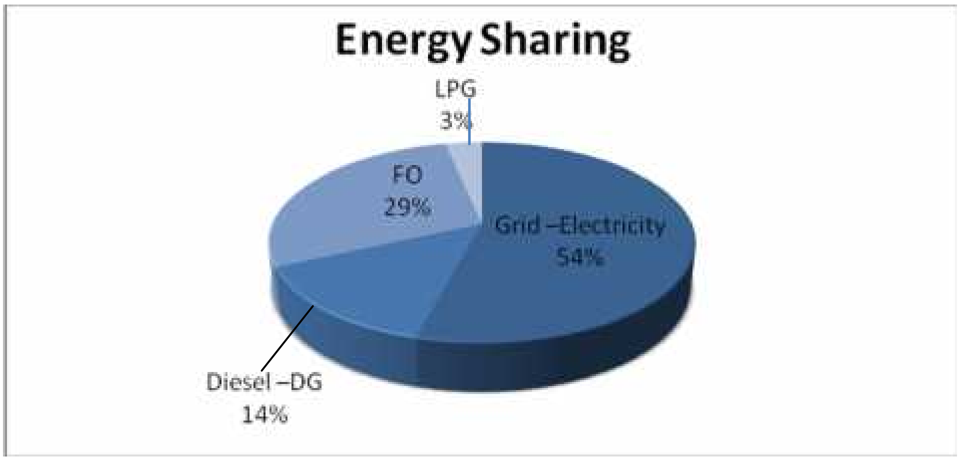


Figure 5: Energy use share

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 in DG sets when grid electricity is not available. Thermal energy consumption is in the form of FO and LPG, which is used for furnace heating.
- FO and LPG used in furnaces account for 20% of the total energy cost and 32% of overall energy consumption.
- Electricity (from both DG and Grid) used in the process accounts for the remaining 80% of the energy cost; diesel used for captive generation accounts for 11% of the overall cost.

3.2 Analysis of electricity consumption by the unit

3.2.1 Electricity load profile

Following observations have been made from the utility inventory:

- The plant and machinery load is 2,527.1 kW
- The utility load (lighting and fan load)is about 99.4 kW including the single phase load

- The plant total connected load is 2,626.5 kW

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

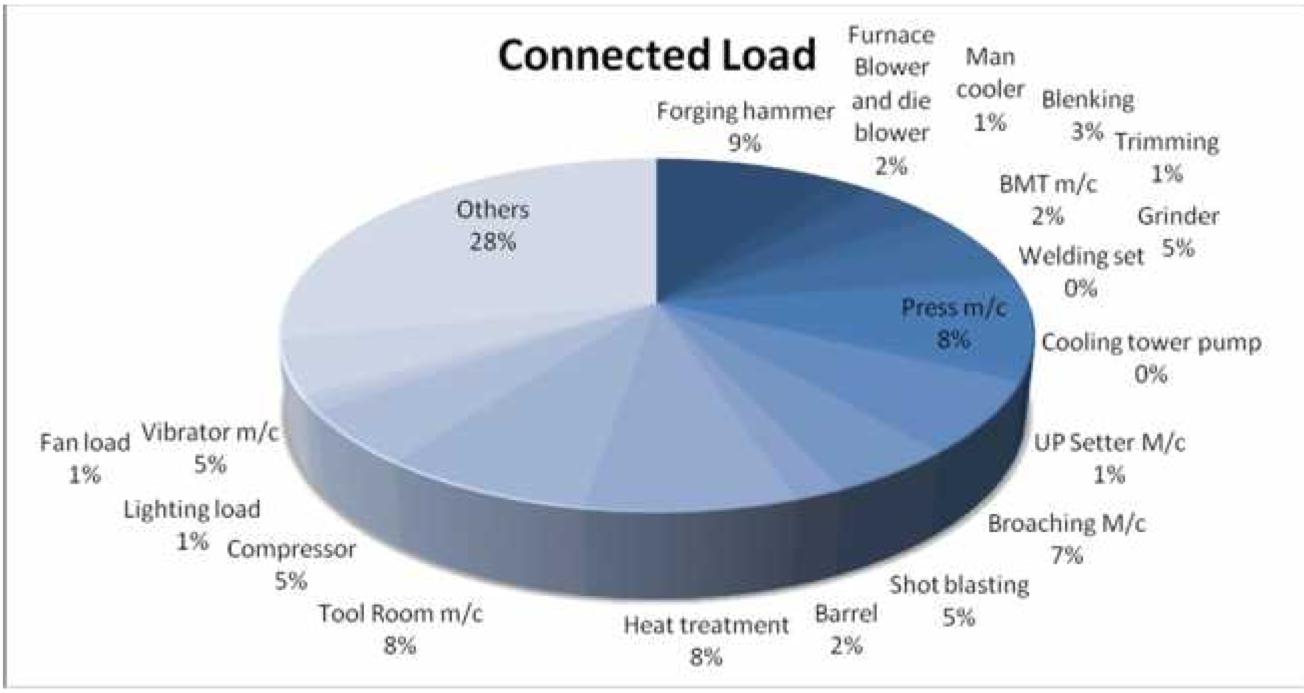


Figure 6: Details of connected load

As shown in the pie chart of connected load, the share of connected load is divided between electroplating – 28%, hammer – 9%, heat treatment and press machine – 8% each, compressor – 5% and broaching - 7%. Lighting and fan load contribute around 1% each 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 6: Area wise electricity consumption (estimated)

Sl. No.	Section	kWh/year	% of Total
1	Forging	905040	18.6%
2	UP Setter	272179	9.8%
3	Packing	39610	0.8%
4	Broaching and grinding	451994	8.7%
5	Tool room	319374	7.7%
6	C/T P/T room and main gate	5445	0.2%
7	Barrel section	49104	1.8%
8	Belt grinding section	159382	5.7%
9	Taiwan rotatory grinder	224611	5.4%
10	Heat treatment	394277	7.6%
11	Stamping	158004	3.8%

12	Lab gauging	10296	0.4%
13	Shot blasting	143748	3.5%
14	Vibrator	205524	4.9%
15	Utility	393588	3.8%
16	Electroplating	482819	17.4%
	Total	4214996	100.0%

This is represented graphically in the figure below:

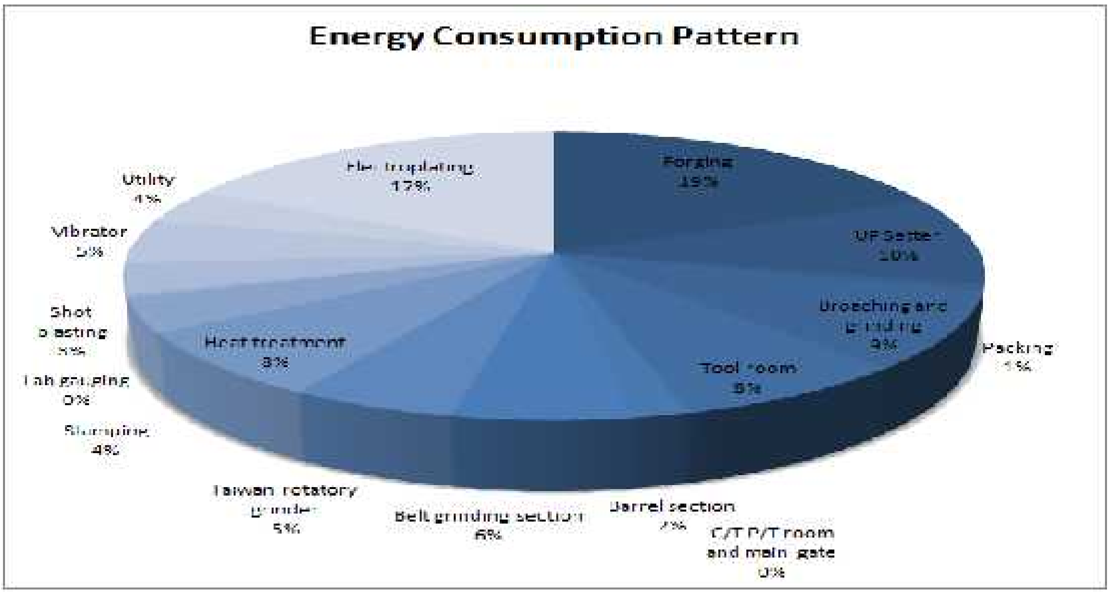


Figure 7: Area wise electricity consumption

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).

3.2.2 Sourcing of electricity

The unit is drawing electricity from two different sources:

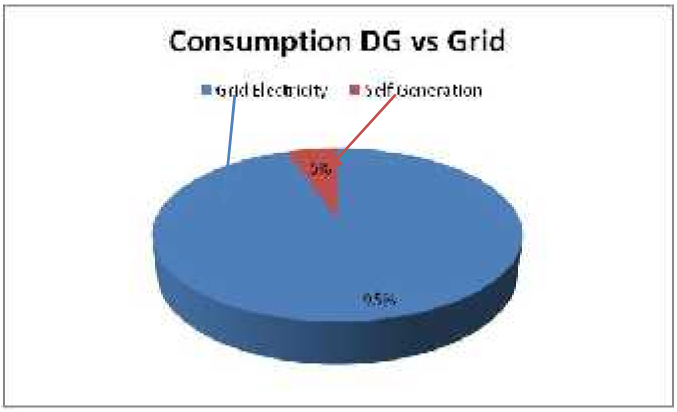
- Utility (PSPCL) through regulated tariff
- Captive DG sets, which are used as backup source for supplying electrical power in case of grid power failure

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

Table 7: Electricity share from grid and DG

	Consumption (kWh)	%	Cost	%
Grid Electricity	3,986,880	95%	29,204,128	87%
Self Generation	226,749	5%	4,519,185	13%
Total	**4,213,629**	**100%**	**33,723,312**	**100%**

This is graphically depicted as follows:



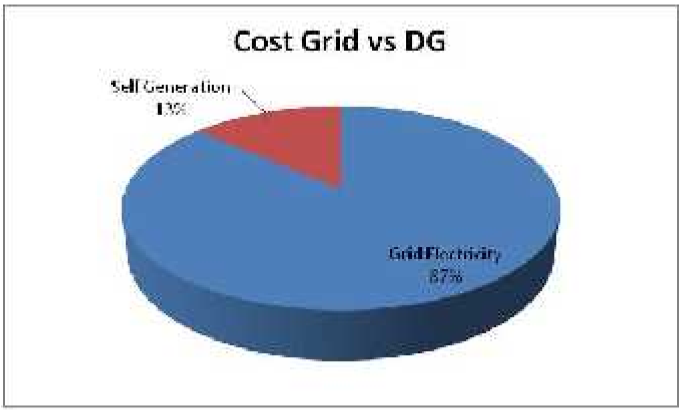


Figure 8: Share of electricity by source and cost

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 5% of the total power which is not very high. Although the share of DG power in terms of kWh is just 5% of the total electrical power, it accounts for about 13% 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, the utilization of DG sets needs to be minimized, but it will depend upon the supply condition of the grid, as well as the power requirement of the plant.

