COMPREHENSIVE ENERGY AUDIT REPORT

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

Gurukrupa Ceramics

Navagam, Thangadh-363530, Gujarat, India

Submitted to

BUREAU OF ENERGY EFFICIENCY

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As a part of this assignment, work in Thangadh Ceramic 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. D C Jalu, General Manager, Gurukrupa Ceramics for showing keen interest in the energy audit and also thankful to the management of Gurukrupa Ceramics 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. Kirti Maru, President, Panchal Ceramic Association Vikas Trust , technology providers and all those who were directly or indirectly involved throughout the study were exemplary. The entire exercise was thoroughly a rewarding experience for DESL.

DESL Team

DESL Team

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ABBREVIATIONS

Abbreviations	Expansions
APFC	Automatic Power Factor Correction
BEE	Bureau of Energy Efficiency
CEA	Comprehensive Energy Audit
DESL	Development Environergy Services Limited
DG	Diesel Generator
EE	Energy Efficiency
EPIA	Energy Performance Improvement Action
GEF	Global Environment Facility
HSD	High Speed Diesel
HVAC	Heating Ventilation and Air Conditioning
PCAVT	Panchal Ceramic Association Vikas Trust
LED	Light Emitting Diode
LT	Low Tension
MD	Maximum Demand
MSME	Micro, Small and Medium Enterprises
MT	Metric Tons
MTOE	Million Tons of Oil Equivalent
PF	Power Factor
PNG	Piped Natural Gas
PGVCL	Paschim Gujarat Vij Company 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 small and medium enterprises (SMEs) sector in India.

As part of this project, DESL has been engaged to implement the project in the MSME ceramic cluster in Thangadh, Gujarat. The ceramic industry of Thangadh cluster can be categorized into 3 segments depending on the products being manufactured – pottery works, insulator & porcelain and sanitary wares. The production process of all the three types of units is almost similar, with main difference being the amount of ceramic material ratios mixed in ball mill and the heating time required in kilns for the 3 different products. The main fuel used in the MSME ceramic units of Thangadh is Pressurized Natural Gas (PNG).

The project awarded to DESL consists of four major tasks:

1) Conducting pre-activity cluster level workshops
2) Conducting comprehensive energy audit (CEA) at 6 units selected by the cluster association – Panchal Ceramic Association Vikas Trust (PCAVT)
3) Submission of reports – comprehensive energy audit, cluster level best operating practices for 5 major energy consuming equipments / processes, list of common regularly monitored parameters for measurement of major energy consuming parameters, list of energy audit equipments
4) Conducting three cluster-level post audit training workshops

Brief Introduction of the Unit

Table 1: Details of Unit

Name of the Unit	Gurukrupa Ceramic
Constitution	Private Limited
MSME Classification	Small
No. of years in operation	NA
Address: Registered Office	Navagam, Thangadh-363530, Gujarat, India
Factory	Navagam, Thangadh-363530, Gujarat, India
Industry-sector	Ceramics
Products Manufactured	Sanitary Ware
Name(s) of the Promoters / Directors	Mr. D. C. Jalu

Comprehensive Energy Audit

The study was conducted in 3 stages:

- **Stage 1:** Walk through energy audit of the plant to understand the process, energy drivers, assessment of the measurement system, assessment of scope, measurability formulation of audit plan and obtaining required information

- **Stage 2:** Detailed energy audit-testing & 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 the unit and freezing of projects for implementation and preparation of energy audit report

Production process of the unit

The main process equipment in the unit includes the following:

- The main energy consuming equipment is kiln, which uses Pressured Natural Gas as the fuel. The temperature maintained in the kiln is approximately 1180 – 1230°C (in heating zone).
- There are other equipments viz. air compressors, ball mills, jigger jollies which also contribute to the production process and consume electrical energy.
- The raw material used is a mixture of Chinaclay, boleclay, thanclay, feldspar and quartz which is mixed along with water to form a plastic mass. The water and air are removed from this plastic mass in various process machines, and the material is provided required shape using dies, and fired in kiln for hardening. Later, the material is cooled and packed for dispatch.

Identified Energy Performance Improvement Actions (EPIA)

The comprehensive energy audit covered all equipments which were in operation during the field study. Kilns consume the maximum energy in an unit, accounting for more than 70% of the total energy used.

The identified energy performance improvement actions in the kilns were providing proper insulation on the kiln to reduce radiation and convection heat loss from kiln surface, excess air control and replacement of kiln car material. It is also proposed to implement energy efficient fans for cooling and drying of molds and energy efficient LED lights in place of conventional tube lights. Another EE measure proposed is power factor improvement. The details of energy improvement actions are given in Table – 2.

Table 2: Summary of EPIA

Sl. No.	Name of the project	Estimated energy savings		Monetary savings	Estimated investment	Simple payback period	Annual Emission reduction
		PNG	Electricity				
		SCM/y	kWh/y	Rs. lakh/y	Rs. lakh	y	tCO2/y
1	Skin loss reduction from the kiln	10896.3		4.2	0.70	0.2	19.4
2	Excess air control in kiln	23494.5	5921	9.5	7.00	0.7	47
3	Replacement of kiln car	15250.9		5.9	4.80	0.8	27.1
4	Installation of LED fixture instead of CFL lighting		10962	0.7	0.63	0.9	9.8
5	Installation of energy efficient fan instead of conventional fan		32603	2.1	4.05	1.9	29.0
6	Energy monitoring system	868.5	10553	0.3	0.45	1.3	10.9
7	Servo Stabilizer for voltage regulation		6850	0.5	0.5	1	6.1
	Total	50510.2	66889	23.6	18.4	0.8	148.9

The projects proposed would result in energy savings of up to 15% in the plant 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 small and medium enterprises (SMEs) 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:

- Increased 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
    - Present energy usage (month wise) for all forms of energy from June-2014 to May-2015 (quantity and cost)
    - Data on production for corresponding period (quantity and cost)
    - Data on production cost and sales for the corresponding period (cost)
    - Mapping of process
    - Company profile including name of company, constitution, promoters, years in operation and products manufactured
    - Existing manpower and levels of expertise
    - List of major equipments and specifications
- Analysis :
    - Energy cost and trend analysis

- Energy quantities and trend analysis
  - Specific consumption and Trend analysis
  - Scope and potential for improvement in energy efficiency
- Detailed process mapping to identify major areas of energy use.
- To identify all areas for energy savings in the following areas:
  - Electrical: Power factor improvement, transformer loading, power quality tests, motor load studies, compressed air systems (including output efficiency tests), conditioned air provisions, cooling water systems, lighting load, electrical metering, monitoring and control system.
  - Thermal: Assessment to ascertain direct and indirect kiln efficiencies with intent to optimize thermal operations, 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 requiring moderate investments and with payback ranging from 1.9 to 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 man power, etc. and to classify the same in order of priority.
- Identify and recommend proper “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 on coverage of the audit:

- Audit covered all possible energy intensive areas & equipments which were operational during the time of 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

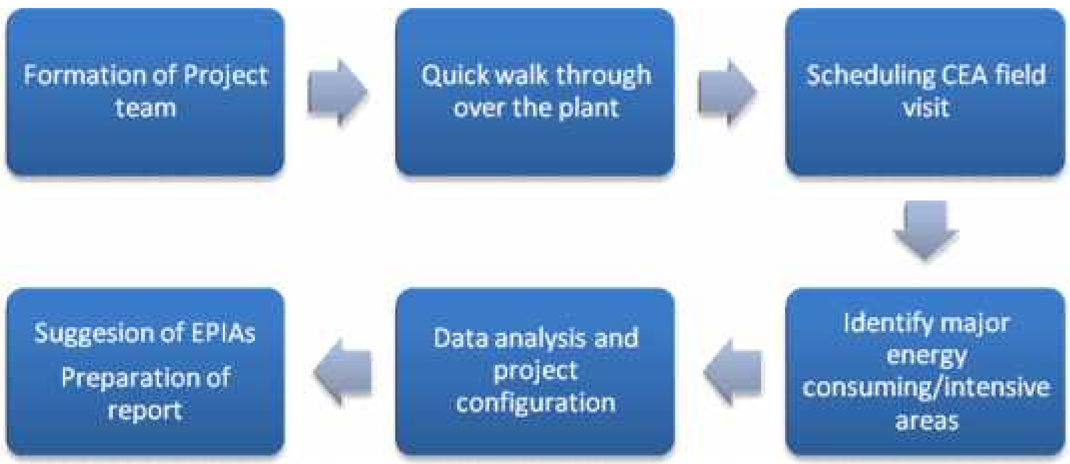


Figure 1: General methodology

The study was conducted in 3 stages:

- **Stage 1:** Walk through energy audit of the plant to understand 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 & measurement for identification of savings potential, technology assessment and understanding of project constraints
- **Stage 3**: Desk work for data analysis, initial configuration of projects, savings quantification, vendor consultation, interaction with the unit and freezing of projects for implementation and preparation of energy audit report

1.3.3 Comprehensive energy audit – field assessment

A walk through audit of the plant was carried out before the comprehensive energy audit with a view to:

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

The audit identified the following potential areas of study:

- PNG fired tunnel kiln
- Electrical motors used in the process
- Fans and lighting loads

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

- Preparation of the process & energy flow diagrams
- Study of the system & associated equipments
- Conducting field testing & 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) followed by 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 efficiency. The various instruments used during the energy audit are as below.

Table 4 Energy audit instruments

Sl. No.	Instruments	Make	Model	Parameters Measured
01	Power Analyzer – 3 Phase (for un balanced Load) with 3 CT and 3 PT	Enercon and Circutor	AR-5	AC Current, Voltage, Power Factor, Power, Energy, Frequency, Harmonics and data recording for minimum 1 sec interval
02	Power Analyzer – 3 Phase (for balance load) with 1 CT and 2 PT	Elcontrol Energy	Nanovip plus mem	AC Current, Voltage, Power Factor, Power, Energy, Frequency, Harmonics and data recording for minimum 2 sec interval
03	Digital Multi meter	Motwane	DM 352	AC Amp, AC-DC Voltage, Resistance, Capacitance
04	Digital Clamp on Power Meter – 3 Phase and 1 Phase	Kusam - Meco	2745 and 2709	AC Amp, AC-DC Volt, Hz, Power Factor, Power
05	Flue Gas Analyzer	Kane-May	KM-900	O2%, CO2%, CO in ppm and Flue gas temperature, Ambient temperature
06	Digital Temperature and Humidity Logger	Dickson		Temperature and Humidity data logging
07	Digital Temp. & Humidity meter	Testo	610	Temp. & Humidity
08	Digital Anemometer	Lutron and Prova	AM 4201 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°C
13	Lux Meter	Kusum Meco (KM-LUX-99) and Mastech		Lumens
14	Manometer	Comark	C 9553	Differential air pressure in duct
15	Pressure Gauge	Wika		Water pressure 0 to 40 kg

1.3.4 Comprehensive energy audit – desk work

Post audit off-site work carried out included:

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

2 ABOUT THE MSME UNIT

2.1 Particulars of the unit

Table 5: General particulars of the unit

Sl. No.	Particulars	Details
1	Name of the unit	Gurukrupa Ceramic
2	Constitution	Private
3	Date of incorporation / commencement of business	NA
4	Name of the contact person Mobile/Phone No. E-mail ID	Mr. D C Jalu (Owner/Founder) +91-98252-17718 NA
5	Address of the unit	Navagam Road, Navagam, Thangadh-363530, Gujarat, India
6	Industry / sector	Ceramic
7	Products manufactured	Sanitary Wares
8	No. of operational hours	24
9	No. of shifts / day	3
10	No. of days of operation / year	300
11	Whether the unit is exporting its products (yes / no)	NA
12	No. of employees	NA

3 DETAILED TECHNICAL FEASIBILITY ASSESSMENT OF THE UNIT

3.1 Description of manufacturing process

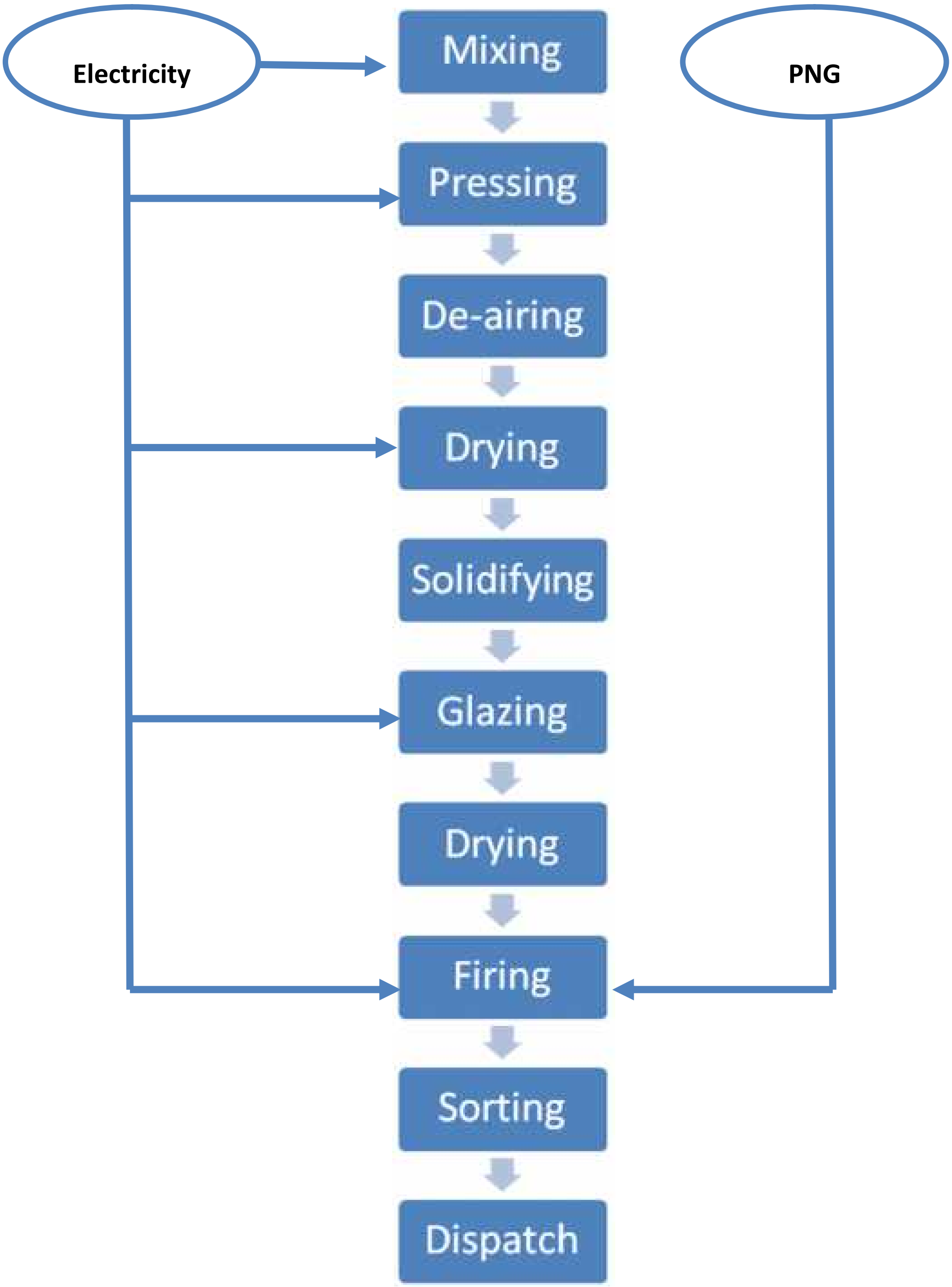


Figure 2: Process Flow Diagram

3.1.1 Process description

Gurukrupa Ceramic is a sanitary ware ceramic manufacturer

The process description is as follows:

- The raw materials clay, feldspar and quartz are mixed together with water in the ball mill for a period of 5 to 7 hours.
- Then they transfer this mixture to the agitator tank for thorough mixing. With the help of centrifugal mud pump, they transfer the mixture to the sieve filter to remove water.
- The slurry is allowed to dry after pouring it into mold dyes made of Plaster of Paris. Pressing of slurry is done using pressurized air to ensure tight bonding in the mold and leaving no chance of cavities.
- The molds are allowed to dry under ceiling fans for about 1-2 days depending on the atmospheric humidity.
- The materials are then glazed, painted and stacked on the kiln cars for firing to obtain strength. The firing zone temperature in the kiln is maintained at 1180 – 1230^{o}C.
- After firing, the products are quality checked, packed and dispatched.

