COMPREHENSIVE ENERGY AUDIT REPORT

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

Tamco Ceramic

S/N 87/5,Opp. Railway Station, Thangadh-363530, Gujarat, India

Submitted to

ENERGY IS LIFE
BEE
CONSERVE IT

BUREAU OF ENERGY EFFICIENCY

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Submitted by

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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. MansuhChavda and Mr. ChiragChavda, Tamco Ceramics for showing keen interest in the energy audit and also thankful to the management of Tamco 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 Tonnes
MTOE	Million Tonnes 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 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 give impetus to the energy efficiency initiatives in the small and medium enterprises (SMEs) sector in India.

As part of this project DESL have been engaged to implement the project in the MSME ceramic cluster in Thangadh, Gujarat. The ceramic cluster in Thangadh consists of three distinct types of units – pottery works, insulator works and sanitary wares. The production process of all these three types of units are mostly same with main difference being the amount of ceramic material ratios being mixed in ball mill and 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 workshop
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 equipment / process, list of common regularly monitored parameters for measurement of major energy consuming parameters, list of energy audit equipment.
4) Conducting three cluster level post audit training workshops

Brief Introduction of the Unit

Table 1 Details of Unit

Name of the Unit	Tamco Ceramic
Constitution	Private Limited
MSME Classification	Small
No. of years in operation	NA
Address: Registered Office:	S/N 87/5,Opp. Railway Station, Thangadh-363530, Gujarat, India
Factory :	S/N 87/5,Opp. Railway Station, Thangadh-363530, Gujarat, India
Industry-sector	Ceramics
Products Manufactured	Electrical Insulators and Porcelain
Name(s) of the Promoters / Directors	Mr. Mansukh T. Chavda

Comprehensive Energy Audit

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:** Detail energy audit-testing & measurement for identification of saving potential, technology assessment and understanding of project constraints
- **Stage 3**: Data analysis, initial configuration of projects, savings quantification, vendor consultation, interaction with 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 in which the fuel used is Pressured Natural Gas. The temperature maintained in kiln is approx. 1180 – 1230 ˚C (in heating zone).
- There are other equipment viz. air compressor, ball mill, hydraulic press, filter press which also contribute to the production process and consumes 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 is removed from this plastic mass in various process machines and the material shaped as per requirement 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 equipment which was operational during the field study. The main energy consuming areas in the unit are kilns which accounts for more than 80% 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. Other EE measures proposed were 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 saving		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	17598.8		6.7	0.70	0.1	31.3
2	Excess air control in kiln	16969.7	434	6.4	7.00	1.1	30.5
3	Replacement of kiln car	11120		4.2	4.80	1.1	19.8
4	Installation of LED fixture instead of conventional lighting system		5513	0.4	0.59	1.4	4.9
5	Installation of energy efficient fan instead of conventional fan		7200	0.52	1.44	2.8	6.4
6	Energy monitoring system	872.8	3720	0.3	0.45	1.45	4.9
	Total	59481.6	16867	18.62	15.5	0.83	97.8

The projects proposed wouldresult in energy savings of up to 18% in the plant on implementation.

1 INTRODUCTION

1.1 Background and Project objective

Bureau of Energy Efficiency (BEE) in association with 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 give impetus to the 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

S.No	Sub – sector	Cluster
1	Brass	Jagadhri, Jamnagar
2	Ceramic	Khurja, Morbi, Thangadh
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 national level;
- Strengthening policy, institutional and decision making frameworks.

1.2 Scope of work of Comprehensive Energy Audit

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

- Data Collection
    - 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 equipment 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 saving 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-long terms requiring moderate investments and with payback ranging from 2.5 to 3 years).
- Classify parameters related to EE enhancements such as estimated quantum of energy saving, 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 & equipment which were working during the field study
- All appropriate measuring system 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.

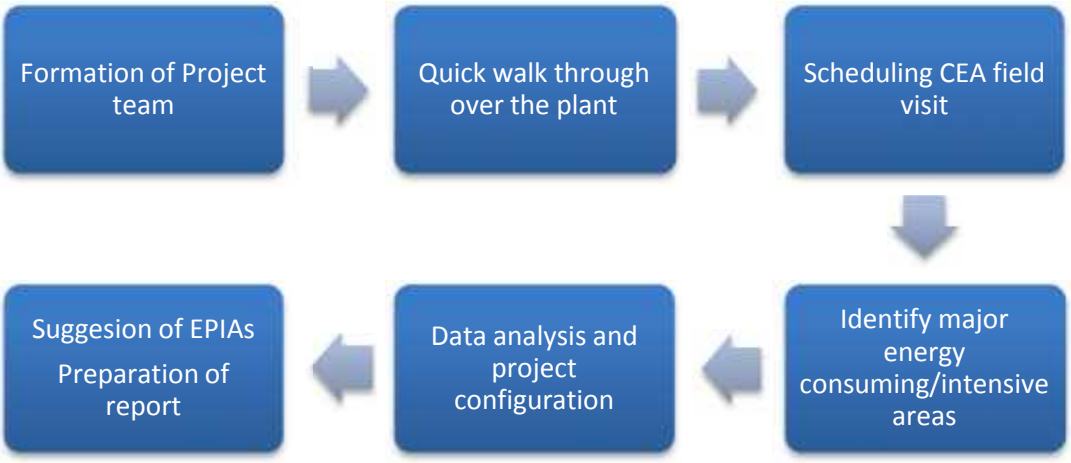


Figure 1 General methodology

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:** Detail energy audit-testing & measurement for identification of saving 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 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 was carried out before the comprehensive energy audit with a view to:

- Understand the manufacturing process and collect historical energy consumption data
- Obtaining cost and other operational data with a view to understand 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 equipment's and systems for testing and measurement

The audit identified the following potential areas of study;

- PNG fired tunnel kiln
- 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 & energy flow diagrams
- Study of the system & associated equipment.
- Conducting field testing & measurement
- Data analysis for preliminary estimation of saving 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 the efficiency. The following instruments were used during the energy audit.