3.2.3 Supply from utility

Electricity is supplied by 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 : 1,450 kVA
c) Sanctioned Load : 2342.565 kVA
d) Nature of Industry : HT – G

The tariff structure is as follows:

Table 8: Tariff structure

Particulars	Tariff Structure	
Present energy charge	6.15	Rs./kVAh
Octroi charge	0.19	Rs./kVA
Fixed charge	6.34	Rs./kVAh
PLEC Charge	0.27	Rs./kVAh
Municipality tax	0.00	Rs./kVAh

(As per bill)

Table 9: Evaluation of Electricity bill

Month	Sanctioned Load	Contract Demand	Peak load allowed	Recorded Maximum Demand	PF	Electricity Consumption		Energy Charges	Energy Charge Rs./kVAh	Fuel Cost Adjustment Charge	Fuel Charge Rs./kVAh	PLEC Charges	PLEC Charge Rs./kVAh	Fixed Charges	Octroi Charges	ED Charges	Total Charge
	kW	kW	kW	kVA		kVAH	kWH	Rs.		Rs		Rs.		Rs	Rs	Rs.	Rs.
Apr-14	2343	1450	525	878	0.99	335729	332240	2065256	6.15	-5846	-0.02	92340	0.27	2129713	61769	241577	2433677
May-14	2343	1450	525	878	0.99	335729	332240	2065256	6.15	-5846	-0.02	92340	0.27	2129713	61769	241577	2433677
Jun-14	2343	1450	525	878	0.99	335729	332240	2065256	6.15	-5846	-0.02	92340	0.27	2129713	61769	241577	2433677
Jul-14	2343	1450	525	849	0.98	306460	299020	1892797	6.18	-37856	-0.12	126968	0.41	1914619	29902	232395	2177835
Aug-14	2343	1450	525	908	0.98	339120	332700	2105991	6.21	-42120	-0.12	119273	0.35	2179586	33270	268303	2482080
Sep-14	2343	1450	525	856	0.98	352340	343640	2163368	6.14	-43505	-0.12	123120	0.35	2254854	34364	277126	2567263
Oct-14	2343	1450	525	814	0.99	329620	326020	2023867	6.14	6592	0.02	119273	0.36	2149735	32962	263960	2447126
Nov-14	2343	1450	525	735	1	307340	306260	1887068	6.14	6147	0.02	107730	0.35	2000941	30734	246118	2278262
Dec-14	2343	1450	525	930	1	355740	354620	2184244	6.14	11117	0.03	123120	0.35	2318481	35574	285397	2639921
Jan-15	2343	1450	525	945	1	375580	374340	2306061	6.14	18779	0.05	111578	0.30	2436421	37558	302229	2776677
Feb-15	2343	1450	525	1038	1	326820	325820	2006675	6.14	16341	0.05	0	0.00	2062467	288121	33267	2384323
Mar-15	2343	1450	525	828	1	328540	327740	2017236	6.14	11895	0.04	0	0.00	1850310	33436	265394	2149609

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

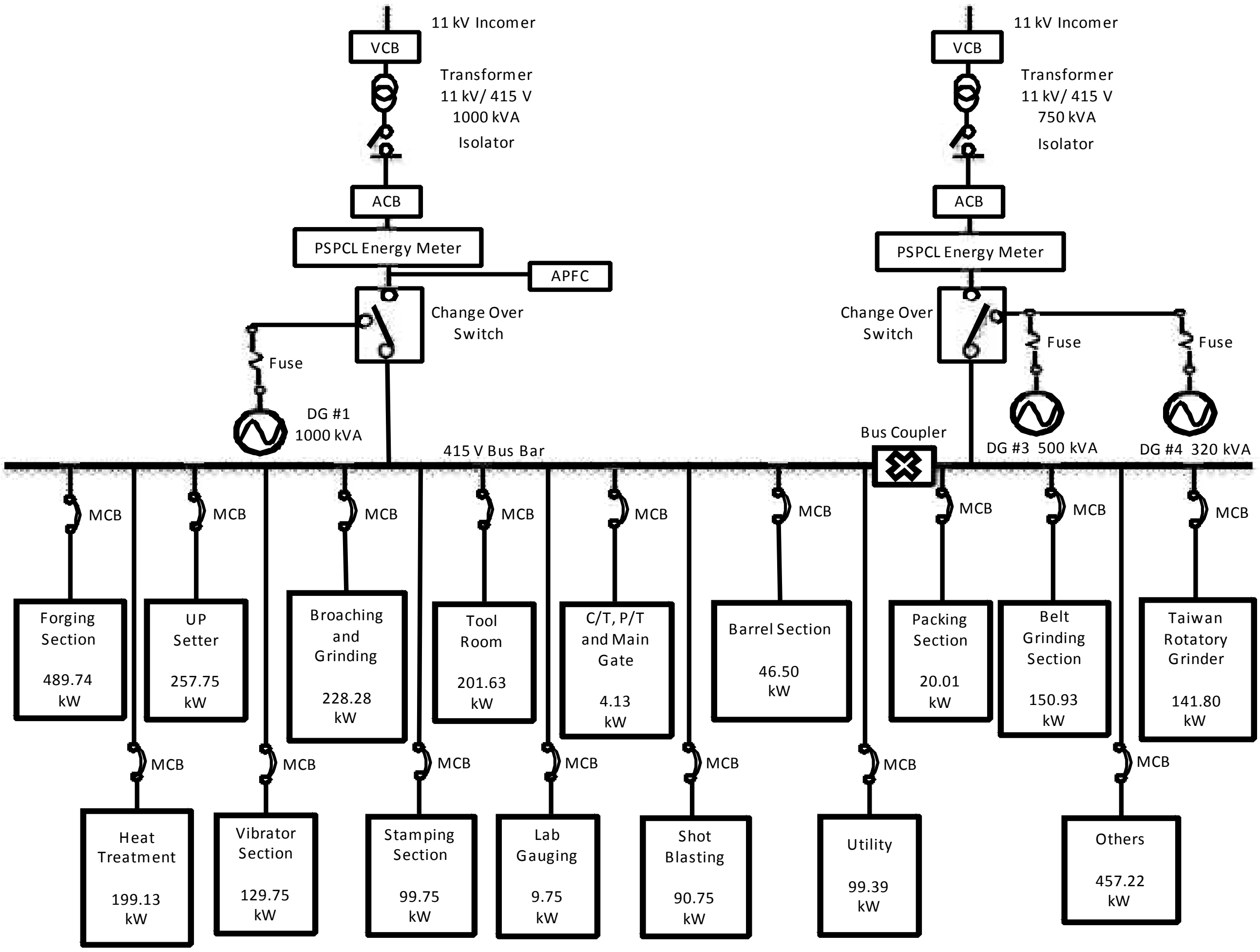


Figure 9: SLD of electrical load

Power factor

The utility bill of the unit reflects the average monthly power factor. A study was conducted by logging the main incomer and recording the electrical parameters. The average power factor recorded was 0.992.

Maximum demand

The average maximum demand recorded from electricity bill analysis was 878 kVA.

3.2.4 Self – generation

The unit has 3 DG sets of 1000 kVA, 500 kVA and 320 kVA ratings respectively. The unit does not have a system for monitoring the energy consumption and fuel usage in DG sets. Diesel purchase records, are however, maintained by the unit. DG performance testing was done during the audit and specific energy consumption of DGs are given below:

- 1000 kVA – 3.64 kWh/litre
- 500 kVA - 2.53 kWh/litre
- 320 kVA - 1.26 kWh/litre

Annual diesel consumption in DG set is 90,384 litres generating 226,749 kWh with a cost of Rs. 45.19 lakh

Note: As the month wise data was not provided by the unit, hence the value has been taken average for the month wise computation.

3.2.5 Month wise electricity consumption

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

Table 10: Electricity consumption & cost

	Electricity Used (kWh)			Electricity Cost (Rs.)		
	Grid	DG	Total	Grid	DG	Total
Months	kWh	kWh	kWh	Rs	Rs.	Rs.
April	332,240	18,896	351,136	2,433,677	376,599	2,810,276
May	332,240	18,896	351,136	2,433,677	376,599	2,810,276
June	332,240	18,896	351,136	2,433,677	376,599	2,810,276
July	299,020	18,896	317,916	2,177,835	376,599	2,554,434
August	332,700	18,896	351,596	2,482,080	376,599	2,858,679
September	343,640	18,896	362,536	2,567,263	376,599	2,943,862
October	326,020	18,896	344,916	2,447,126	376,599	2,823,725
November	306,260	18,896	325,156	2,278,262	376,599	2,654,861
December	354,620	18,896	373,516	2,639,921	376,599	3,016,519
January	374,340	18,896	393,236	2,776,677	376,599	3,153,276
February	325,820	18,896	344,716	2,384,323	376,599	2,760,922
March	327,740	18,896	346,636	2,149,609	376,599	2,526,207
Total	3,986,880	226,749	4,213,629	29,204,127	4,519,185	33,723,312

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

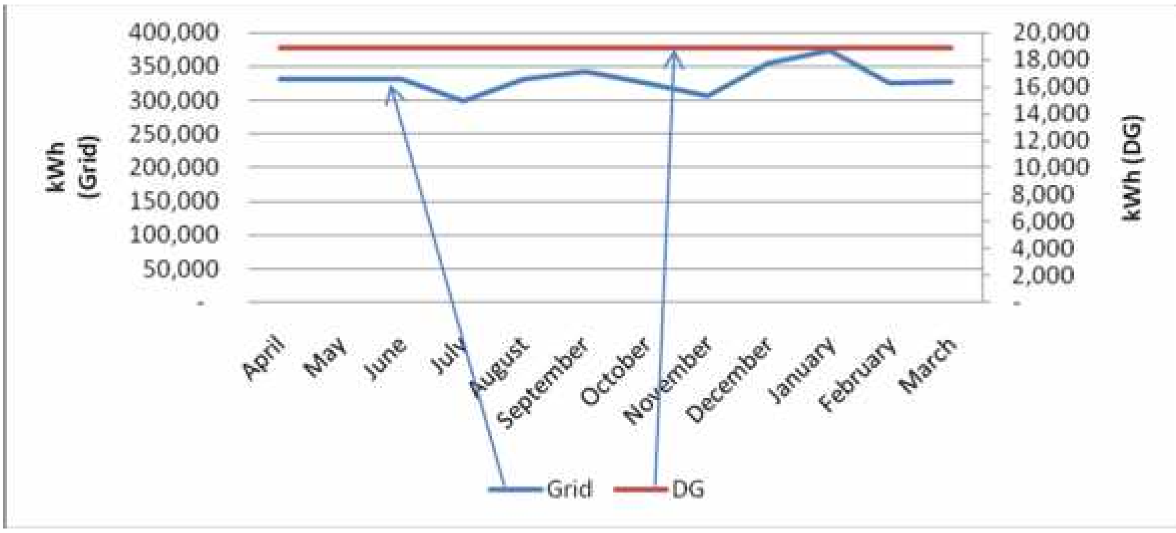


Figure 10: Month wise variation in electricity consumption from different sources