3.2 Inventory of process machines / equipments and utilities

The major energy consuming equipments in the plant are:

- **Ball mill:** Here the raw materials like clay, feldspar and quartz are mixed in the ratio of 2:1:1 respectively along with water to form a plastic mass.
- **Glaze mill:** For producing glazing material used on sanitary product.
- **Air Compressor:** Pressurized air is used at several locations/processes in a unit viz. pressing of slurry, air cleaning, glazing, etc.
- **Agitator:** The plastic mass after getting mixed in the ball mill is poured into a sump where an agitator is fitted for thorough mixing of the material and preventing it to settle at the bottom.
- **Tunnel Kiln:** The shaped materials are glazed, painted and then stacked on the kiln car, which are then sent for firing in the tunnel kiln with the help of pusher motor kept at a specified rpm. The tunnel is about 60 m long and the temperature gradually increases up to firing zone and then decreases (in the cooling zone) with the highest temperature being 1221^{o}C. Once the kiln car comes out of the cooling zone, the materials are further cooled, quality tested and packed for dispatch.

3.2 Types of energy used and description of usage pattern

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

- Electricity is supplied from two different sources:
    - From the Utility, Paschim Gujarat Vij Company Ltd (PGVCL)
    - Captive backup DG sets for whole plant

- Thermal energy is used for following applications:
    - PNG for tunnel kiln

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

Table 6: Energy cost distribution

Particular	Energy cost distribution		Energy use distribution	
	Rs. In Lakhs	% of total	MTOE	% of total
Grid – Electricity	22.9	14.6	30.25	9.2
Diesel – DG	NA	0	0	0
Thermal – PNG	134.1	85.4	298.76	92.8
Total	157	100	329.02	100

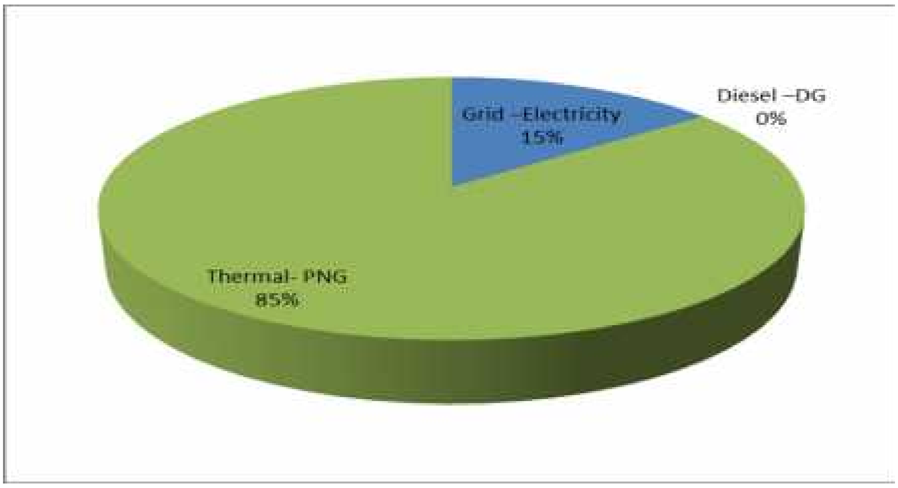


Figure 3: Energy cost share (Rs. Lakh)

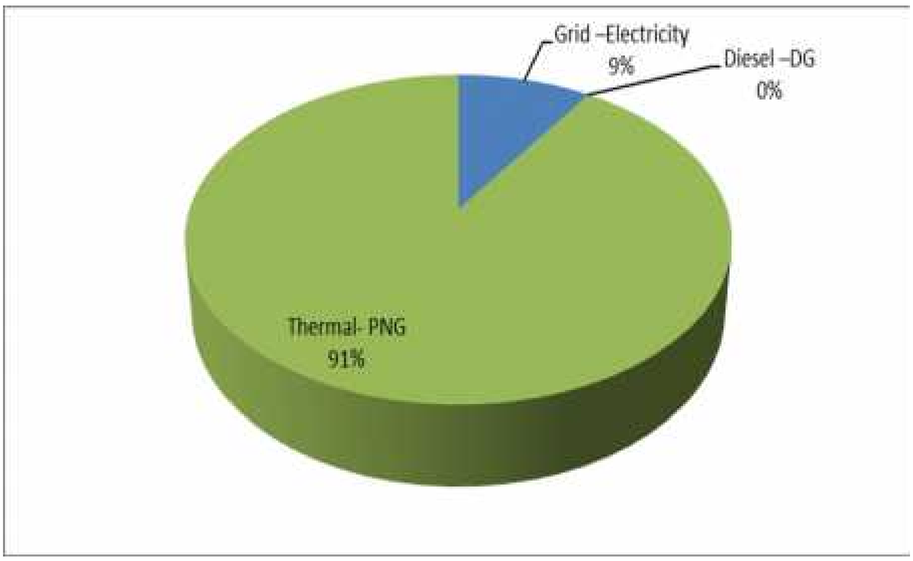


Figure 4: Energy use share (MTOE)

Major observations are as under:

- The unit uses both thermal and electrical energy for carrying out manufacturing operations. Electricity is sourced from the grid as well as self-generated through DG sets when the grid power is not available. Source of thermal energy is from combustion of PNG, which is used for firing in the kiln.
- PNG used in kilns accounts for 85% of the total energy cost and 91% of the overall energy consumption.
- Electricity used in the process accounts for the remaining 9% of the energy cost.

3.3 Analysis of electricity consumption by the unit

3.3.1 Electricity load profile

Following observation has been made from the utility inventory:

- The plant and machinery load is 57 kW
- The utility load (lighting & fans) is about 23.31 kW including the single phase load
- The plant total connected load is 83kW

Table 7: Equipment wise connected load

Sl. No.	Equipment	Numbers	Capacity (kW)	Total capacity
1	Ball mill motor	5	7.5	37.5
2	Glazing Ball Bill	3	1.5+1.5+3.75	6.75
3	Compressor	1	15	15
4	Air blower	3	1.5+3.75+2.25	7.5
5	Disperser Motor	2	1.5	3
6	Slurry Pump	2	1.5	3
7	Lighting loads	70	0.035	2.45
8	Fan Load	135	0.06	8.1
	Total			**80.1**