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
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	CIG		Temperature upto 1300℃

	Temperature Meter			
13	Lux Meter	KusumMeco (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 database or through vendor interactions as required
- Configuration of individual energy performance improvement actions
- Preparation of audit report

2 ABOUT THE MSME UNIT

2.1 Particulars of the unit

Table 5 General particulars of the unit

S. No	Particulars	Details
1	Name of the unit	Tamco Ceramic
2	Constitution	Private
3	Date of incorporation / commencement of business	NA
4	Name of the contact person Mobile/Ph.No. E-mail ID	Mr. ChiragChavda (co-owner) +91-9979-072777 chiragchawda@yahoo.co.in
5	Address of the unit	S/N 87/5,Opp Railway Station, Thangadh-363530, Gujarat, India
6	Industry / sector	Ceramic
7	Products manufactured	Ceramic Electric Porcelain
8	No. of operational hours	24
9	No. of shifts / day	3
10	No. of days of operation / year	250
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

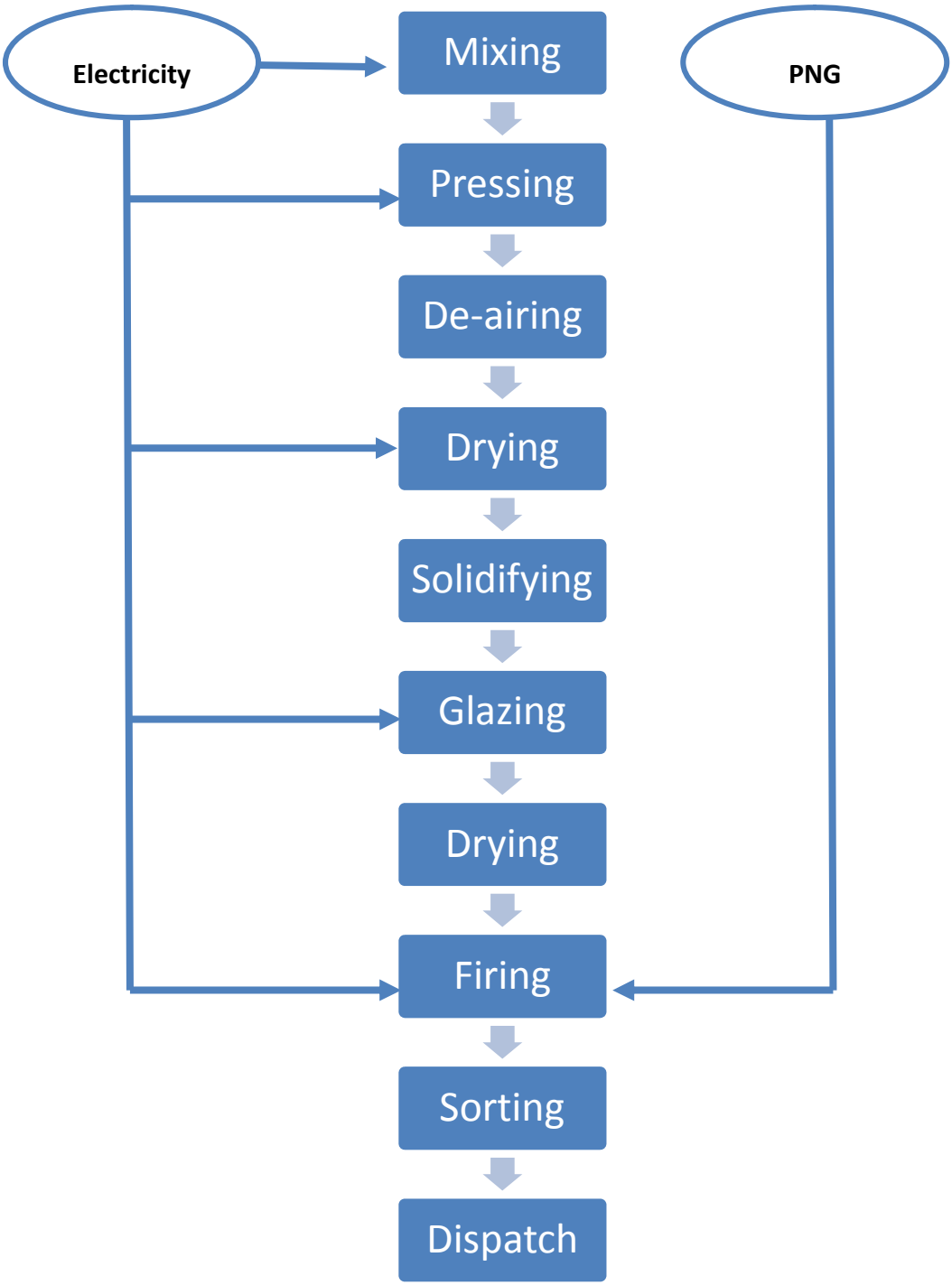


Figure 2 Process Flow Diagram

3.1.1 Process description

Tamco Ceramic is a electric ceramic porcelain 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.
- It is then transferred in to the filter press for extracting moisture. The press creates cakes of raw material which is then allowed to dry into natural atmosphere.
- These cakes after drying are powdered and used in dye press for shaping. The dye press is operated in two ways, manually and using hydraulic power.
- The molds are allowed to dry under ceiling fans for about 1 day depending on atmospheric humidity.
- Then the materials are 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 / equipment and utilities