As shown in the figure above, the consumption of electrical energy was on higher side during the months of September'14, December'14 and January'15. However, it was noticed that the electricity consumption during the months of July'14 and November'14 were low, which indicates that the production during those months might have been low. The corresponding month wise variation in electricity cost is shown graphically in the figure below:

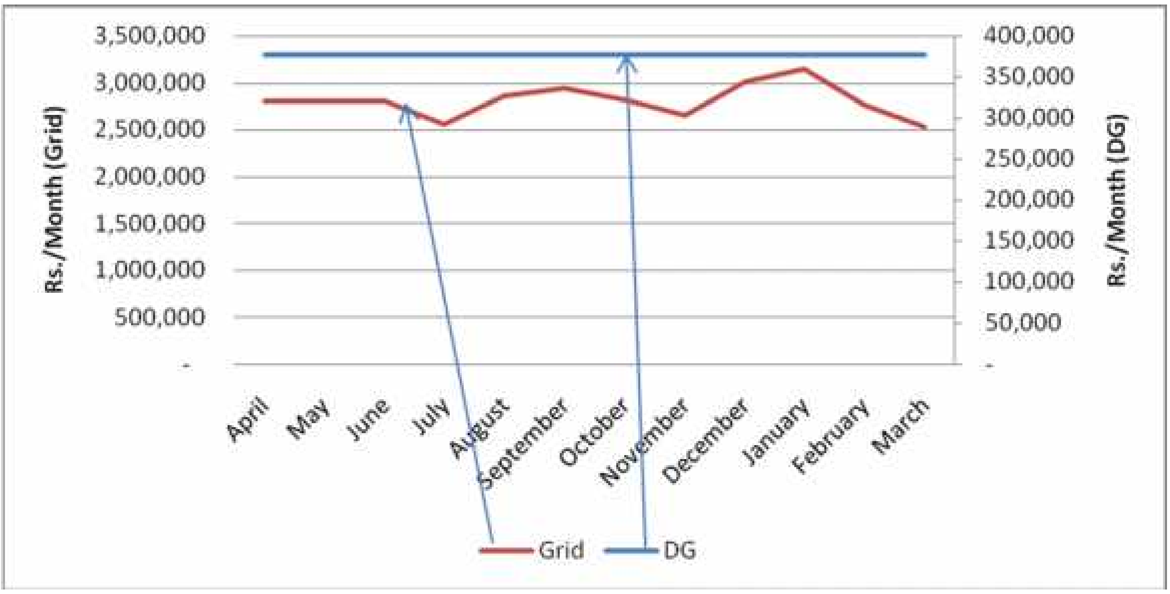


Figure 11: Month wise variation in electricity cost from different sources

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

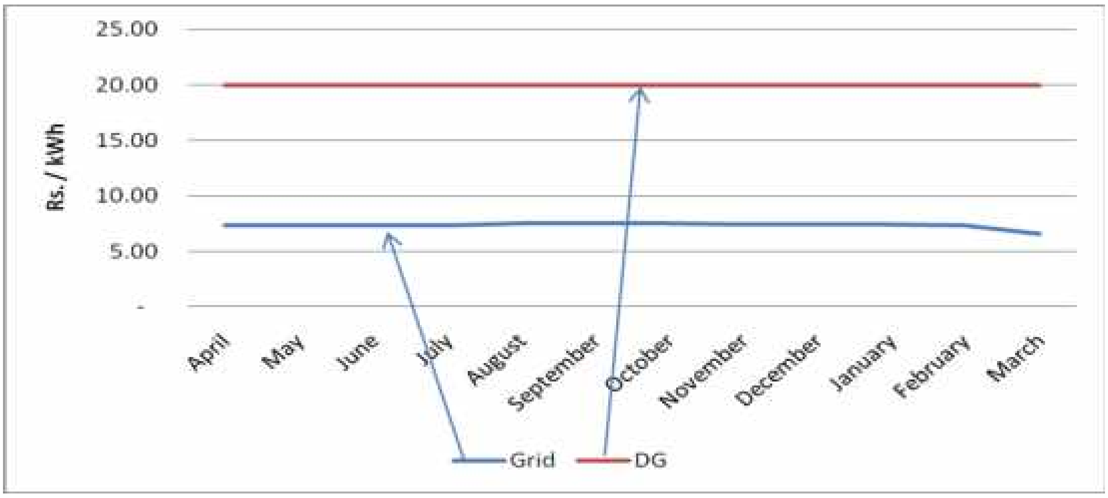


Figure 12: Average cost of power (Rs./kWh) from different sources

The above graph clearly indicates that the cost of electrical energy from DG sets was very high, nearly 3 times the cost of utility power.

3.3 Analysis of thermal consumption by the unit

The fuels used in forging furnaces are FO and LPG; whose costs were Rs. 40 / litre and Rs. 50 / kg respectively. There is no meter installed for measurement of fuel consumption in forging furnaces. Apart from this, in electroplating section, HSD was used as fuel in boiler for steam generation. Annual FO consumption is 184,305 Litres costing about Rs. 73.72 lakh and annual LPG consumption is 19,149 kg costing about Rs. 9.57 lakh

Note: The fuel consumption in furnace is considered constant as monthly fuel consumption data was not provided by the plant personnel. The above data is based only on verbal discussions with the plant personnel.

3.4 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 11: Overall specific energy consumption

Parameters		
Annual Grid Electricity Consumption	3,986,880	kWh
Annual DG Generation Unit	226,749	kWh
Annual Total Electricity Consumption	4,213,629	kWh
Diesel Consumption for Electricity Generation	90,384	Litres
Annual Thermal Energy Consumption (FO)	184,305	Litre
Annual Thermal Energy Consumption (LPG)	19,140	Kg

Annual Energy Consumption; MTOE	633	MTOE
Annual Energy Cost	420.53	Lakhs Rs.
Annual Production	4981	MT
SEC; electricity from grid	846	kWh/MT
SEC; Thermal	44	Litre/MT
SEC; Overall	0.127	MTOE/MT
SEC; Cost Based	8443	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 (kg oil equivalent) : 10,000 kCal
- GCV of Diesel : 11,840 kCal/ kg
- Density of HSD : 0.8263 kg/litre
- GCV of LPG : 10,950 kCal/kg
- Density of LPG : 0.557 kg/litre
- GCV of FO : 10,500 Kcal/kg
- Density of FO : 0.9337 kg/litre
- CO_2 Conversion factor
  - Grid : 0.89 kg/kWh
  - Diesel : 3.07 tons/ ton
  - FO : 3.1 tons/litre
  - LPG : 2.99 tons/kg

3.5 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 costs shown are the landed costs.

Table 12: Baseline parameters

Electricity Rate (Excluding Rs/kVA)	6.15	Rs./ KVAH inclusive of taxes
Weighted Average Electricity Cost	6.94	Rs./ kWh for 2012-13
Percentage of total DG based Generation	5%	
Average Cost of HSD	50	Rs./Litre for April 2015
Average Cost of FO	40	Rs./Litre for April 2015
Average Cost of LPG	50	Rs./kg for April 2015
Annual Operating Days per year	330	
Annual Operating Hours per day	24	
Production	4981	MT

3.6 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 for were developed. Summary of key observations is as follows:

3.6.1 Electricity supply from Grid

The electrical parameters at the main in-comer from PSPCL of the unit were recorded for24 hours using a portable power analyzer. Following are the graphs obtained by data from power analyzer:

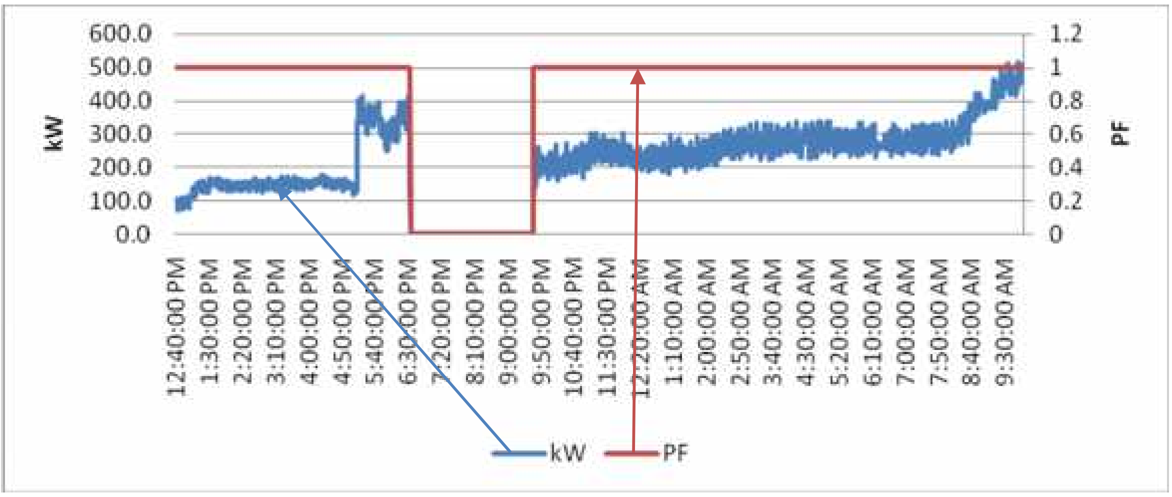


Figure 13: Power factor and load profile

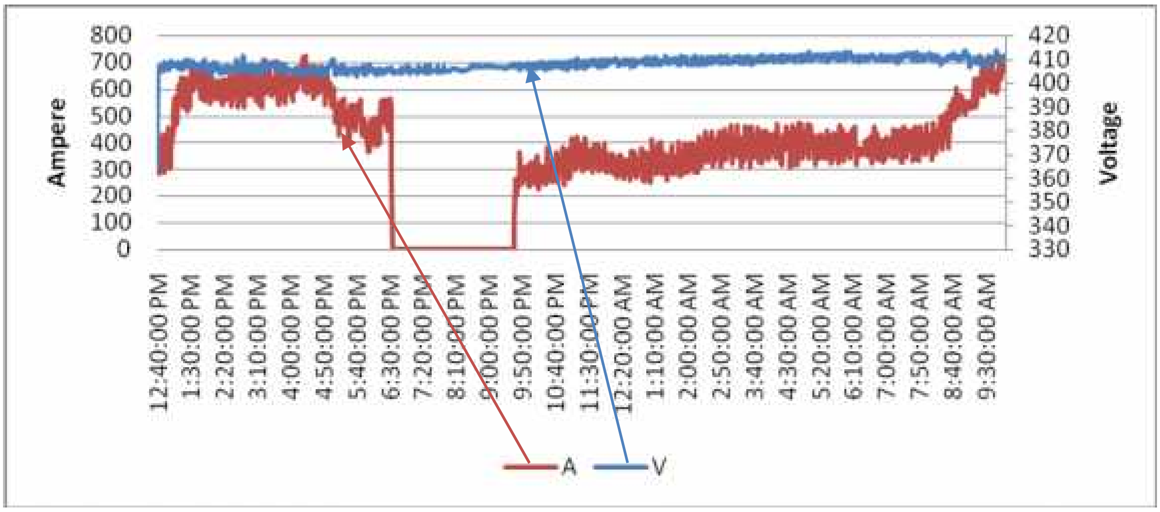


Figure 14: Current and voltage profile

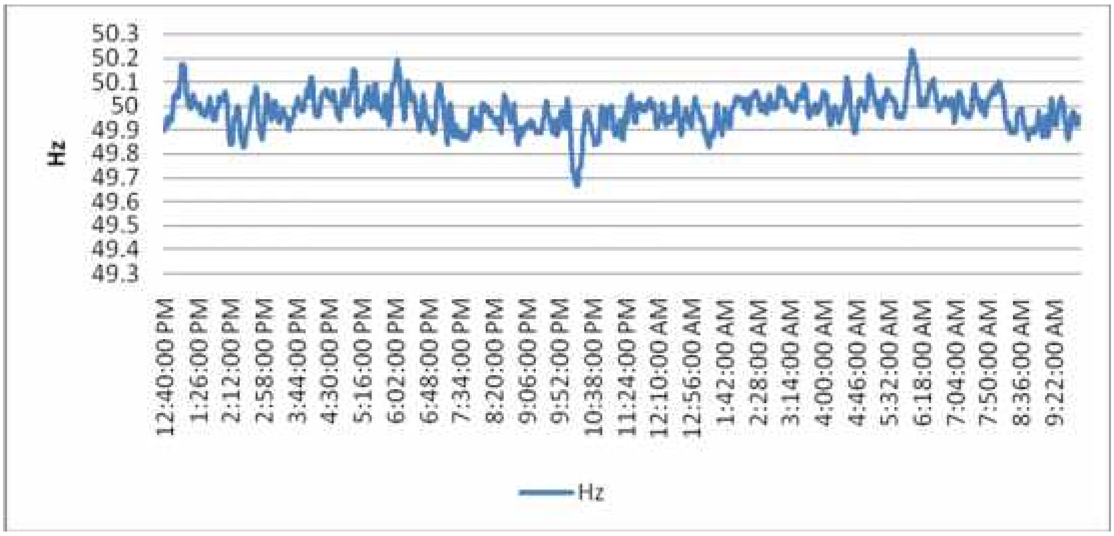


Figure 15: Harmonics profile

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	Power is supplied to this unit from PSPCL through 2 separate transformers. The unit has a HT connection. The contract demand of the unit is 1450 kVA and sanctioned load is 2342.565 kW.	The maximum kVA identified from the electricity bill was 1038 kVA which was less than the contract demand.	No EPIAs were suggested.
Power Factor	Unit has an HT connection and billing is in kVAh. The utility bills reflect the PF of the unit. The unit has an APFC panel installed to maintain high power factor.	The average PF found during the measurement was 0.992 and maximum was 1.	No EPIA's 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 put a separate lighting feeder and install a servo stabilizer for lighting and fan load to reduce the voltage from 409.2 V	Installation of servo stabilizer for lighting and fan load is recommended.

		(current voltage) to 390 V for the lighting load.	
Load Shifting	The unit has 2 transformers of rating 1000 kVA and 750 kVA. The percentage loading on the transformers were 70% and 32%.	If possible, to shift the load from 1000 kVA transformer to 750 kVA, then losses will reduce.	Increasing the loading of 750 kVA transformer from 32% to 50%.

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

3.6.2 DG Performance

The unit has 3 DGs set of 1000 kVA, 500 kVA and 320 kVA ratings. The unit does not have a system for monitoring the energy generation and fuel usage in 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 consumption (by measuring the top up to the diesel tank) and recording of kWh generated during the same period. The key performance indicators of the DG sets are evaluated and Specific Energy Consumption of 3 DG sets are as follows:

Table 14: Analysis of DG set

Particulars	Rated kVA	Specific Energy Generation (kWh/Litre)
DG – 1	1000	3.64
DG - 2	500	2.53
DG – 3	320	1.26

The observations made are as under:

- The SEGR of DG set 1 was good and that of DG set 2 was satisfactory.
- The SEGR of DG set 3 was low and it is recommended to be replaced with a new energy efficient DG set.

3.6.3 Electrical consumption areas

The section-wise consumption of electrical energy is indicated in Table 6. About 96.2% of the total energy consumption is for manufacturing operations and about 3.8% is in the utilities.

The details of the measurements conducted, observations made and 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>Forging</td><td>There are 5 blanking machines having capacities ranging from 11 kW to 22 kW. There are 6 hammer motors for forging ranging from 20 HP to 100 HP. Hammer constitutes 9.4% of total energy consumption.</td><td>Study was conducted on one blanking machine and hammer motor no. 3.

The results of the study are as below:
<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Blanking M/c</td><td>1.727</td><td>0.12</td></tr><tr><td>Hammer 3</td><td>27.64</td><td>0.75</td></tr></table></td><td>No EPIAs were suggested for blanking and hammer.</td></tr>
<tr><td>Broaching</td><td>There are 8 broaching machines having capacities ranging from 10 HP to 50 HP and study was conducted on 3 machines.</td><td>The results of the study are as below:
<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Broaching 3</td><td>7.6</td><td>0.40</td></tr><tr><td>Broaching 2</td><td>2.59</td><td>0.44</td></tr><tr><td>Broaching 1</td><td>1.64</td><td>0.53</td></tr></table></td><td>It is recommended to install VFD on broaching machine to reduce the power consumption during unloading time.</td></tr>
<tr><td>Air compressor</td><td>There are 4 air compressors and they account for about 5% of the total plant energy.</td><td>2 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 1</td><td>14.08</td><td>0.18</td></tr><tr><td>Compressor 2</td><td>14.08</td><td>0.17</td></tr></table></td><td>No EPIA's were suggested.</td></tr>
<tr><td>Heat treatment section</td><td>In heat treatment section, the study was conducted on</td><td>All heaters, blowers and conveyors were studied.

The results of the study are as below:</td><td>No EPIAs were suggested for its operation.</td></tr>
</table>

	both hardening and tempering furnaces, hardening heaters, tempering heaters, conveyor and blower motor.	

Machine	Avg. kW	Avg. PF
Hardening heater 1	41.65	0.44
Hardening heater 2	62.02	0.907
Tempering heater 1	26.8	0.99
Tempering heater 2	12.57	0.59
Tempering heater 3	15.3	0.99

3.6.4 Thermal consumption areas

As discussed in the earlier section, about Rs. 83.29 lakh of energy cost and 32% of the energy is used 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:

Name of Area	Present Set-up	Observations during field Study & measurements	Proposed Energy performance improvement actions
Forging furnace	The fuels used for heating in forging furnaces are FO (Furnace – 3, 5) and LPG (furnace – 1). The required air for fuel combustion is supplied by electrical driven blower (FD fan). The furnace insulation is poor.	There was no metering system available for measuring fuel consumption. The O_2 level in flue gas at exit of furnaces 1, 3 and 5 were measured to be above 10%. The temperature of furnace surface especially side walls was high.	Installation of flow meters is recommended. Installation of PID for excess air control is eing recommended. Reduction of skin losses by providing adequate insulation and refractory.

4 EE TECHNOLOGY OPTIONS AND TECHNO – ECONOMIC FEASIBILTY

During CEA of the plant, all energy consuming equipment and processes were studied. The analysis of all major energy consuming equipment 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; each of which are described below:

4.1 EPIA 1, 2 & 3: Excess air control in forging furnaces using PID

Technology description

It is necessary to maintain optimum excess air levels in combustion air supplied for proper combustion of the fuel. The excess air level in combustion air is 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 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 help in measuring the oxygen levels in the flue gases at the exit of the furnace. Based on that, the combustion air flow from FD fan (blower) can be regulated and 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 no excess air 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 flue gases of forging furnace 1 (LPG fired), forging furnace 3 (FO fired) and forging furnace 5 (FO fired) were 10.64%, 13.24% and 14.67% 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 15: Cost benefit analysis (EPIA 1) – Forging furnace-1

Production of material	Tph	0.09	
Parameters	**UOM**	**Present**	**Proposed**
Oxygen level in flue gas	%	10.64	2.00
Excess air level	%	102.76	10.53
Dry flue gas loss	%	2.43	
Specific fuel consumption	kg/t	62.93	57.13
Saving in specific fuel consumption	kg/h		0.53
Operating hrs of forging furnace	hr/y	3,300	3,300
Saving in fuel consumption per year	kg/y		1,765
Savings in fuel cost	Rs. lakh/y		0.88
Installed capacity of blower	kW	1.49	1.49
Running load of blower	kW	1.19	1.07
Operating hours	hr/y	3,300	3,300
Electrical energy consumed	kWh/y	3,933	3,540
Savings in terms of power consumption	kWh/y		393.36
Savings in terms of cost of electrical energy	Rs. lakh/y		0.03
Reduction in the burning loss inside the furnace	%		0.30
Total material saving	tpy		0.91
Cost of saved material	Rs. lakh/y		0.46
Monetary savings	Rs. lakh/y		1.37
Estimated investment	Rs. lakh		7.00
Simple payback	Years		5.12

Table 16: Cost benefit analysis (EPIA 2) – Forging furnace-3

Production of material	tph	0.09	
Parameters	**UOM**	**Present**	**Proposed**
Oxygen level in flue gas	%	13.24	4.00
Excess air control	%	170.62	23.53
Dry flue gas loss	%	17.67	
Specific fuel consumption	kg/t	79.80	68.07
Saving in specific fuel consumption	kg/h		1.10
Operating hrs of forging furnace	hr/y	3,300	3,300