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

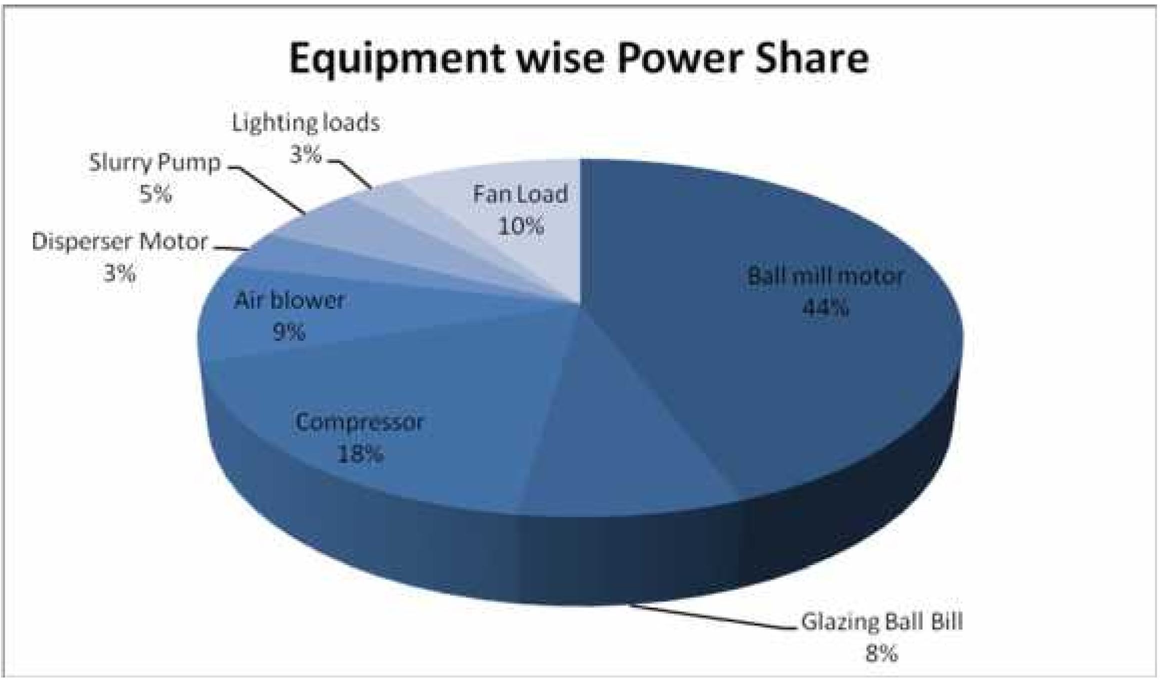


Figure 5: Details of connected load

As shown in the pie chart of connected loads, the maximum share of connected electrical load is for the ball mill – 44%, followed by air compressor – 18%, ceiling fan – 10%, kiln air blowers – 9%, glazing ball mill- 8%. Other machinery includes slurry mud pump – 5% and lighting load and disperser motor (agitator) each of 3%.

3.3.2 Supply from utility

Electricity is supplied by the Paschim Gujarat Vij Company Ltd. (PGVCL).
The tariff structure is as follows:

Table 8: Tariff structure

Particulars	Tariff structure	
Energy Charges	4.7	Rs./kWh
Reactive power charges	0.1	Rs./kVARh
Fuel Surcharge	1.60	Rs./kVAh
Electricity duty	0.1	Rs./kVAh
Meter charges	225	Rs.

Electricity bill is not provided by the unit owner.

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

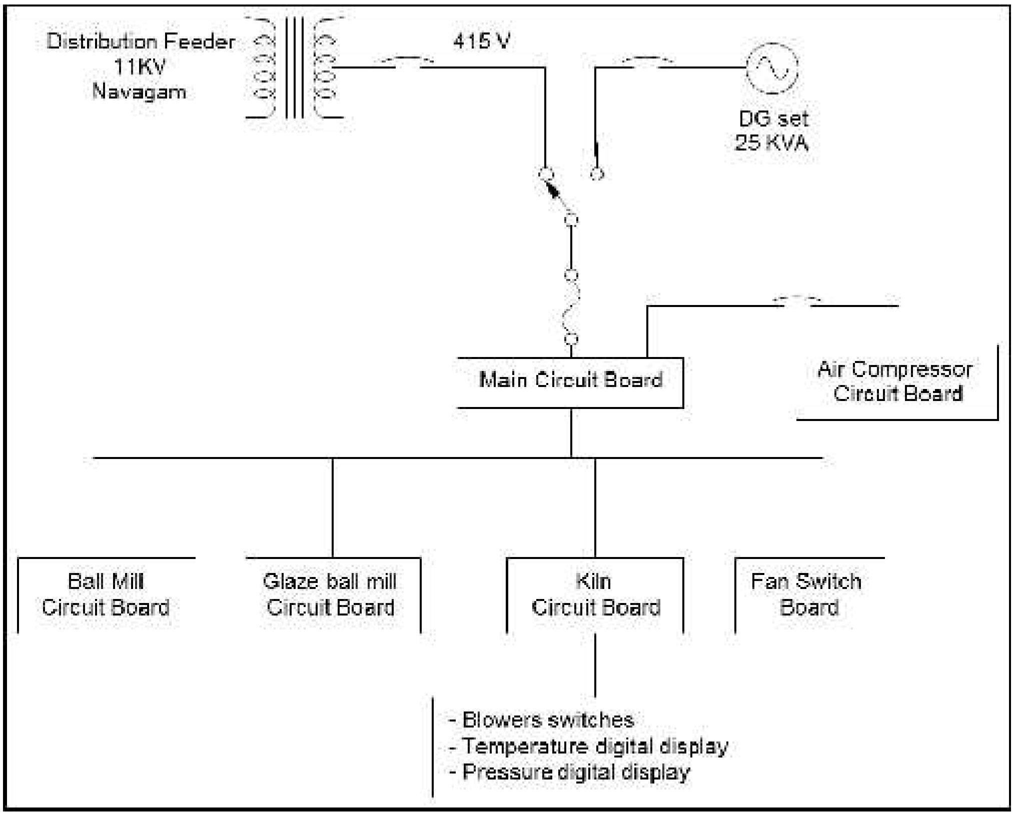


Figure 6: SLD of electrical load

Power factor

The utility bills of the unit reflect the power factor. A study was conducted by logging the electrical parameters of the main incomer using a power analyzer. The average power factor was found to be 0.81 with the minimum being 0.68 and the maximum being 0.934.

3.3.3 Month wise electricity consumption

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

Table 9: Electricity consumption & cost

	Electricity Used (kWh)	Electricity Cost (Rs.)
Total	**351775.8**	**2290363.0**

3.4 Analysis of thermal consumption by the unit

PNG is used as the fuel for firing in the kiln. PNG is available throughout Thangadh cluster with GSPC (Gujarat State Petroleum Company) as a common supplier[1].

Table 10: PNG used as fuel

Month	Fuel Consumption (SCM/year)	Amount (Rs.)
Total	**347400**	**13548600**

3.5 Specific energy consumption

Annual production data was available from the unit in metric tons (MT). Based on the available information, various specific energy consumption parameters have been estimated as shown in the following table:

Table 11: Overall specific energy consumption

Parameters	Value	UoM
Annual Grid Electricity Consumption	351776	kWh
Annual DG Generation Unit	NA	kWh
Annual Total Electricity Consumption	351776	kWh
Annual Thermal Energy Consumption (PNG)	347400	SCM
Annual Energy Consumption; MTOE	329.33	MTOE
Annual Energy Cost	157	Lakh Rs
Annual Production	2520	MT
SEC; Electricity from Grid	140	kWh/MT
SEC; Thermal	138	SCM/MT
SEC; Overall	0.13	MTOE/MT
SEC; Cost Based	6230	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
- GCV of Diesel : 11,840 kCal/ kg
- Density of HSD : 0.8263 kg/litre
- GCV of PNG : 8600kCal/scm
- CO_2 Conversion factor
  - Grid : 0.89 kg/kWh
  - Diesel : 3.07 tons/ ton

[1] Gas bill of any month has not been shared by the unit owner. The data in table 9 is extrapolated based on real time gas meter reading

3.6 Baseline parameters

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

Table 12: Baseline parameters

Electricity cost (Excluding Rs/kVA)	NA	Rs./ KVAH inclusive of taxes
Weighted Average Electricity Cost	6.5	Rs./ kWh for 2013-14
Percentage of total DG based Generation	NA	
Average Cost of PNG	38.6	Rs./SCM
Operating Days per year	300	days / year
Operating Hours per day	24	Hours / day
Production	2520	MT

3.7 Identified energy conservation measures in the plant

Diagnostic Study

A detailed study was conducted during CEA in the unit and some observations were made and a few ideas of EPIAs were developed. Summary of key observations is as follows:

3.7.1 Electricity Supply from Grid

The electrical parameters at the main electrical incomer feeder from PGVCL of the unit are recorded for 8 hours using portable power analyzer. 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 PGVCL through a common distribution feeder. The contract demand of the unit is 83 kVA	The maximum kVA recorded during study period was 37 kVA. As utility bill was not provided by unit owners, maximum demand cannot be determined	No EPIAs were suggested
Power Factor	Unit has an LT connection and billing is in kVAh. The unit does not have an APFC panel installed to control the power factor	The average PF found during the measurement was 0.84. It varied between 0.81 and 0.87	EPIA on power factor improvement is suggested

<table>
<tr><td>Voltage variation</td><td>The unit has no Servo stabilizers for voltage regulation</td><td>The voltage profile of the unit was satisfactory and average voltage measured was 432 V. Maximum voltage was 441 V and minimum was 426 V</td><td>EPIA of Servo stabilizer for voltage regulation is suggested</td></tr>
</table>

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

3.7.3 Electrical consumption areas

The section-wise consumption of electrical energy is shown in Table 6. Over 80% of the energy consumption is in the manufacturing operations, while remaining 20% is in utilities.

The details of measurements conducted, observations made and ideas generated for energy conservation measures are as follows:

<table>
<tr><th>Name of Area</th><th>Present Set-up</th><th>Observations during field Study & measurements</th><th>Proposed Energy performance improvement actions</th></tr>
<tr><td>Ball mill</td><td>There are 8 ball mills in the unit, out of which 5 are connected with 10 HP motors, 1 with a 5 HP motor and 2 with 2 HP motors respectively. Ball mills account for 47% of overall electrical power consumption</td><td>Out of the 5 ball mills, 2 of 1.5 T was on operation during CEA and its characteristics were studied

The results of the study are below:<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Mill 1 (10 HP)</td><td>5.90</td><td>0.82</td></tr></table></td><td>No EPIAs were suggested for ball mill</td></tr>
<tr><td>Air Compressor</td><td>The unit has an air compressor. Rated load is 15 KW and operating set point pressure is 7.6 bar</td><td>Many air leaks were found inside the unit. Loading power of compressor was as below:<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Air Comp</td><td>16.05</td><td>0.87</td></tr></table></td><td>Savings in compressed air power through attending leakages</td></tr>
<tr><td>Kiln blower</td><td>The unit has kiln blowers which are used for supplying combustion and cooling air in the tunnel kiln. The blowers account for 9% of the total</td><td>Data logging was carried out on the cooling zone blower to establish the power profile.

The results of the study are below:<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Cooling Zone</td><td>2.47</td><td>0.86</td></tr></table></td><td>EPIA suggested for maintaining the draft pressure by adjusting kiln blowers</td></tr>
</table>

	electricity consumption.	Fire Zone Preheating	3.68 1.46	0.88 0.85	

3.7.4 Thermal consumption areas

As discussed in the earlier section, kiln accounts for about 85% of energy cost and 91% of the energy use. The details of present set-up, key observations made and potential areas for energy cost reduction have been mentioned in the table below:

Table 14: Kiln and Kiln car details

Sl. No.	Parameters	Value	Unit
1	**Kiln operating time**	**24**	**hour**
2	**Number of burner to left**	**4**	**-**
3	**Number of burner to right**	**4**	**-**
4	**Kiln car residence time**	**18**	**hour**
5	**Kiln cars per day**	**34**	**-**
6	**Stock weight per kiln car**	**200-250**	**kg**
7	**Waste heat recovery option**	**No**	

Table 15: Kiln Dimensions

Zone	Height	Width	Length	UoM
Preheating	2	1.6	22	meter
Firing	2.35	2	8	meter
Cooling	2	1.6	22	meter

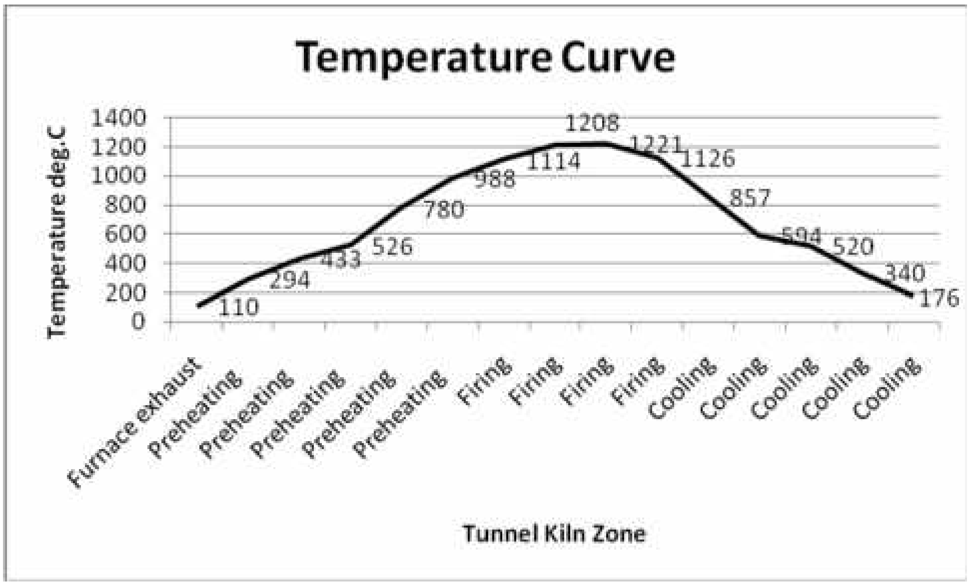


Figure 7: Temperature curve of kiln

<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>Kiln</td>
<td>PNG is used as a fuel in the kiln to heat the ceramic material to the required temperature.

The required air for fuel combustion is supplied by a blower (FD fan).

The dead weight of kiln car was high.</td>
<td>The fuel consumption of kiln has been identified by dip stick method as no metering system was available.

<table>
<tr><th>Machine</th><th>Oxygen Level measured in Flue Gas</th><th>Ambient Air Temp</th><th>Exhaust Temperature of Flue Gas</th></tr>
<tr><td>Tunnel kiln</td><td>10.1%</td><td>38Deg C</td><td>110Deg C</td></tr>
</table>

From the above Table, it is clear that the oxygen level measured in flue gas was high.

The inlet temperature of raw material in kiln was in the range of 35 – 42°C which was the ambient air temperature.

The kiln car is made up of fire clay bricks, pillars and tiles to stack the materials. All these materials have different specific heats. It is to be noted that the kiln car takes away a lot of useful heat.</td>
<td>No waste heat recovery recommendation has been suggested, as the exit flue gas temperature is low and cannot be used for waste heat recovery.

Reducing the radiation and convection losses from the kiln surface by improving insulation is recommended in firing zone of the kiln.

Reducing opening losses in kiln is recommended.

It is recommended to change the kiln car material with other materials of lower specific heat values that absorb lesser heat.</td>
</tr>
</table>

4 EE TECHNOLOGY OPTIONS AND TECHNO – ECONOMIC FEASIBILTY

During CEA of plant, all energy consuming equipments and processes were studied. The analysis of all major energy consuming equipments and appliances were carried out and the same has already been discussed in an 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: Reduction in radiation and convection losses from surface of kiln

Technology description

A significant portion of losses in a kiln occur as radiation and convection loss from the kiln walls and roof. These losses are substantially higher on areas of openings or in case of infiltration of cold air. Ideally, optimum amount of refractory and insulation should be provided on the kiln walls and roof to maintain the skin temperature of the furnace at around 45-50°C , so as to avoid heat loss due to radiation and convection. Refractories are heat-resistant materials that constitute the linings for high-temperature tunnel kilns. 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 for reduction in heat transfer (the transfer of thermal energy between objects of differing temperatures) between objects in thermal contact or in range of radiative influence.