The major energy consuming equipment's in the plants 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 porcelain product.
- **Air Compressor:** Pressurized air is used at several locations in a unit viz. pressing of slurry, air cleaning, glazing etc.
- **Filter press:** Extraction of water from the liquid ceramic composition takes place in it. At the end of press cakes of ceramic composition is formed.
- **Hydraulic press:** Powdered ceramic composition is pressed into dye for shaping. The press stress is set so as to meet the designed solid strength of product.
- **Tunnel Kiln:** The shaped materials are glazed, painted and then stacked on the kiln car which is then sent for firing in the tunnel kiln with the help of pusher motor kept at a specified rpm. The tunnel is about 42 m long and the temperature gradually increases up to firing zone and then decreases (in the cooling zone) with the highest temperature being 1230 ^{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 is used in different manufacturing processes. The overall energy use 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 July-14 to June-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	9.43	9.4	10.66	4.86
Diesel – DG	NA	0	0	0
Thermal – PNG	91	90.6	208.68	95.14
Total	100.4	100	219.34	100

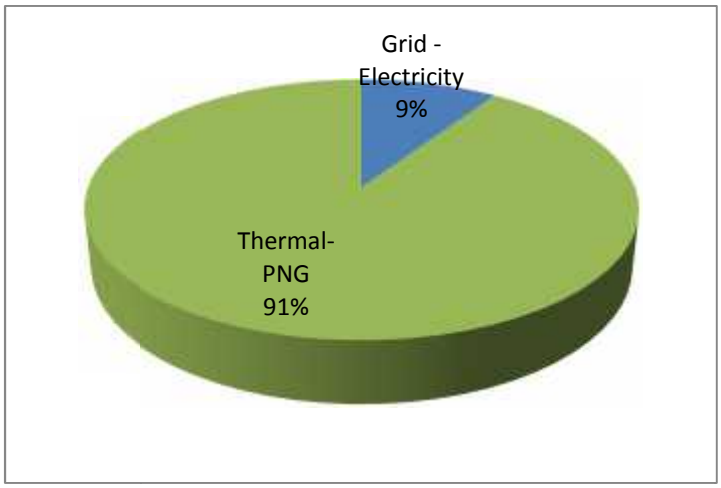


Figure 3 Energy cost share (Rs. Lakh)

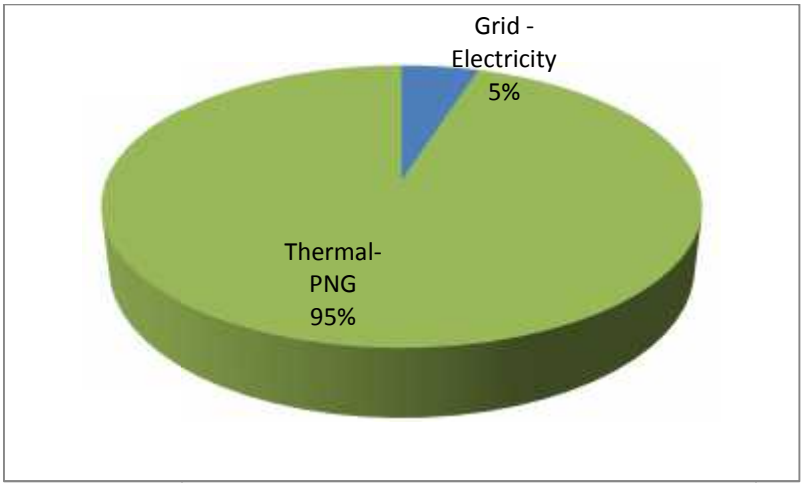


Figure 4 Energy use share (MTOE)

The major observations are as under

- The unit uses both thermal and electrical energy for the manufacturing operations. Electricity is sourced from the grid as well as self-generated in 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 account for 91% of the total energy cost and 95% of overall energy consumption.
- Electricity used in the process accounts for the remaining 5% 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 51.4 kW
- The utility load (lighting, compressed air and fans) is about 16.4 kW including the single phase load
- The plant total connected load is 67.8kW

Table 7 Area wise electricity consumption (estimated)

Sr. No.	Equipment	Numbers	Capacity (kW)	Total capacity
1	Ball mill motor	5	3.75	18.75
2	Glazing Ball Bill	3	2.25	6.75
3	Compressor	1	11.25	11.25
4	Air blower	2	3.75+5.6	9.375
5	Filter Press	1	7.5	7.5
6	Hydraulic Press	3	3	9
7	Lighting loads	50	0.045	2.25
8	Fan Load	48	0.06	2.8
	Total			**67.75**