Saving in fuel consumption per year	kg/y		3,626
Savings in fuel cost	Rs. lakh/y		1.55
Installed capacity of blower	kW	5.60	5.60
Running load of blower	kW	4.48	4.03
Operating hours	hr/y	3,300	3,300
Electrical energy consumed	kWh/y	14,784	13,306
Savings in terms of power consumption	kWh/y		1,478.40
Savings in terms of cost of electrical energy	Rs. lakh/y		0.10
Reduction in the burning loss inside the furnace	%		0.50
Total material savings	tpy		1.54
Cost of saved material	Rs. lakh/y		0.77
Monetary savings	Rs. lakh/y		2.43
Estimated investment	Rs. lakh		7.00
Simple payback	Years		2.88

Table 17: Cost benefit analysis (EPIA 3) – Forging furnace-5

Production of material	tph	0.44	
Parameters	**UOM**	**Present**	**Proposed**
Oxygen level in flue gas	%	14.67	4.00
Excess air control	%	231.83	23.53
Dry flue gas loss	%	15.46	
Specific fuel consumption	kg/t	40.04	31.70
Saving in specific fuel consumption	kg/h		3.70
Operating hrs of forging furnace	hr/y	3,300	3,300
Saving in fuel consumption per year	kg/y		12,194
Savings in fuel cost	Rs. lakh/y		5.22
Installed capacity of blower	kW	3.73	3.73
Running load of blower	kW	2.98	2.69
Operating hours	hr/y	3,300	3,300
Electrical energy consumed	kWh/y	9,847	8,862
Savings in terms of power consumption	kWh/y		984.72
Savings in terms of cost of electrical energy	Rs. lakh/y		0.07
Reduction in the burning loss inside the furnace	%		0.20
Total material savings	tpy		2.92
Cost of saved material	Rs. lakh/y		1.46
Monetary savings	Rs. lakh/y		6.75
Estimated investment	Rs. lakh		7.00
Simple payback	Years		1.04

4.2 EPIA 4: 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 higher current than required. The 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 machines 1, 2, 3 and 5 were drawing high current even during unloading.

Recommended action

It is recommended to install VFD on the broaching machines 1, 2, 3 and 5. This will ensure that the machine draws minimal current during unloading by sensing the load. The cost benefit analysis of energy conservation measure is given below:

Table 18: Cost benefit analysis (EPIA 4)

Sl. No.	VFD on broaching machine		Broaching M/c-1		Broaching M/c-2		Broaching M/c-3		Broaching M/c-5	
	Parameters	**Unit**	**As Is**	**To Be**	**As Is**	**To Be**	**As Is**	**To Be**	**As Is**	**To Be**
1	Installed capacity of motor	kW	7.5	7.5	15.0	15.0	37.5	37.5	22.5	22.5
2	Estimated energy savings by installing VFD on broaching machine	%		20.0		20.0		20.0		20.0
3	Average power consumption	kW	1.6	1	2.6	2	7.6	6	6.8	5
4	Percentage load	%	22.0	17.6	17.3	13.8	20.3	16.3	30.0	24.0
4	No of operating hours per day	hr	24	24	24	24	24	24	24	24
5	Operating days per Year	days	330	330	330	330	330	330	330	330
6	Savings in terms of power consumption	kWh	13,052	10,442	20,560	16,448	60,405	48,324	53,460	42,768
7	Annual electricity saving	kWh/y		2,610		4,112		12,081		10,692
8	Average weighted cost of electricity	Rs/kWh	6.94	6.94	6.94	6.94	6.94	6.94	6.94	6.94
9	Monetary savings	Rs. lakh		0.18		0.29		0.84		0.74
10	Estimated investment	Rs. lakh		0.4		0.8		0.9		0.7
11	Simple Payback	Years		2.1		2.8		1.0		0.9

4.3 EPIA 5: Replacement of old, inefficient (and several times re-wounded) motors with energy efficient motors

Technology description

Replacing old, inefficient (and several times re-wounded) existing motors of the plant with energy efficient motors will reduce power consumption of those motors by approximately 50%. Following motors have been identified for replacement with EE motors:

- Hammer cooling motor
- Hammer cooling tower fan motor
- Boiler feed water pump motor
- Cooling tower (cooling water pump) motor of HT furnace
- Water circulating submersible pump
- HT furnace outlet to cooling tower
- HT furnace polymer shift
- HT furnace cooling water pump
- Cooling tower pump for HT furnace
- HT furnace cooling pump

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 many motors which are re-wounded several times and are having efficiency below 60%.

Recommended action

It is recommended to replace the existing 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 19: Cost benefit analysis (EPIA 5)

Parameters	UOM	Hammer Cooling		Hammer C/T		Boiler		C/T HT Furnace		Water Circulating		C/T HT furnace outlet		HT Furnace Polymer shift		Induction furnace Cooling		Cooling Tower		HT furnace cooling pump	
Rated Power	kW	3.73	3.73	3.73	3.73	3.73	3.73	7.50	7.5	5.50	5.5	2.20	2.2	3.73	3.73	5.50	5.5	3.73	3.73	2.20	2.2
Efficiency of motor	%	45%	90%	58%	90%	58%	90%	58%	90%	58%	90%	40%	90%	59%	90%	47%	90%	59%	90%	40%	90%
Average Load	kW	2.61	1.31	2.6	1.68	2.6	1.68	5.2	3.38	3.85	2.48	1.54	0.68	2.61	1.71	3.85	2.01	2.6	1.71	1.54	0.68
Net Power Savings	kW		1.31		0.93		0.93		1.87		1.37		0.86		0.90		1.84		0.90		0.86
Running Hours	hr/y		7,344		7,344		7,344		7,344		7,344		7,344		7,344		7,344		7,344		7,344
Annual Energy Savings	kWh/y		9,588		6,818		6,818		13,709		10,053		6,283		6,605		13,509		6,605		6,283
Avgearge weighted cost of electricity	Rs./kWh		6.94		6.94		6.94		6.94		6.94		6.94		6.94		6.94		6.94		6.94
Investment	Rs. lakh		0.23		0.23		0.23		0.37		0.32		0.18		0.23		0.32		0.23		0.18
Monetary Savings	Rs. lakh		0.67		0.47		0.47		0.95		0.70		0.44		0.46		0.94		0.46		0.44
Simple Payback	Years		0.35		0.49		0.49		0.39		0.46		0.41		0.50		0.34		0.50		0.41

4.4 EPIA 6: Replacement of DG set-3 with new energy efficient DG set

Technology description

Replacement of DG set -3 with a new energy efficient DG set will help in increasing its Specific Fuel Consumption, i.e. units of electricity generated from 1 litre of diesel. Normally, the standard SFC given for a new DG is 3.5 kWh / litre.

Study and investigation

The SFC of 320 kVA DG set - 3 was 1.26 kWh / litre which was low as per standards.

Recommended action

Replacing the 320 kVA DG set with a new energy efficient DG set having SEC of 3.5 kWh / litre. The cost benefit analysis for the same is given in table below:

Table 20: Cost benefit analysis (EPIA 6)

Parameters	UOM	DG Replacement	
Rated kVA	kVA	320.00	320
Operating Hours	hr	340	340
No of Units generated	kWh/y	22,427	22,427
Diesel Consumed	litres	22,427	6,408
Specific Energy Consumption	kWh/litre	1.00	3.50
Annual Diesel savings	litre/y		16,019
Diesel Cost	Rs.		50
Investment	Rs. lakh		16.72
Monetary Savings	Rs. lakhs		8.01
Simple Payback	Years		2.09

4.5 EPIA 7: Replacing conventional ceiling fans with energy efficient fans

Technology description

Replacing old conventional ceiling fans installed at 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 arecontrolled by electronic drives which on speed reduction automatically sense the rpm and reduce power consumption.

Study and investigation

The unit is having about 104 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 21: Cost benefit analysis (EPIA 7)

Data & Assumptions	UOM	Ordinary fan	Super fan
Number of fans in the facility	Nos.	104	104
Run hours per day	hr/day	18	18
Power consumption at maximum speed	Watts	70	35
Number of working days/year	days	300	300
Avg. weighted cost of electricity	Rs./kWh	6.94	6.94
Fan unit price	Rs./pc	1,500	3,000
Electricity consumption			
Electricity demand	kW	7.28	3.64
Power consumption by fans in a year	kWh/y	39,312	19,656
Savings in terms of power consumption	kWh/y		19,656
Savings in terms of cost	Rs. lakh/y		1.36
Estimated investment	Rs. lakh/y		3.12
Payback period	Years		2.29

4.6 EPIA 8 & 9: Replacing present lighting fixtures with Energy Efficient lighting fixture

Technology description

Replacing conventional lights like T-12s, T-8s, and 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 102 nos. T-12 tube lights, 69 nos. 45 W CFLs, 37 nos. 23 W CFLs, 22 nos. 250 W mercury vapour (MV) lamps.

Recommended action

It is recommended to replace the above mentioned light 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 22: Cost benefit analysis (EPIA 8)

Particulars	Unit	Existing	Proposed
Power consumed	W	40	16
Power consumed	W	12	0
Total power consumption	W	52	16
Operating hours/day	hr	24	24
Annual days of operation	day	304	304
Energy Used per year/fixture	kWh	379	117
Avg. weighted cost of electricity	Rs./kWh	6.94	6.94
No. of Fixtures	Nos.	103	103
Power consumption per year	kWh/y	39,077	12,024
Operating cost per year	Rs. lakh/y	2.71	0.83
Saving in terms of electrical energy	kWh/y		27,054
Savings in terms of cost	Rs. lakh/y		1.88
Investment per fixture of LED	Rs.		2,000
Estimated Investment	Rs. lakh		1.72
Payback period	Years		0.92

Table 23: Cost benefit analysis (EPIA 9)

Particulars	Unit	Existing	Proposed	Existing	Proposed	Existing	Proposed
Fixture	**UOM**	**45 W CFL**	**18 Watt LED Square Round Panel**	**23 W CFL**	**10 Watt LED Star Bulb**	**250 W MV lamp**	**80 Watt LED Bay light**
Power consumed	W	45	18	23	10	250	80
Power consumed	W	10	0	7	0	40	0
Total power consumption	W	55	18	23	10	290	80
Operating hours/day	Hr	24	24	24	24	24	24
Annual days of operation	Day	304	304	304	304	304	304
Energy Used per year/fixture	kWh	401	131	168	73	2,116	584

Average weighted cost of electricity	Rs/kWh	6.94	6.94	6.94	6.94	6.94	6.94
No. of Fixtures	Unit	69	69	37	37	22	22
Power consumption per year	kWh/Year	27688	9062	6209	2700	46548	12841
Operating cost per year	Rs. lakh/Year	1.92	0.63	0.43	0.19	3.23	0.89
Savings in terms of power consumption	kWh/Year		18627		3509		33708
Monetary savings	Rs. lakh/Year		1.29		0.24		2.34
Investment per fixture of LED	Rs. lakh		0.02		0.01		0.12
Investment of project	Rs. lakh		1.2075		0.296		2.706
Payback period	Years		0.93		1.22		1.16