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

Study and investigation

There are three different zones in a kiln, i.e. pre-heating, firing and cooling zones. The surface temperatures of all the zones were measured. The average surface temperature of the kiln body in the firing zone must be in the range of 45-50°C, but it was measured as high as 130˚C. Hence, the kiln surface has to be properly insulated to keep the surface temperature within the specified range.

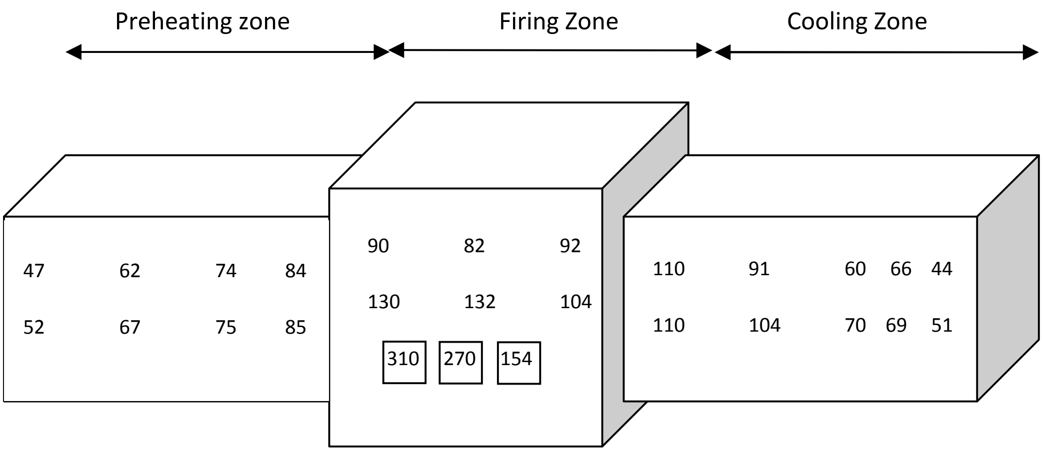


Figure 8: Surface temperature of Kiln

Recommended action

Recommended surface temperature of the firing zone has to be brought to within 50°C to reduce the heat loss due to radiation and convection and utilize the useful heat. The amount of heat lost through radiation and convection in each zone is given in the table below.

Table 16: R & C losses

Total radiation and convection heat loss per hour	Units	Value
Pre-Heating Zone	kCal / hr	10,458
Heating Zone	kCal / hr	14,241
Cooling Zone	kCal / hr	15,005
Total R&C loss	kCal / hr	39,704

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

Table 17: Cost benefit analysis (EPIA 1)

Parameters	Unit of Measurement	Value
Present average skin temperature of Heating zone	deg. C	97.00
Recommended skin temperature of Heating Zone	deg. C	50.00
Present heat loss due to Radiation & Convection from Work side wall	kCal / hr	14,241
Recommended heat loss due to Radiation &	W / m2	43.84

Parameters	Unit of Measurement	Value
Convection from Heating zone	kCal / m2	37.70
	kCal / hr	1,604
Total reduction in heat loss due to Radiation & convection by limiting skin temperature at Heating zone	kCal / hr	12,637
Calorific value of Fuel	kCal / kg	12,652
Equivalent savings in Fuel	kg / hr	1.00
	Nm3 / hr	
Plant running time	days / year	300
	hrs / day	23
Annual savings in Fuel	**kg/y**	**6,892**
Cost of fuel	Rs / kg	59.091
Annual Monitory savings	**Rs / Year**	**407,248**
	Rs. lakhs **/ Year**	**4.07**
Estimated investment	Rs. lakhs	0.7

4.2 EPIA 2: Excess air control

Technology description

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

In general, in most of the kilns, fuel is fired with too much of excess air. This results in formation of excess flue gases, taking away the heat produced from the combustion and increasing the fuel consumption. This also results in the formation of excess GHG emissions.

A PID controller, if installed, measures the oxygen levels in the flue gases at the exit of the kiln and based on that the combustion air flow from FD fan (blower) is regulated and subsequently proper temperature and optimum excess air for combustion is attained in the kiln.

Study and investigation

There was no proper automation and control system installed in the kiln to monitor and maintain optimum excess air levels at the time of the study. Fuel was fired from the existing burner system and no air flow control mechanism was in place for maintaining proper combustion of the fuel. The combustion air and cooling air (through air curtains) were being supplied from the same FD fan. The pressures required for combustion and for cooling air were different and supplying both the air from one common FD fan was not a good practice.

Recommended action

Two separate blowers have been recommended for supplying combustion air and cooling air. It is proposed to install control system to regulate the supply of excess air for proper 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 18: Cost benefit analysis (EPIA 2)

Parameters	UOM	Present	Proposed
Oxygen level in flue gas	%	10.20	3.00
Excess air control	%	94.44	16.67
Dry flue gas loss	%	4.65	
Saving in fuel	Every 10% reduction in excess air leads to savings in specific fuel consumption by 1%		
Specific fuel consumption	kg/t	79.11	72.96
Saving in specific fuel consumption	kg/h		2.15
Savings in fuel consumption per year	kg/y		15506
Savings in fuel cost	Rs. Lakh/y		9.07
Installed capacity of blower	kW	5.00	4.18
Operating hours	hrs/y	7200.00	7200.00
Electrical energy consumed	kWh/y	36000.00	30078.72
Savings in electrical energy	kWh/y		5921.28
Cost of electrical energy	Rs. Lakh/y	2.34	1.96
Savings in terms of energy cost	Rs. Lakh/Y		9.45
Estimated investment	Rs. lakh		7.00
Simple payback	y		0.74

4.3 EPIA 3: Replacement of Kiln car material

Technology description

The existing kiln car consists of refractory bricks and tiles which are very heavy and hence increase the dead weight of the car. The present kiln car also carries away much of the useful heat supplied to the kilns resulting in reduced efficiency. Instead of the existing kiln car material, a new material called ultralite[2] can be used in the kiln car construction, which will help in reducing its dead weight. This will also help in reduction in kiln losses due to useful heat carried away by kiln car, as this material has lesser specific heat.

Study and investigation

Presently, kiln car used is made up of HFK bricks, quadrite tiles and pillars and these materials contribute to a dead weight (of kiln car) of 500 kg. The ceramic materials to be heated are placed on the kiln car on make-shift racks and this kiln car travels all along the length of the kiln from pre-heating zone to heating (or firing) zone to cooling zone. The kiln car also gains useful heat that is supplied by fuel to heat the ceramic materials and they carry the same with them out of the kiln. The heat gained by kiln car is wastage of useful heat, as the heat is being supplied to heat the ceramic material and not the kiln car. So, in order to reduce this necessary wastage, it is recommended to select kiln car material that shall absorb as minimum heat as possible, so that most of the heat supplied is gained by the ceramic material. This will also help in reduced fuel consumption in the kiln.

Recommended action

It is recommended to replace the existing kiln car material with "ultralite" material with a little modification in the arrangement of refractories. This will help in reducing the dead weight of the kiln car, thereby reducing the heat gained by the same and also help in reduction in fuel consumption in the kiln by approximately 30%. The cost benefit analysis for the EPIA is given in the table below:

Table 19: Cost benefit analysis (EPIA 3)

Data	UOM	As is	To be
Production of the material	tph	0.35	0.35
Weight of existing kiln car	kg	500	500
Total number of kiln car inside kiln	Nos.	33	33
Initial temperature of kiln car	Deg c	40	40
Final temperature of kiln car	Deg c	1216	1216
Estimated percentage savings by new kiln car material	%		30
Heat carried away by the kiln material	kcal/hr	51,586	36,110
Reduction in heat carried by the kiln	kcal/hr		15,476
Operating hours of kiln	hrs	7200	7200

[2] Kiln car material by Interkiln Industries, Ahmedabad, Gujarat.

Data	UOM	As is	To be
Savings in terms of fuel consumption	kg/y		8,807
Savings in terms of cost	Rs. Lakh/y		5.2
Estimated investment of kiln material	Rs. Lakh/y		4.80
Payback period	y		0.9

4.4 EPIA 4: Energy efficient light fixture

Technology description

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

Study and investigation

The unit is having 70 CFL, each of 45W capacity.