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

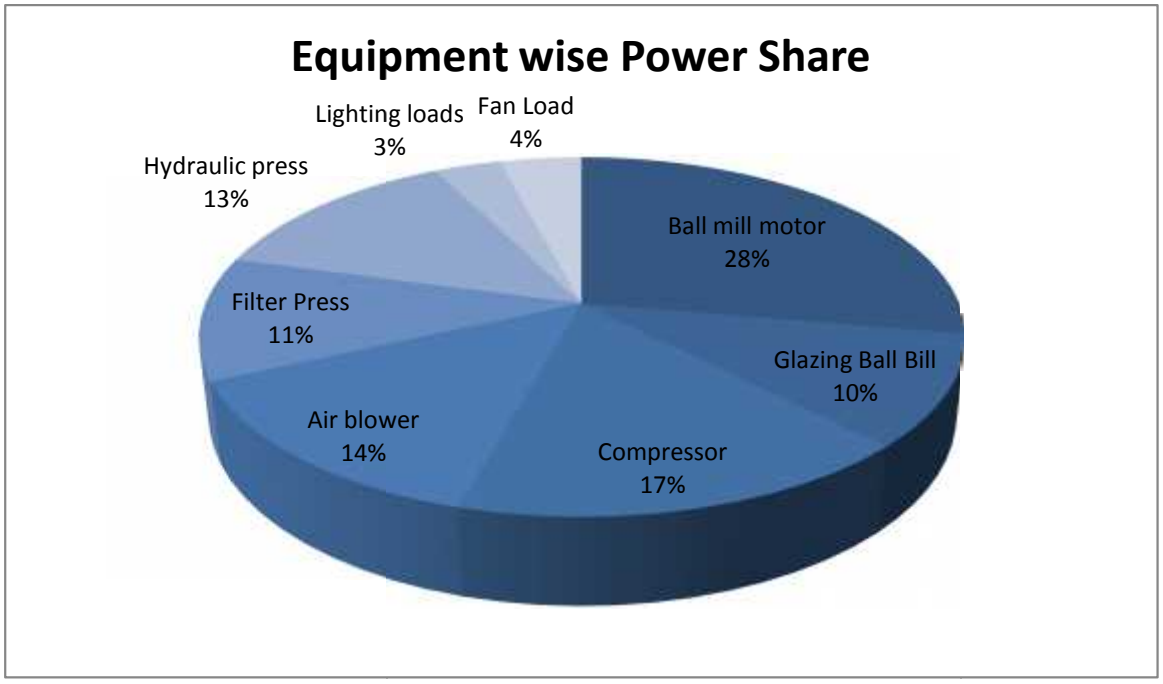


Figure 5 Details of connected load

As shown in the pie chart of connected loads, the maximum share of connected electrical load is for the ball mill – 38%, followed by air compressor – 17%, Air blower – 14%, Hydraulic press – 13%, Other machinery includes filter press – 11%, ceiling fan- 4% and lighting load – 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.

(As per bill for June – 15)

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

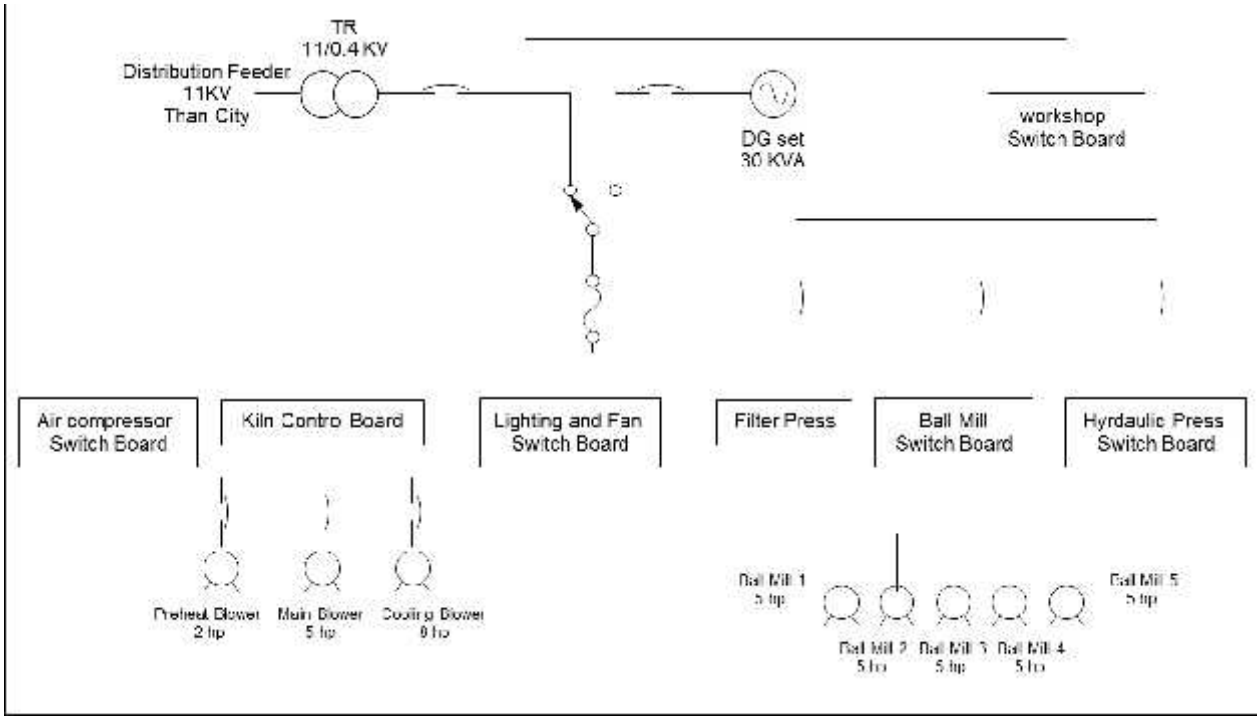


Figure 6 SLD of electrical load

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 0.7 with the minimum being 0.59 and the maximum being 0.86.

Maximum demand

Maximum demand as reflected in the utility bill is 65 kVA from the bill analysis.