4.7 EPIA 10: 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 monitoring energy consumption. It was also noticed that there were no proper fuel monitoring system 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 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 reducing energy consumption by approximately 3% from its present levels. The cost benefit analysis for this project is given below:

Table 24: Cost benefit analysis (EPIA 10)

Parameters	Unit	As Is	To Be
Energy monitoring savings (Electrical sections)	%		3.00
Energy consumption of major machines per year	kWh/y	3,986,880	3,867,274
Savings in terms of power consumption	kWh/y		119,606
Weighted Average cost	Rs./kWh		6.94
Annual monetary savings	Rs. lakh/y		8.30
Estimate of Investment	Rs. lakh		0.35
Simple Payback	Years		0.04
Energy monitoring savings (furnace fuel)	%		3.00
Current fuel consumption	kg/y	172,086	166,923
Annual fuel savings per year	kg/y		5,163
Unit Cost of fuel	Rs./kg		40.00
Monetary savings	Rs. Lakh / year		2.07
Estimate of Investment	Rs. lakh		0.20
Simple Payback	Years		0.10
Energy monitoring saving (DG fuel)	%		3.00
Current fuel consumption	litres/y	90,384	87,672
Annual fuel saving per year	litres/y		2,712
Diesel cost per unit	Rs./litre		50
Monetary savings	Rs. lakh		1.36
Investment for the DG fuel consumption meter	Rs. lakh		0.20
Simple Payback	Years		0.15

4.8 EPIA 11: 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 on areas of openings or in case of infiltration of cold air in a 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 50-60℃ to minimize 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 (the transfer of thermal energy between objects of differing temperature) between objects in thermal contact or in range of radiative influence.

Furnace walls 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 temperature of the side walls of forging furnace-1, forging furnace-2 and forging furnace-5 were 95.51℃, 85.69℃ and 124.31℃ respectively. It was seen that the high temperature on furnace walls was due to poor insulation and the temperature should be in the range of 50℃ which was 10℃ above ambient conditions.

Recommended action

Recommended surface temperature of the furnace has to be brought to within 50℃ to reduce the heat loss through radiation and convection.

Table 25: Losses calculation

	Forging furnace-1	Forging furnace-3	Forging furnace-5	
Natural convection heat transfer rate from sidewall surfaces	2.2	2.2	2.2	*Kcal/m2degC*
External temp. of side walls	369	359	397	*deg K*
Sidewall surface area	10.72	7.37	8.47	*m2*
Room temperature	317	317	317	*deg K*
Recommended temperature	323	323	323	*deg K*
Loss at current situation	5,462	2,897	7,567	*kcal/hr*
Loss after insulation	444	306	351	*kcal/hr*
Temperature at current condition	96	86	124	*deg K*
Operating hours	3,300	3,300	3,300	*hrs/year*

The cost benefit analysis for the EPIA is given in the table:

Table 26: Cost benefit analysis (EPIA 11)

		Forging-1		Forging-3		Forging-5	
Parameters	UOM	Present	Proposed	Present	Proposed	Present	Proposed
Temperature of side walls	Deg C	95.51	50	85.69	50	124.31	50
Temperature of side walls	K	368.51	323	358.69	323	397.31	323
Total wall area	m^2	10.72	10.72	7.38	7.38	8.47	8.47

Heat loss from surface	kcal/h	5,462	444	2,897	306	7,567	351
Reduction in heat loss	kcal/h		5,018		2,592		7,216
Savings in fuel	kg/h		0.46		0.24		0.66
Operating hours of furnace	hr/y	3,300	3,300	3,300	3,300	3,300	3,300
Savings in fuel per year	kg/y		1,519		785		2,185
Monetary savings	Rs. lakh		0.65		0.34		0.94
Estimated investment	Rs. lakh		0.16		0.11		0.13
Simple payback period	Years		0.25		0.33		0.14

4.9 EPIA 12: Transformer load shifting

Technology description

Distribution transformers work at their maximum efficiency when their loading is at 50%. At maximum efficiency, the iron losses will be equal to copper losses. So, if two or more transformers are in operation, to achieve a better performance, it is always better to operate the transformers close to 50% loading so that their operating efficiency will be maximum and losses will be minimum. This can be achieved by shifting loads from one transformer to the other.

Study and investigation

Presently, the unit has 2 transformers of 1000 kVA and 750 kVA rating. The percentage loading on the transformers were 70% and 32% respectively.

Recommended action

Shifting of load from 1,000 kVA transformer to 750 kVA transformer.

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

Table 27: Cost benefit analysis (EPIA 12)

Data	UOM	Present	Proposed
Rated capacity of transformer	kVA	750	750
Voltage of transformer	V	409	409
Current of transformer	A	336	917
Running capacity of transformer	kVA	242	375
Loading percentage of transformer	%	32.28	50
Efficiency of transformer	%	97.75	98.64
Losses in transformer	%	2.25	1.36

Power factor of transformer		1.00	1.00
Loading on transformer	kW	242	375
Losses in transformer	kW	5.45	5.1
Saving in losses	kW		0.35
Operating hrs of transformer	hr/y		7,920
Savings in terms of power consumption	kWh/y		2,744
Monetary savings	Rs. lakh		0.19
Estimated investment	Rs.		10,000
Payback period	Years		0.53

4.10 EPIA 13: Installation of servo stabilizer with separate feeder for lighting and fan load

Technology description

Normally, single phase loads such as lighting and fan loads require only 390 V instead of 415 V. A separate lighting feeder with reduced voltage can serve the purpose.

Study and investigation

Currently, the single phase loads are operating at 409.2 V and there is no separate feeder for lighting loads.

Recommended action

Reduction of voltage from 409.2 V to 390 V for lighting and fan loads and installation of separate feeder for lighting loads.

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

Table 28: Cost benefit analysis (EPIA 13)

Parameter	Unit	As Is	To Be
Load considered for voltage reduction (Light + Fan)	kW	39.89	39.89
Load considered for voltage reduction (Light + Fan)	KVA	40.24	40.24
Average Voltage	V	409.2	390.0
% reduction In voltage	%		4.7%
% reduction in Energy consumption	%		9.15%
Average Power Factor of System	EB Bill	0.99	0.99
Operating Hours in a year	hr		3,672
Energy Consumption before Voltage Regulation	kWh/y		146,480
Energy Consumption after Voltage Regulation	kWh/y		133,078
Efficiency of Servo Stabilizer	%		95%
Net Savings from Voltage Regulation	kWh/y		12,732

Savings in kVAh	kVAh/y		12,845
Average weighted cost of electricity	Rs./kVAh	6.94	6.94
Monetary Savings	Rs. lakh		0.89
Sizing of Servo Stabilizer	kVA		42.36
Estimated investment	Rs. lakh		0.8
Payback	Years		0.90

4.11 EPIA 14: Replacement of conventional (desert) cooler fan with energy efficient fan

Technology description

Installation of new industrial fans of 380 W instead of large capacity rated desert (man) cooler fans, which can serve with the same speed and flow as compared to the existing fans.

Study and investigation

Presently, the plant is having 10 man cooler fans of capacity 1.49 kW and 2 fans of capacity 2.02 kW.

Recommended action

It is recommended to replace the existing fans with 380 W industrial fans.

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

Table 29: Cost benefit analysis (EPIA 14)

Parameters	UOM	Man Cooler - Power reduction		Man Cooler - Power reduction	
		AS IS	TO BE	AS IS	TO BE
Rated Power	kW	1.49	0.38	2.24	0.38
Average Load	kW	1.34	0.34	2.02	0.34
Net Power Savings	kW		1.00		1.67
Nos. of fans			10		2
Running Hours	hr/y		7,344		7,344
Annual Energy Savings	kWh/y		73,367		24,588
Avgerage weighted cost of electricity	Rs./kWh		6.94		6.94
Investment per fan	Rs. lakh		0.05		0.05
Investment for project	Rs. lakh		0.50		0.10
Monetary Savings	Rs. lakh		5.09		1.71
Simple Payback	Years		0.01		0.03

4.12 EPIA 15: 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 30: Furnace specifications for the EE burners

Parameters	UoM	Forging furnace-1	Forging furnace-3	Forging furnace-5
Fuel Firing rate	Litres/hr	62.7	81.7	386.8
Production	kg/hr	92.16	93.6	443.1
Area of the furnace	m2	2.7	1.8	2.7

Recommended action

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

Table 31 Cost benefit analysis (EPIA 15)

		Forging furnace-1		Forging furnace-3		Forging furnace-5	
Parameters	Unit	As Is	To Be	As Is	To Be	As Is	To Be
Production rate of the forging furnace	kg/hr	92	92	94	94	443	443
Total numbers of burners	Nos.	1.0	1.0	1.0	1.0	1.0	1.0
Total numbers of energy efficient burner required	Nos.	1.0	1.0	1.0	1.0	1.0	1.0
Estimated saving by energy efficient burner	%		5.0		5.0		5.0
Current fuel firing in forging furnace	kg/hr	6	6	7	7	18	17
Savings in fuel per hours	kg/hr		0.29		0.37		0.89
Number of operating days	days	330	330	330	330	330	330
Number of operating hours per day	hrs	10	10	10	10	10	10
Total savings per year into fuel firing	kg/yr		957		1232		2927

Unit cost of fuel	Rs./kg	42.84	42.84	42.84
Cost savings per year	Rs. lakh/yr	0.41	0.53	1.25
Estimated investment for all burners	Rs. lakh	0.2	0.2	0.2
Payback period	Yr	0.6	0.5	0.2

4.13 EPIA 16: 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. This will result in reduction in fuel consumption.

The proposed project envisages reducing 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 liters/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 32: Cost benefit analysis (EPIA 15)

Parameters	UoM	AS IS	To Be
Process Water Required Per Day	Lt	100	100
Inlet Water Temp	Deg C	70	70
Temperature required	oC	90	90
Initial Change in Enthalpy for water	kCal	2000	2000
Fuel required	kCal/day	1174007	1174007
Energy supplied by SWH	kCal/day	-	731200
Present Fuel consumption: EH	Litres/day	120	45
No of Working Days	Day/year	300	300

Cost of Energy	Rs./litre	53.0	53.0
Savings in fuel consumption	litre/year		22,422
Monetary savings	Rs. lakh/y		11.88
Investment required	Rs. Lakhs		61.50
Payback Period	years		5.2