Recommended action

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

Table 20: Cost benefit analysis (EPIA 4)

Particulars	Unit	Existing	Proposed
Fixture		**45 watt and 23 watt CFL**	**16 Watt LED light**
Power consumed by CFL, 45 watt	W	45	16
Total no. of 45 watt CFLs	Nos.	70	70
Power consumed by the CFL, 23 Watt	W	23	16
Total no. of 23 watt CFLs	Nos.	-	0
Total power consumption	kW	3	1
Operating Hours/day	Hr	18	18
Annual days of operation	Day	300	300
Energy Used per year/fixture	***kWh***	***17,010***	***6,048***
Energy Rate	Rs/kWh	**6.51**	**6.51**
Operating cost per year	Rs. Lakh/Year	1.11	0.39
Saving in terms of electrical energy	kWh/Year	10962	
Savings in terms of cost	Rs. Lakh/Year	0.71	
Investment per fixture of LED	Rs. Lakh	0.009	
Investment of project	Rs. Lakh	0.63	
Payback period	Years	0.88	

4.5 EPIA 5: Replacing conventional ceiling fans with Energy efficient fans

Technology description

Replacing the old fans of conventional type installed in various sections of the plant with energy efficient fans will reduce the power consumption by almost half. The energy efficient fans have a noiseless operation and are controlled by electronic drives which on speed reduction will automatically sense the rpm and reduce the power consumption. Since a large number of ceiling fans are used in the ceramic units for drying purposes, so energy efficient fans can be best suited for energy conservation.

Study and investigation

The unit is having about 135 conventional ceiling fans which are very old and can be replaced with EE fans.

Recommended action

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

Table 21: Cost benefit analysis (EPIA 5)

Data & Assumptions:	UOM	Ordinary fan	Superfan
Number of fans in the facility	Nos	135	135
Run hours per day	H/d	23	23
Power consumption at maximum speed	kW	0.07	0.04
Number of working days/year	days	300	300
Tariff for Unit of electricity	Rs./kWh	6.51	6.51
Fan unit price* (use '0' for ordinary fan if replaced)	Rs./piece	0	3000
Electricity consumption:			
Electricity demand	kW	9.45	4.73
Power consumption by fans in a year	kWh/y	65205	32603
Savings in terms of power consumption	kWh/y		32603
Savings in terms of cost	Rs. Lakh/y		2.12
Estimated investment	Rs. Lakh/y		4.05
Payback period	y		1.91

4.6 EPIA 6: Energy monitoring system

Technology description

Installation of energy monitoring system on a unit will monitor the 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

It was observed during the audit that online data measurement was not being done on the main incomer as well as at various electrical panels for the energy consumption. It was also noticed that there were no proper fuel monitoring systems installed in the DG sets and in kilns 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. This measure will help in reduction in energy consumption by approximately 3% from its present levels. The cost benefit analysis for this project is given below:

Table 22: Cost benefit analysis (EPIA 6)

Parameters	Unit	As Is	To Be
Energy monitoring savings	%	3.00	
Energy consumption of major machines per year	kWh/Yr	351,776	341,223
Annual electricity savings per year	kWh/Yr		10,553
W. Average Electricity Tariff	Rs/kWh		6.51
Annual monetary savings	lakh Rs/yr		0.69
Estimate of Investment	Lakh Rs		0.25
Simple Payback	Months		4.37
Energy monitoring savings	%	3.00	
Current fuel consumption	kg/y	19,107	18534
Annual fuel savings per year	kg/y		**573**
Unit Cost	Rs./kg		59.09
Annual monetary savings	Lakhs Rs/year		0.34
Estimate of Investment	Lakhs Rs		0.20
Simple Payback	years		0.59

4.7 EPIA 7: Servo Stabilizer for Voltage Regulation

Technology Description

Overvoltage in electrical system leads to voltage stress on cable insulation which can cause safety hazard at the work place. Also frequent overvoltage may lead to insulation failure resulting in damage to motor winding and other electrical equipments. A servo stabilizer is a protective electrical device that regulates the voltage in permissible limits in each phase. The permissible limits are 390 V to 430 V.

Study Investigation

During the field study, the voltage across main incomer was measured and recorded for 4 hours. The average voltage in the system was found to be 432V, maximum of 441 V and minimum 426 V was recorded.

Recommended action

Installing servo stabilizer at main incomer to regulate over and under voltages.

Table 23: Servo Stabilizer for voltage regulation (EPIA 7)

Parameters	Unit	As Is	To Be
Load considered for voltage reduction (Light + Fan)	kW	10.55	10.55
Load considered for voltage reduction (Light + Fan)	KVA	10.99	10.99
Average Voltage	V	432.3	390.0
% reduction In voltage	%	9.8%	
% reduction in Energy consumption	%	18.61%	
Average Power Factor of System	EB Bill	0.96	0.96
Operating Hours in a year	hr	3672.00	
Energy Consumption before Voltage Regulation	kWh/year		38,740
Energy Consumption after Voltage Regulation	kWh/year		31,529
Efficiency of Servo Stabilizer	%		95%
Net Saving from Voltage Regulation	kWh/year		6,850
Electricity tariff from Grid	Rs./kWh	6.94	6.94
Annual Monetary Savings	Lakh Rs.		0.48
Sizing of Servo Stabilizer	kVA		11.57
Investment Estimate	Lakh Rs.		0.5
Payback	Years		1.05

5 ANNEXURE

1. Kiln efficiency calculations

Input parameters

Input Data Sheet		
Type of Fuel	PNG	
Source of fuel	GSPC	
	Value	Units
Tunnel Kiln Operating temperature (Heating Zone)	1216	*Deg C*
Initial temperature of kiln car	40	*Deg C*
Avg. fuel Consumption	27.7	*kg/hr*
Flue Gas Details		
Flue gas temp.	110	*deg C*
Preheated air temp./Ambient	40	*deg C*
O2 in flue gas	10.2	*%*
CO2 in flue gas	6.4	*%*
CO in flue gas	4965	*ppm*
Atmospheric Air		
Ambient Temp.	40	*Deg C*
Relative Humidity	35	*%*
Humidity in ambient air	0.03	*kg/kgdry air*
Fuel Analysis		
C	*74.57*	%
H	*24.70*	%
N	*0.72*	%
O	*0.00*	%
S	*0.01*	%
Moisture	*0.0*	%
Ash	*0.00*	%
GCV of PNG	*12652*	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 Kiln car material	250	*Kg/Hr*
Weight of ceramic material being heated in Kiln	450	*Kg/Hr*
Weight of Stock	450	*kg/hr*