3.3.3 Month wise electricity consumption

Electricity bill from month April-2015 to July-2015 were shared by unit owner. A month wise total electrical energy consumption from different source is shown as under:

Table 9 Electricity consumption & cost

Month	Electricity Consumption (kWh\Month)	Electricity cost (Rs.\Month)
Aug-14	10334.3	77140
Sep-14	10334.3	77140
Oct-14	10334.3	77140
Nov-14	10334.3	77140
Dec-14	10334.3	77140
Jan-15	10334.3	77140

Feb-15	10334.3	77140
Mar-15	10334.3	77140
Apr-15	13690	95290
May-15	6779	51075.4
Jun-15	10960	76342.4
Jul-15	9908	78129.4
Total	124011.4	917957.2

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. Based on the gas bill shared for the month of May-15 to July-15 an annual fuel consumption has been extrapolated as under:

Table 10 PNG used as fuel

Month	Fuel Consumption (SCM/Month)	Rs./Month
Jun-14	20177.1	762695.6
Jul-14	20177.1	762695.6
Aug-14	20177.1	762695.6
Sep-14	20177.1	762695.6
Oct-14	20177.1	762695.6
Nov-14	20177.1	762695.6
Dec-14	20177.1	762695.6
Jan-15	19744.1	746327.0
Feb-15	19744.1	746327.0
Mar-15	16576.2	626580.4
Apr-15	14863	557362.5
May-15	29092.2	1088048.3
Total	**241259.53**	**9103514.6**

3.5 Specific energy consumption

Annual production data was available from the unit in metric tonnes (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	124011	kWh
Annual DG Generation Unit	NA	kWh
Annual Total Electricity Consumption	124011	kWh
Annual Thermal Energy Consumption (PNG)	241259.53	SCM
Annual Energy Consumption; MTOE	219.35	MTOE
Annual Energy Cost	100.29	Lakh Rs
Annual Production	1150	MT
SEC; Electricity from Grid	108	kWh/MT
SEC; Thermal	210	SCM/MT
SEC; Overall	0.19	MTOE/MT
SEC; Cost Based	8720	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
- GCV of PNG : 8650kCal/SCM
- CO_2 Conversion factor
  - Grid : 0.89 kg/kWh
  - Diesel : 3.07 tons/ ton

3.6 Baseline parameters

The following are the general base line parameters, which have been considered for the techno-economic evaluation of various identified energy cost reduction projects as well as for the purpose of comparison 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	7.2	Rs./ kWh for 2013-14
Percentage of total DG based Generation	NA	
Average Cost of PNG	37.8	Rs./SCM
Operating Days per year	250	Days / year
Operating Hours per day	24	Hours / day
Production	1150	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 few ideas of EPIAs were developed. Summary of key observations are 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 observation has 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 77 kVA	The maximum kVA recorded during study period was82 kVA. As per utility bill; the MD is77 KVA which is more than the contract demand.	No EPIAs were suggested.
Power Factor	Unit has an LT connection and billing is in kWh. The utility bills reflect the PF of the unit. The unit does not have an APFC panel installed to control the power factor.	The average PF found during the measurement was 0.7.It varies between 0.6 and 0.86.	No EPIAs suggested as the actual cost of reactive power is too low
Voltage variation	The unit has no Servo stabilizers for voltage regulation.	The voltage profile of the unit is satisfactory and average voltage measured was 420 V. Maximum voltage was 425 V and minimum was 416 V.	No EPIAs suggested

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 and about 20% is in utilities.

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

Name of Area	Present Set-up	Observations during field Study & measurements	Proposed Energy performance improvement actions
Ball mill	There are 8 ball mills in the unit out of which 5 are	Out of the 5ball mills 2 of 1.5 T was on operation during CEA and its characteristics were studied.	No EPIAs were suggested for ball mill.

<table>
<tr><td></td><td>connected with 5 HP motors and 3 with a 4 HP motor respectively. Ball mills account for 38% of overall electrical power consumption.</td><td>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 (5 HP)</td><td>2.09</td><td>0.68</td></tr></table></td><td></td></tr>
<tr><td>Air Compressor</td><td>The unit has 1 air compressor. Rated load is 11.25 KW and operating set point pressure is 6 bar</td><td>Many air leaks were found inside the unit. Loading power of compressor is as below:<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Air compressor</td><td>9.5</td><td>0.92</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.</td><td>Data logging was carried out on 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>2.82</td><td>0.785</td></tr><tr><td>Fire Zone</td><td>3.22</td><td>0.575</td></tr></table></td><td>EPIA suggested for maintaining the draft pressure by adjusting Kiln blowers. VFD operated air blower controlled by PID automation is suggested.</td></tr>
</table>

3.7.4 Thermal consumption areas

As discussed in our earlier section Kiln accounts for about 90% of energy cost and 93% 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

Sr. No	Parameter	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**	28	hour
5	**Kiln cars per day**	16	-
6	**Stock weight per kiln car**	320-350	kg
7	**Waste Heat recovery option**	No	

Table 15 Kiln Dimensions

Zone	Height	Width	Length	UoM
Preheating	1.4	1.4	16	Meter
Firing	1.7	3	8	Meter
Cooling	1.4	1.4	18	Meter