5 ANNEXURE

Furnace 1 efficiency calculations

Input parameters

Input Data Sheet		
Type of Fuel		**LPG**
Source of fuel	**Local vendor**	
	Value	**Units**
Furnace Operating temperature (Heating Zone)	817	*deg C*
Final temperature of material (at outlet of Heating zone)	759	*deg C*
Initial temperature of material	44	*deg C*
Average fuel Consumption	5.8	*kg/hr*
Flue Gas Details		
Flue gas temperature after	88	*deg C*
Preheated air temperature	44	*deg C*
O2 in flue gas	10.6	*%*
CO2 in flue gas	7.27	*%*
CO in flue gas	5,099.2	*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	*65.00*	**%**
H	*11.00*	**%**
N	*0.72*	**%**
O	*1.00*	**%**
S	*0.10*	**%**
Moisture	*0.00*	**%**
Ash	*0.00*	**%**
Weighted Average GCV of Fuel-mix	*10,950*	kcal/kg
Ash Analysis		
Unburnt in bottom ash	*0.00*	%
Unburnt in fly ash	*0.00*	%
GCV of bottom ash	*0*	kCal/kg
GCV of fly ash	*0*	kCal/kg
Material and flue gas data		
Weight of material (Raw material) being heated in furnace	92	*Kg/hr*
Weight of Stock	92	*kg/hr*
Specific heat of material	0.12	*kCal/kg deg C*
Average specific heat of fuel	0.56	*kCal/kg deg C*

fuel temperature	44	*deg C*
Specific heat of flue gas	0.26	*kCal/kg deg C*
Specific heat of superheated vapor	0.45	*kCal/kg deg C*
Heat loss from surfaces of various zone		
For Ceiling		
Natural convection heat transfer rate from ceiling	2.8	*kCal/m2 deg C*
External temperature of ceiling	347	*deg K*
Room Temperature	317	*deg K*
Ceiling surface area	4.18	*m2*
Emissivity of furnace body surface	0.75	
For side walls		
Natural convection heat transfer rate from sidewall surfaces	2.2	*kCal/m2 deg C*
External temperature of side walls	369	*deg K*
Sidewall surface area	10.72	*m2*
For Hearth		
Natural convection heat transfer rate from flue gas duct surfaces	1.5	*kCal/m2 deg C*
External temperature of side walls	345.3	*deg K*
External surface area	2.66	*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	0.56	*m2*
Coefficient based on profile of furnace opening	0.7	
Maximum temperature of air at furnace door	418	*deg K*

Efficiency calculations

Calculations	Values	Unit
Theoretical Air Required	11.33	kg/kg of fuel
Excess Air supplied	102.76	%
Actual Mass of Supplied Air	22.97	kg/kg of fuel
Mass of dry flue gas	22.76	kg/kg of fuel
Amount of Wet flue gas	23.97	Kg of flue gas/kg of fuel
Amount of water vapour in flue gas	0.99	Kg of H2O/kg of fuel
Amount of dry flue gas	22.98	kg/kg of fuel
Specific Fuel consumption	62.93	kg of fuel/ton of material
Heat Input Calculations		
Combustion heat of fuel	689,128	Kcal/ton of material
Sensible heat of fuel	-	Kcal/ton of material

Total heat input	689,128	Kcal/ton of material
Heat Output Calculation		
Heat carried away by 1 ton of material (useful heat)	92,766	Kcal/ton of material
Heat loss in dry flue gas per ton of material	16,733	Kcal/ton of material
Loss due to H2 in fuel	37,634	Kcal/ton of material
Loss due to moisture in combustion air	14	Kcal/ton of material
Loss due to partial conversion of C to CO	15,157	Kcal/ton of material
Loss due to convection and radiation (openings in furnace - inlet & outlet door of furnace)	4,246	Kcal/ton of material
Loss Due to Evaporation of Moisture Present in Fuel	-	Kcal/ton of material
Total heat loss from furnace body	80,782	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	441,797	Kcal/ton of material
Heat loss from furnace body and ceilings		
Heat loss from furnace body ceiling surface	1495	Kcal/hr
Heat loss from furnace body side walls surfaces	5462	Kcal/hr
Heat loss from hearth	488	Kcal/hr
Total heat loss from furnace body	80782	Kcal/tons
Furnace Efficiency	**13.46**	**%**

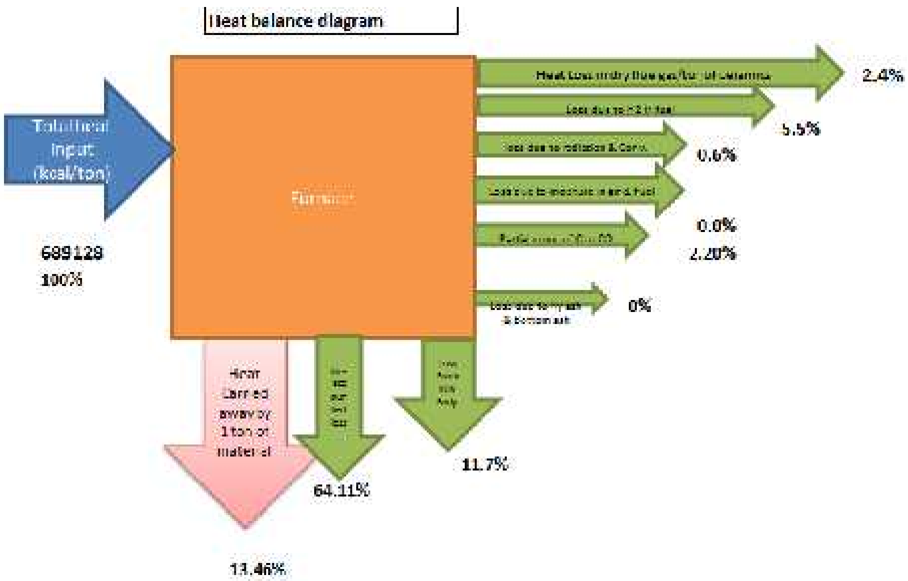


Figure 16: Sankey diagram of forging furnace-1

Furnace 3 efficiency calculations

Input Data Sheet		
Type of Fuel		Furnace Oil
Source of fuel	Local vendor	
	Value	Units
Furnace Operating temperature (Heating Zone)	1,078	*deg C*
Final temperature of material (at outlet of Heating zone)	1,024	*deg C*
Initial temperature of material	44	*deg C*
Average fuel Consumption	7.5	*kg/hr*
Flue Gas Details		
Flue gas temperature after APH	233	*deg C*
Preheated air temp erature	150	*deg C*
O2 in flue gas	13.24	*%*
CO2 in flue gas	5.9	*%*
CO in flue gas	27.7	*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-mix	*10,500*	kCal/kg
Ash Analysis		
Unburnt in bottom ash	*0.00*	%
Unburnt in fly ash	*0.00*	%
GCV of bottom ash	*0*	kCal/kg
GCV of fly ash	*0*	kCal/kg
Material and flue gas data		
Weight of material (Raw material) being heated in furnace	94	*kg/hr*
Weight of Stock	94	*kg/hr*
Specific heat of material	0.12	*Kcal/kg deg C*
Avg. specific heat of fuel	0.417	*kCal/kg deg C*
fuel temperature	70	*deg C*
Specific heat of flue gas	0.26	*kCal/kg deg C*

Specific heat of superheated vapor	0.45	*kCal/kg deg C*
Heat loss from surfaces of various zone		
For Ceiling		
Natural convection heat transfer rate from ceiling	2.8	*kCal/m2 deg C*
External temp. of ceiling	375	*deg K*
Room Temperature	317	*deg K*
Ceiling surface area	2.93	*m2*
Emissivity of furnace body surface	0.75	
For side walls		
Natural convection heat transfer rate from sidewall surfaces	2.2	*kCal/m2 deg C*
External temperature of side walls	359	*deg K*
Sidewall surface area	7.3785	*m2*
For Hearth		
Natural convection heat transfer rate from flue gas duct surfaces	1.5	*kCal/m2 deg C*
External temperature of side walls	345.3	*deg K*
External surface area	1.7854	*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	0.56	*m2*
Coefficient based on profile of furnace opening	0.7	
Maximum temperature of air at furnace door	428	*deg K*

Efficiency calculations

Calculations	Values	Unit
Theoretical Air Required	14.01	*kg/kg of fuel*
Excess Air supplied	170.62	*%*
Actual Mass of Supplied Air	37.91	*kg/kg of fuel*
Mass of dry flue gas	37.82	*kg/kg of fuel*
Amount of Wet flue gas	38.91	*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	37.83	*kg/kg of fuel*
Specific Fuel consumption	79.80	*kg of fuel/ton of material*
Heat Input Calculations		
Combustion heat of fuel	837,936	*Kcal/ton of material*
Sensible heat of fuel	872	*Kcal/ton of material*
Total heat input	838,808	*kCal/ton of material*
Heat Output Calculation		
Heat carried away by 1 ton of material (useful heat)	124,054	*kCal/ton of material*
Heat loss in dry flue gas per ton of material	148,228	*kCal/ton of material*

Loss due to H2 in fuel	57,659	*kCal/ton of material*
Loss due to moisture in combustion air	97	*kCal/ton of material*
Loss due to partial conversion of C to CO	178	*kCal/ton of material*
Loss due to convection and radiation (openings in furnace - inlet & outlet door of furnace)	4,029	*kCal/ton of material*
Loss Due to Evaporation of Moisture Present in Fuel	-	*kCal/ton of material*
Total heat loss from furnace body	59,802	*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	444,761	*kCal/ton of material*
Heat loss from furnace body and ceilings		
Heat loss from furnace body ceiling surface	2,373	*kCal/hr*
Heat loss from furnace body side walls surfaces	2,897	*kCal/hr*
Heat loss from hearth	327	*kCal/hr*
Total heat loss from furnace body	59,802	*kCal/tons*
Furnace Efficiency	**14.80**	*%*