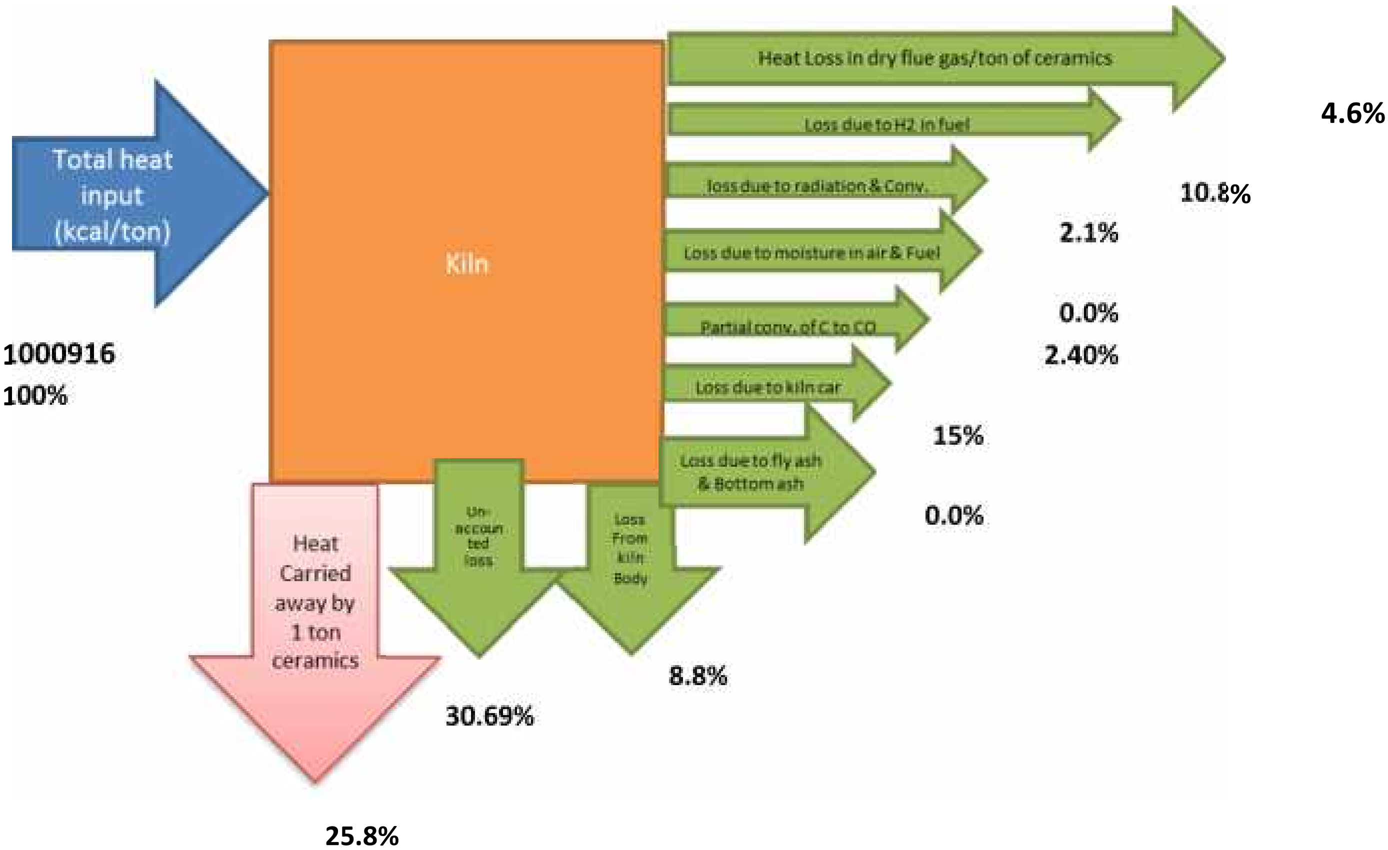
Specific heat of clay material	0.22	*Kcal/kgdegC*
Specific heat of kiln car material	0.23	*Kcal/kgdegC*
Avg. specific heat of fuel	0.559	*Kcal/kgdegC*
fuel temp	40	*deg C*
Specific heat of flue gas	0.26	*Kcal/kgdegC*
Specific heat of superheated vapour	0.45	*Kcal/kgdegC*
Heat loss from surfaces of various zone		
Radiation and from preheating zone surface	10458	*kcal/hr*
Radiation and from heating zone surface	14241	*kcal/hr*
Radiation and from firing zone surface	15005	*kcal/hr*
Heat loss from all zones	39704	*kcal/hr*
For radiation loss in furnace(through entry and exit of kiln car)		
Time duration for which the Kiln car enters through preheating zone and exits through cooling zone of kiln	24	*Hr*
Area of opening in m2	1.904	*m2*
Coefficent based on profile of kiln opening	0.7	
Max operating temp. at door	353	*deg K*

Efficiency calculations

Calculations	Values	Unit
Theoretical Air Required	17.25	*kg/kg of fuel*
Excess Air supplied	94.44	*%*
Actual Mass of Supplied Air	33.53	*kg/kg of fuel*
Mass of dry flue gas	32.31	*kg/kg of fuel*
Amount of Wet flue gas	34.53	*Kg of flue gas/kg of fuel*
Amount of water vapour in flue gas	2.22	*Kg of H2O/kg of fuel*
Amount of dry flue gas	32.31	*kg/kg of fuel*
Specific Fuel consumption	79.11	*kg of fuel/ton of billet*
Heat Input Calculations		
Combustion heat of fuel	1000916	*Kcal/ton of billet*
Sensible heat of fuel	0	*Kcal/ton of billet*
Total heat input	1000916	*Kcal/ton of billet*
Heat Output Calculation		
Heat carried away by 1 ton of ceramics (useful heat)	258720	*Kcal/ton of billet*
Heat loss in dry flue gas per ton of ceramics	46524	*Kcal/ton of billet*
Loss due to H2 in fuel	108249	*Kcal/ton of billet*
Loss due to moisture in combustion air	32	*Kcal/ton of billet*
Loss due to partial conversion of C to CO	24014	*Kcal/ton of billet*
Loss due to convection and radiation (openings in kiln - inlet & outlet of kiln car)	20,568	*Kcal/ton of billet*
Loss Due to Evaporation of Moisture Present in Fuel	0.0	*Kcal/ton of billet*

Total heat loss from kiln (surface) body	88230	*Kcal/ton of billet*
Heat loss due to unburnts in Fly ash	0	*Kcal/ton of billet*
Heat loss due to unburnts in bottom ash	0	*Kcal/ton of billet*
Heat loss due to kiln car	147390	*Kcal/ton of billet*
Unaccounted heat losses	307189	*Kcal/ton of billet*
Heat loss from kiln body and other sections		
Total heat loss from kiln	88230	*Kcal/tons*
Kiln Efficiency	25.8	*%*

2. Heat Balance Diagram



LIST OF VENDORS

EPIA 1: Radiation and convection loss reduction from surface of kiln

S.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 : 0161-2819388 Mobile : 9417004025	Email: kk.mitra@lloydinsulation.com

EPIA 2: 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	# 1698, First Floor, Canara Bank Building,	Office: +91-161-4624392,	Email: interautoinc@yahoo.com

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
	Contact Person Sanjeev Sharma)	Near Cheema Chowk, Link Road, Ludhiana	Mobile: +91-9815600392	
3	Happy Instrument	Yogesh 20, Proffulit Society, Nr Navo Vas, Rakhial, Ahmedabad-380021	079-22771702 9879950702	yogesh@happyinstrument.com
4	Wonder Automation	Kulwinder Singh E-192, Sector 74, Phase 8-B, Industrial Area, SAS nagar Mohali	0172-4657597 98140 12597	info@wonderplctrg.com admn.watc@gmail.com hs@wonderplctrg.com

EPIA 3: Replacement of kiln car material

.No	Name of Company	Address	Phone No.	E-mail
1	INTERKILN INDUSTRIES LTD.	Sanghavi Chambers, Beside Canara Bank, Navrangpura ,Ahmedabad	+91-79-30911069 079-6438180	ik@interkiln.com

EPIA 4: Energy efficient light

S.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@philips.com, sandeep.raina@philips.com

S.No	Name of Company	Address	Phone No.	E-mail
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 5: Replacing conventional ceiling fans with energy efficient fans

S.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)r	Email: kb_singh@ushainternational.com

EPIA 6: Energy Monitoring System

S.No	Name of Company	Address	Phone No.	E-mail
1	Iadept Marketing Contact Person: Mr. Brijesh Kumar Director	S- 7, 2nd Floor, Manish Global Mall, Sector 22 Dwarka, Shahabad Mohammadpur, New Delhi, DL 110075	Tel.: 011-65151223	iadept@vsnl.net ,info@iadeptmarketing.com
2	Aimil Limited	Naimex House A-8, Mohan Cooperative Industrial Estate,	Office: 011-30810229, Mobile: +91-	manjulpandey@aimil.com

S.No	Name of Company	Address	Phone No.	E-mail
	Contact Person: Mr. Manjul Pandey	Mathura Road, New Delhi - 110 044	981817181	
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 7: Servo stabilizer

S.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