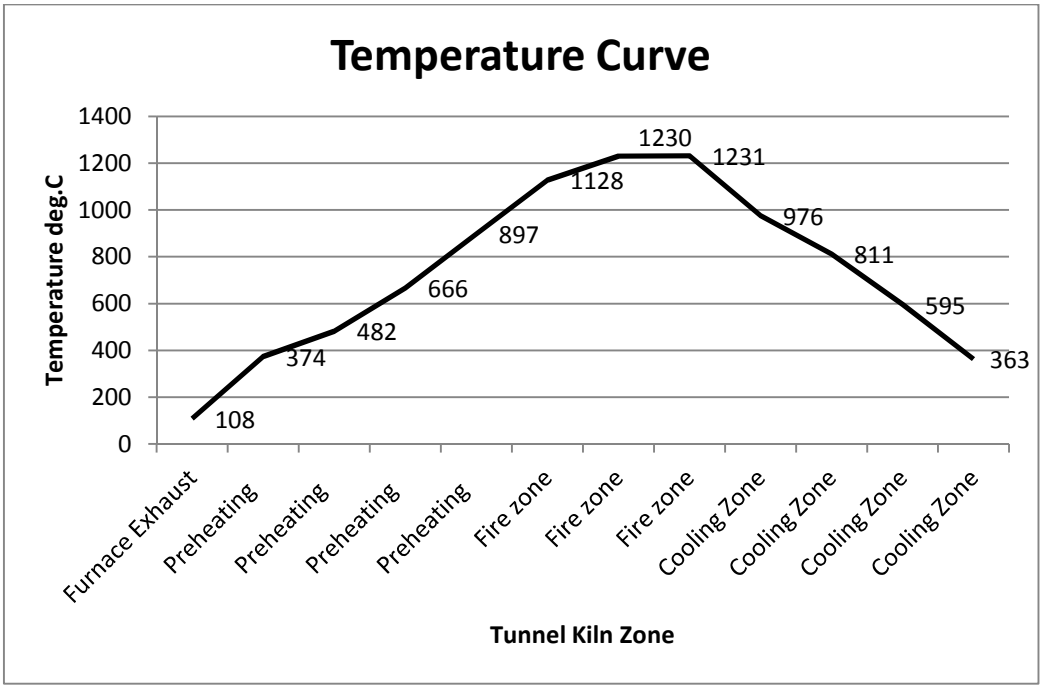


Figure 7 Temperature curve of Tunnel kiln

Name of Area	Present Set-up	Observations during field Study & measurements	Proposed Energy performance improvement actions
Kiln	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.	The fuel consumption of kiln has been identified by dip stick method as no metering system was available. **Machine** / **Oxygen Level measured in Flue Gas** / **Ambient Air Temp** / **Exhaust Temperature of Flue Gas** Tunnel kiln / 10.5% / 38Deg C / 108Deg C 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 – 42deg 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	No waste heat recovery recommendations 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 kiln. Reducing opening

	car takes away lot of useful heat.	losses in kiln is recommended. It is recommended to change the kiln car material with other materials of lower specific heat values and that absorbs lesser heat.

4 EE TECHNOLOGY OPTIONS AND TECHNO – ECONOMIC FEASIBILTY

During CEA of plant all energy consuming equipment and processes were studied. The analysis of all major energy consuming equipment and appliances were carried out and the same was discussed in earlier section of this report.

Based on the analysis, Energy Performance Improvement Actions (EPIA) has 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 the losses in a kiln occurs 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 45-50DegC, 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 temperature) between objects in thermal contact or in range of radiative influence.

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

Study and investigation

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

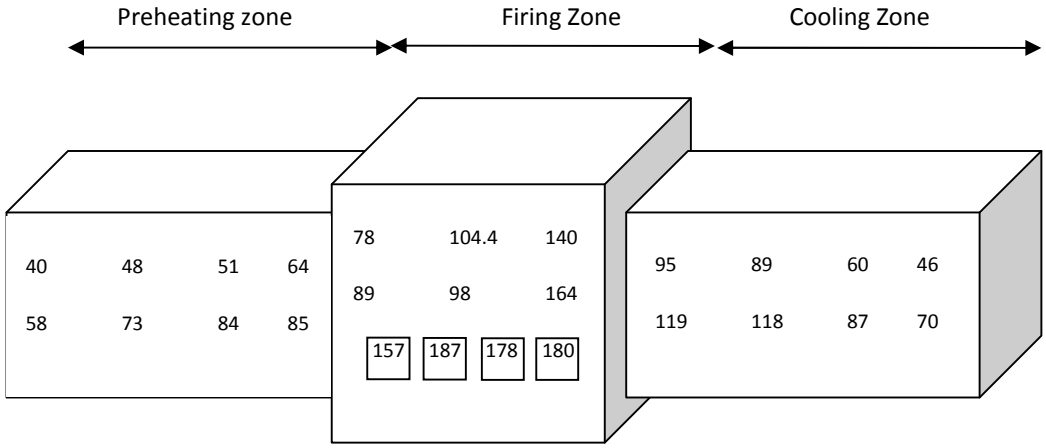


Figure 8 Surface temperature at each zone

Recommended action

Recommended surface temperature of the firing zone has to be brought to within 50 deg. 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	3,167
Heating Zone	kCal / hr	26,832
Cooling Zone	kCal / hr	9,240
Total R&C loss	kCal / hr	39,239

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

Table 17 Cost benefit analysis (EPIA 1)

Parameters	UoM	Value
Present average skin temperature of Heating zone	deg. C	133.00
Recommended skin temperature of Heating Zone	deg. C	50.00
Present heat loss due to Radiation & Convection from Work side wall	kCal / hr	26,832
Recommended heat loss due to Radiation & Convection from Heating zone	W / m2	66.70
	kCal / m2	57.36
	kCal / hr	2,340

Parameters	UoM	Value
Total reduction in heat loss due to Radiation & convection by limiting skin temperature at Heating zone	kCal / hr	24,492
Calorific value of Fuel	kCal / kg	12,652
Equivalent savings in Fuel	kg / hr	1.94
Plant running time	days / year	250
	hrs / day	24
Annual savings in Fuel	kg/y	11615
Cost of fuel	Rs / kg	57.27
Annual Monitory savings	Rs / Year	**665,233**
	Rs. Lacs / Year	**6.65**
Estimated investment	Rs. Lakh	1.2

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 process requires 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 whereas too little excess air results in in-complete combustion of fuel and formation of black colored smoke in flue gases.