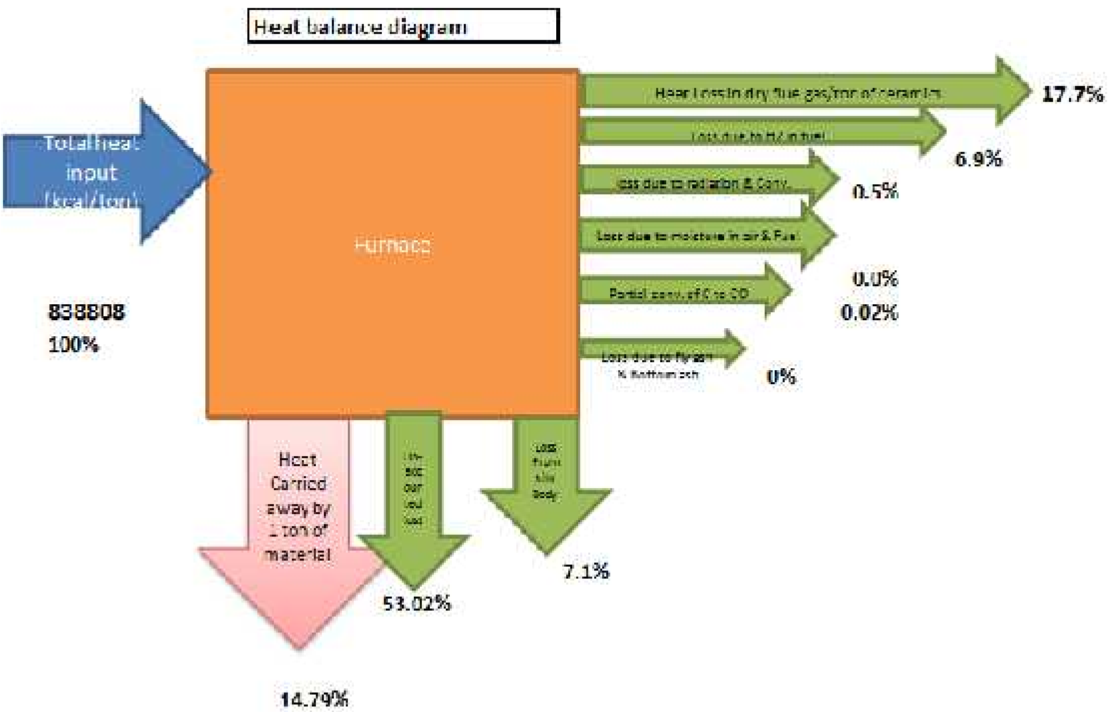


Figure 17: Sankey diagram of forging furnace-3

Furnace 5 efficiency calculations

Input Data Sheet		
Type of Fuel		Furnace Oil
Source of fuel	Local vendor	
	Value	**Units**
Furnace Operating temperature (Heating Zone)	1,191	*deg C*
Final temperature of material (at outlet of Heating zone)	1,090	*deg C*
Initial temperature of material	44	*deg C*
Average fuel Consumption	17.7	*kg/hr*
Flue Gas Details		
Flue gas temperature after APH	179	*deg C*
Preheated air temp erature	160	*deg C*
O2 in flue gas	15	*%*
CO2 in flue gas	4.7	*%*
CO in flue gas	21.1	*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-mix	*10,500*	kcal/kg
Ash Analysis		
Unburnt in bottom ash	*0.00*	%
Unburnt in fly ash	*0.00*	%
GCV of bottom ash	*0*	kCal/kg
GCV of fly ash	*0*	kCal/kg
Material and flue gas data		
Weight of material (Raw material) being heated in furnace	433	*kg/hr*
Weight of Stock	433	*kg/hr*
Specific heat of material	0.12	*kCal/kg deg C*
Average specific heat of fuel	0.417	*kCal/kg deg C*
fuel temperature	70	*deg C*
Specific heat of flue gas	0.26	*kCal/kg deg C*
Specific heat of superheated vapor	0.45	*kCal/kg deg C*

Heat loss from surfaces of various zone		
For Ceiling		
Natural convection heat transfer rate from ceiling	2.8	*kCal/m2 deg C*
External temperature of ceiling	367	*deg K*
Room Temperature	317	*deg K*
Ceiling surface area	3.10	*m2*
Emissivity of furnace body surface	0.75	
For side walls		
Natural convection heat transfer rate from sidewall surfaces	2.2	*kCal/m2 deg C*
External temperature of side walls	397	*deg K*
Sidewall surface area	8.4746	*m2*
For Hearth		
Natural convection heat transfer rate from flue gas duct surfaces	1.5	*kCal/m2 deg C*
External temperature of side walls	357	*deg K*
External surface area	2.7007	*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	0.56	*m2*
Coefficient based on profile of furnace opening	0.7	
Maximum temperature of air at furnace door	413	*deg K*

Efficiency calculations

Calculations	Values	Unit
Theoretical Air Required	14.01	*kg/kg of fuel*
Excess Air supplied	231.83	*%*
Actual Mass of Supplied Air	46.48	*kg/kg of fuel*
Mass of dry flue gas	46.40	*kg/kg of fuel*
Amount of Wet flue gas	47.48	*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	46.40	*kg/kg of fuel*
Specific Fuel consumption	40.04	*kg of fuel/ton of material*
Heat Input Calculations		
Combustion heat of fuel	420,386	*kCal/ton of material*
Sensible heat of fuel	438	*kCal/ton of material*
Total heat input	420,824	*kCal/ton of material*
Heat Output Calculation		
Heat carried away by 1 ton of material (useful heat)	137,706	*kCal/ton of material*

Heat loss in dry flue gas per ton of material	65,066	*kCal/ton of material*
Loss due to H2 in fuel	27,873	*kCal/ton of material*
Loss due to moisture in combustion air	85	*kCal/ton of material*
Loss due to partial conversion of C to CO	86	*kCal/ton of material*
Loss due to convection and radiation (openings in furnace - inlet & outlet door of furnace)	658	*kCal/ton of material*
Loss Due to Evaporation of Moisture Present in Fuel	-	*kCal/ton of material*
Total heat loss from furnace body	23,364	*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	165,985	*kCal/ton of material*
Heat loss from furnace body and ceilings		
Heat loss from furnace body ceiling surface	2,059	*kCal/hr*
Heat loss from furnace body side walls surfaces	7,567	*kCal/hr*
Heat loss from hearth	727	*kCal/hr*
Total heat loss from furnace body	23364	*kCal/tons*
Furnace Efficiency	**32.76**	*%*

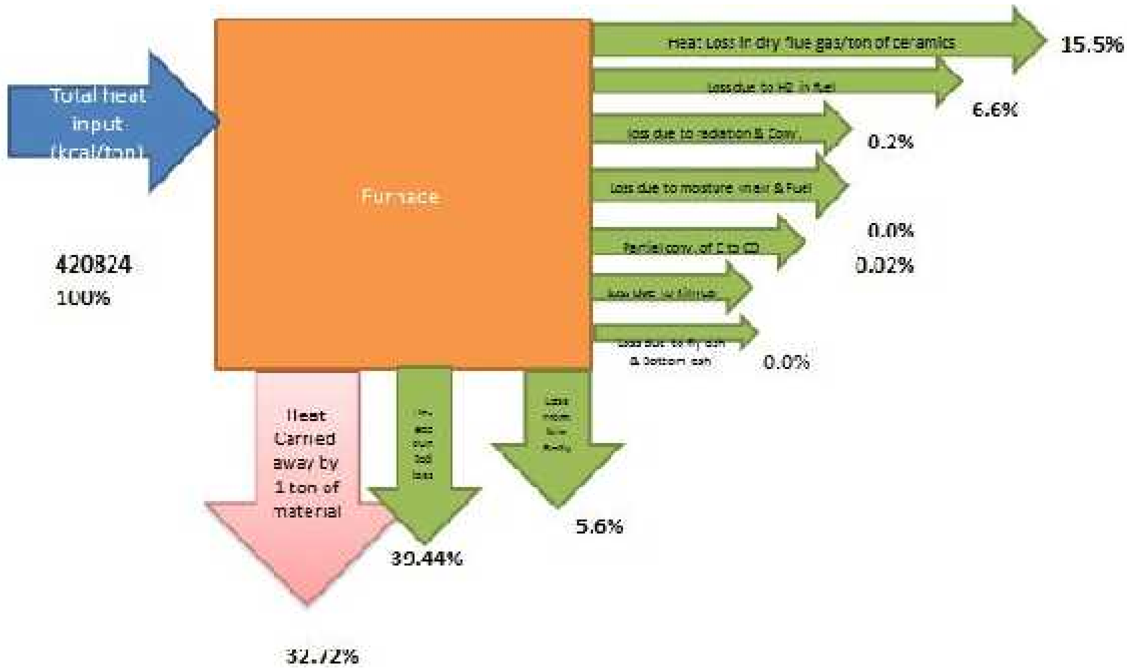


Figure 18: Sankey diagram of forging furnace-5

6 LIST OF VENDORS

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

EPIA 1, 2 & 3: 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 4: VFD on broaching machines

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 5: 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 6: DG Replacement

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

Sl. No.	Name of Company	Address	Phone No.	E-mail / Website
1	Mahindra Powerol Engines & DG set Contact Person: Mr.Pankaj Katiyar Marketing	Jeevan Tara Building,5,Parliament street,delhi-1	Mobile: +91-9818494230	katiyar.pankaj@mahindra.com
2	Cummins Power Generation Contact Person: Rishi Gulati Senior Manager-Power Electronics	Cummins India Limited Power Generation Business Unit 35/A/1/2, Erandawana, Pune 411 038, India	Phone: (91) 020-3024 8600 , +91 124 3910908 Mobile: +91 9350191881	cpgindia@cummins.com rishi.s.gulati@cummins.com
3	BNE Company Contact Person: Mr Bhavneet Singh, Marketing	7B, Kiran Shankar Roy Road, 3rd Floor, Kolkata 700 001	Mobile : +91- 9831048994	bnecompany@gmail.com, bne_company@yahoo.com

EPIA 7 & 13: 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 8 & 9: 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 10: Energy Monitoring System

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
Automation				
1	Iadept Marketing Contact Person:	S- 7, 2nd Floor, Manish Global Mall, Sector 22 Dwarka, Shahabad	Tel.: 011-65151223	iadept@vsnl.net ,info@iadeptmarketing.com

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
	Mr. Brijesh Kumar Director	Mohammadpur, New Delhi, DL 110075		
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 11: 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 Mr. Rajneesh Phone : 0161-	Email: kk.mitra@lloydinsulation.com

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

EPIA 13: Installation of servo-stabilizer with separate feeder of lighting and fan load

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Servostar Contact Person: Mr. Salman Khan	40, Shakarpur Khas, Near Modern Happy School,Delhi	Salman-9811273753, 9350033639), 011- 22460453, 22040519 , Fax No-011-22459653	sales@servostar.in jeewangarg@servostar.in salman@servostar.in
2	Jindal Electricals Contact Person: Mr. Rahul Kumar Shrivasatava	41, Shakarpur Khas, (Near Modern Happy School) Delhi – 92 (India)	9910993167(Mr.Rahul), (011) 22460453, 9350809090	Email: delhi@jindalrectifiers.com

EPIA 15: Installation of EE Burners

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
Automation				
1	ENCON Thermal Engineers (P) Ltd Contact Person: Mr V B Mahendra, Managing Director Mr. Puneet Mahendra, Director	297, Sector-21 B Faridabad – 121001 Haryana	Tel.: +91 129 4041185 Fax: +91 129 4044355 Mobile: +919810063702 +919971499079	sales@encon.co.in kk@encon.co.in www.encon.co.in

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
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 16: Installation of Solar heat pipes 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