In general, in most of the kilns, fuel is fired with too much excess air. This result in the 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

Presently there was no proper automation and control system installed in the kiln to monitor and maintain optimum excess air levels. 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 percent of excess air will save one percent 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	%	10.50	3.00
Excess air control	%	100.00	16.67
Dry flue gas loss	%	4.92	
Saving in fuel	With every 10% reduction in excess air leads to a saving in specific fuel consumption by 1%		
Specific fuel consumption	kg/t	116.87	107.13
Saving in specific fuel consumption	kg/h		1.87
Saving in fuel consumption per year	kg/y		11200
Savings in fuel cost	Rs. Lakh/y		6.41
Installed capacity of blower	kW	4.25	4.18
Operating hours	hrs/y	6000.00	6000.00
Electrical energy consumed	kWh/y	25500.00	25065.60
Savings in electrical energy	kWh/y		434.40
Cost of electrical energy	Rs. Lakh/y	1.91	1.88
Savings in terms of energy cost	Rs. Lakh/Y		6.45
Estimated investment	Rs. lakh		7.00
Simple payback	y		1.09

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 increases the dead weight of the car. The present kiln car also carries away much of the useful heat supplied to the kilns. This reduces the kiln efficiency. Instead of the present kiln car material, a new material called ultralite[1] 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 450 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 supplied as the heat is being supplied to heat the ceramic material and not the kiln car, but this is a necessary wastage as the materials has to be placed on kiln cars to travel along the kiln. 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 present kiln car material with "ultralite" material with little modification in the arrangement of refractories which will help reduce 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 30% approximately. 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	0.19	0.19
Weight of existing kiln car	kg	450	450
Total number of kiln car inside kiln	Nos.	16	16
Initial temperature of kiln car	Deg c	36	36
Final temperature of kiln car	Deg c	1229	1229
Estimated percentage saving by new kiln car material	%		30
Heat carried away by the kiln material	kcal/hr	51,584	36109
Reduction in the heat carried by the kiln	kcal/hr		15,475

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

Operating hrs of kiln	hrs	6000	6000
Savings in terms of fuel consumption	kg/y		7,339
Savings in terms of cost	Rs. Lakh/y		4.2
Estimated investment of kiln material	Rs. Lakh/y		4.80
Payback period	y		1.1

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 the power consumption and also result in higher illumination (lux) levels for the same power consumption.

Study and investigation

The unit is having 30 CFLs each of 45W.

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 CFL	Nos.	35	35
Power consumed by the CFL 23 Watt	W	23	16
Total no. of 23 watt CFL	Nos.	30	30
Total power consumption	kW	2	1
Operating Hours/day	Hr	18	18
Annual days of operation	Day	250	250
Energy Used per year/fixture	***kWh***	***10,193***	***4,680***
Energy Rate	Rs/kWh	**7.50**	**7.50**
Operating cost per year	Rs. Lakh/Year	0.76	0.35
Saving in terms of electrical energy	kWh/Year		5513
Savings in terms of cost	Rs. Lakh/Year		0.41
Investment per fixture of LED	Rs. Lakh		0.009
Investment of project	Rs. Lakh		0.59

Payback period	Years	1.41

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 half. The energy efficient fans have a noiseless operation and it is controlled by electronic drives which on speed reduction will automatically sense the rpm and reduce the power consumption. Since large number of ceiling fans are used in the ceramic units for drying purposes these EE fans can be best suited for energy conservation.

Study and investigation

The unit is having about 48 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	48	48
Run hours per day	H/d	24	24
Power consumption at Maximum speed	kW	0.06	0.04
Number of working days/year	days	250	250
Tariff for Unit of electricity	Rs./kWh	7.2	7.2
Fan unit price* (use '0' for ordinary fan if replaced)	Rs./piece	0	3000
Electricity consumption:			
Electricity demand	kW	2.88	1.68
Power consumption by fans in a year	kWh/y	17280	10080
Savings in terms of power consumption	kWh/y	7200	
Savings in terms of cost	Rs. Lakh/y		0.52
Estimated investment	Rs. Lakh/y		1.44
Payback period	y		2.78

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. From this we can set 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 is not 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 system installed in the DG sets and in kilns like on-line flow-meters.

Recommended action

It is recommended to install online electrical energy monitoring systems (smart energy meters) on the main incomer and on the various electricity distribution panels.. This measure will help in reduction in energy consumption by 3% approx. 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 saving	%	3.00	
Energy consumption of major machines per year	kWh/Yr	124,011	120,291
Annual electricity saving per year	kWh/Yr		3,720
W. Average Electricity Tariff	Rs/kWh		7.50
Annual monetary savings	lakh Rs/yr		0.28
Estimate of Investment	Lakh Rs		0.25
Simple Payback	Months		10.75
Energy monitoring saving	%		3.00
Current fuel consumption	kg/y	19,201	18625
Annual fuel saving per year	kg/y		**576**
Unit Cost	Rs./kg		57.27
Annual monetary savings	Lakhs Rs/year		0.33
Estimate of Investment	Lakhs Rs		0.20
Simple Payback	years		0.61

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)	1229	*Deg C*
Initial temperature of kiln car	36	*Deg C*
Avg. fuel Consumption	22.4	*kg/hr*
Flue Gas Details		
Flue gas temp.	108	*deg C*
Preheated air temp./Ambient	36	*deg C*
O2 in flue gas	10.5	*%*
CO2 in flue gas	6.3	*%*
CO in flue gas	5650	*ppm*
Atmospheric Air		
Ambient Temp.	36	*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	450	*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*

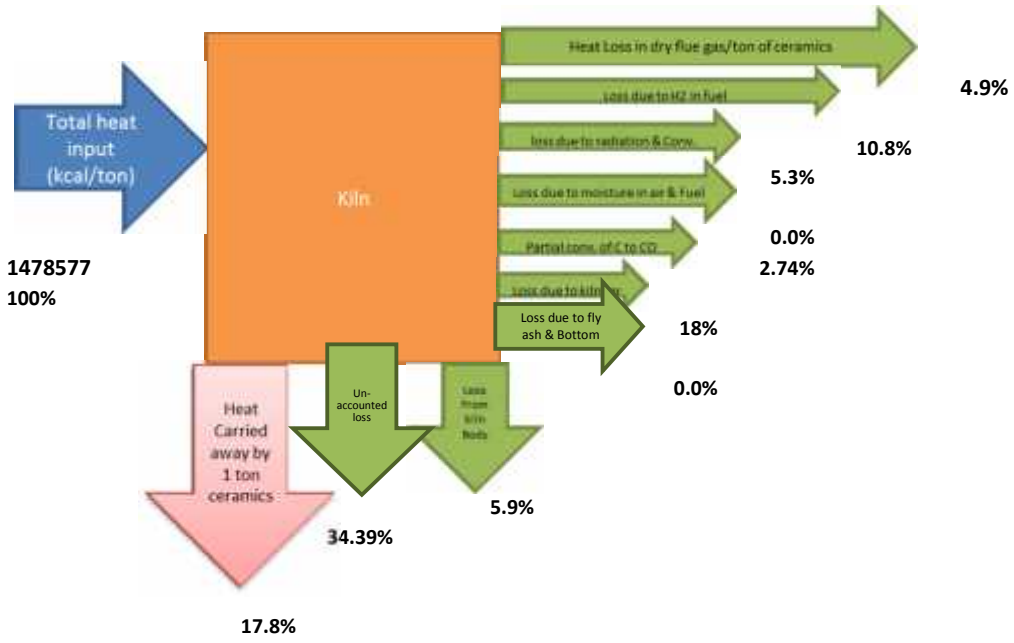
Input Data Sheet		
Specific heat of kiln car material	0.23	*Kcal/kgdegC*
Avg. specific heat of fuel	0.559	*Kcal/kgdegC*
fuel temp	36	*deg C*
Specific heat of flue gas	0.26	*Kcal/kgdegC*
Specific heat of superheated vapour	0.45	*Kcal/kgdegC*
Heat loss from surfaces of various zone		
Radiation and from preheating zone surface	3167	*kcal/hr*
Radiation and from heating zone surface	26832	*kcal/hr*
Radiation and from firing zone surface	9240	*kcal/hr*
Heat loss from all zones	39239	*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	28	*Hr*
Area of opening in m2	5.712	*m2*
Coefficient 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	100.00	*%*
Actual Mass of Supplied Air	34.49	*kg/kg of fuel*
Mass of dry flue gas	33.27	*kg/kg of fuel*
Amount of Wet flue gas	35.49	*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	33.27	*kg/kg of fuel*
Specific Fuel consumption	116.87	*kg of fuel/ton of billet*
Heat Input Calculations		
Combustion heat of fuel	1478577	*Kcal/ton of billet*
Sensible heat of fuel	0	*Kcal/ton of billet*
Total heat input	1478577	*Kcal/ton of billet*
Heat Output Calculation		
Heat carried away by 1 ton of ceramics (useful heat)	262460	*Kcal/ton of billet*
Heat loss in dry flue gas per ton of ceramics	72787	*Kcal/ton of billet*
Loss due to H2 in fuel	160141	*Kcal/ton of billet*
Loss due to moisture in combustion air	34	*Kcal/ton of billet*
Loss due to partial conversion of C to CO	40554	*Kcal/ton of billet*
Loss due to convection and radiation (openings in kiln - inlet & outlet of kiln car)	77,833	*Kcal/ton of billet*

Calculations	Values	Unit
Loss Due to Evaporation of Moisture Present in Fuel	0.0	*Kcal/ton of billet*
Total heat loss from kiln (surface) body	87198	*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	269136	*Kcal/ton of billet*
Unaccounted heat lossess	508435	*Kcal/ton of billet*
Heat loss from kiln body and other sections		
Total heat loss from kiln	87198	*Kcal/tons*
Kiln Efficiency	17.8	*%*

1. *Heat Balance Diagram*



6 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 GurinderJeet 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	# 1698, First Floor, Canara Bank Building, Near CheemaChowk, Link	Office: +91-161-4624392, Mobile: +91-	Email: interautoinc@yahoo.com

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
	Sanjeev Sharma)	Road, Ludhiana	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. VinayBharti	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	1st Floor	9810997486,	r.nandakishore@phillips.com,

S.No	Name of Company	Address	Phone No.	E-mail
	Electronics Contact Person: Mr. R. Nandakishore	Watika Atrium, DLF Golf Course Road, Sector 53, Sector 53 Gurgaon, Haryana 122002	9818712322(Yogesh-Area Manager), 9810495473(Sandeep-Faridabad)	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.RahulKhare), (9899660832)Mr.AtulBaluja, 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

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

S.No	Name of Company	Address	Phone No.	E-mail
	Director	Delhi, DL 110075		
2	Aimil Limited Contact Person: Mr. ManjulPandey	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: NeerajVashisht	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