COMPREHENSIVE ENERGY AUDIT REPORT

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

Nawal Ceramics

Industrial Area, G.T Road, Khurja

17-07-2015

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 Khurja 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. Rakesh Aggarawal, MD & CEO for showing keen interest in the energy audit and also thankful to the management of M/s Nawal Ceramics for their wholehearted support and cooperation for the preparation of 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. Tariq Anwar, President, Khurja Pottery Manufacturers associations (KPMA) and Mr. Dushyant K. Singh, Secretary, Khurja Pottery Manufacturers associations (KPMA), Dr. L.K.Sharma, Scientist-in-charge, Central Glass and Ceramic Research Institute (CGCRI), Khurja, its 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
KPMA	Khurja Pottery Manufacturers Association
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
PVVNL	Paschimanchal Vidyut Vitran Nigam 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 Khurja, Uttar Pradesh. The ceramic cluster in Khurja consists of three distinct types of units – pottery works, insulator works and crockery works. The production process of all the three types of units are almost similar in nature and the main difference is in the amount of ceramic material ratios mixed in ball mills and the Firing time required in kilns for the 3 different products. The mail fuel used in the MSME ceramic units of Khurja are diesel blend and 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 – Khurja Pottery Manufacturers Association (KPMA)
3) Submission of reports – comprehensive energy audit, cluster level best operating practices for 5 major energy consuming equipments / processes, list of common regularly monitorable 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	M/s Nawal Ceramics
Constitution	Private Limited
MSME Classification	Small
No. of years in operation	NA
Address: Registered Office	Indl. Area, G.T Road, Khurja – 203131
Administrative Office	Indl. Area, G.T Road, Khurja – 203131
Factory	Indl. Area, G.T Road, Khurja – 203131
Industry-sector	Ceramics
Products Manufactured	Pot
Name(s) of the Promoters / Directors	Mr. Rakesh Aggarawal

Comprehensive Energy Audit

The study was conducted in 3 stages:

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

- **Stage 2:** Detailed energy audit data collection & field measurements for performance evaluation of equipment/system, estimation of saving potential, technology assessment and understanding of project constraints
- **Stage 3**: Data analysis, initial configuration of projects, savings quantification, vendor consultation, interaction with the unit and freezing of projects for implementation and preparation of energy audit report

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 diesel blend. The temperature maintained in kiln is approximately 1150 – 1200℃ (in firing zone).
- There are other equipments, viz. ball mills, filter presses, pug mills, jigger jollies which also contribute to the production process and consume electrical energy.
- The raw material used is a mixture of clay, feldspar and quartz which is mixed along with water to form a slurry. The water and air are removed from this slurry in various process machines and the material is given shape as per requirement using dies and then fired in the kiln for hardening. Later, the material is cooled and packed for dispatch.

Identified Energy Performance Improvement Actions (EPIA)

The comprehensive energy audit covered all of the equipments, which were operational during the field study. The main energy consuming areas in the unit are kilns, which consume more than 70% of the total energy used.

The identified energy performance improvement actions in the kilns include proper insulation on the kiln to reduce radiation and convection heat loss from kiln surface, excess air control and replacement of kiln car material. VFD application is recommended in the pug mill to control its speed. It is also proposed to implement energy efficient fans for cooling and drying of moulds and energy efficient LED lights in place of conventional tube lights. Other EE measures proposed were power factor improvement, reduction in frequency of power generated by DG sets and installing energy monitoring system. 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						
		Diesel Blend	Electricity	HSD	Others	Monetary savings	Estimated investment	Simple payback period
		Liter/y	kWh/y	Liter/y	Rs/y	Rs. lakh/y	Rs. lakh	y
1	Skin loss reduction from the kiln	1437.9				0.7	0.10	0.1
2	Excess air control with separate blower for cooling and combustion air supply	3251	-1611.4			1.4	7.00	5.1
3	Installation of energy efficient fan instead of conventional fan		5292.0			0.5	1.05	2.2
4	Installation of LED fixture instead of T12 tube light system		6804.0			0.6	0.56	0.9
5	VFD installation on PUG mill		2487.5			0.2	0.70	3.1
6	DG Replacement			11103.5		6.0	2.48	0.4
7	Energy monitoring system	2538.0	465.2			1.2	0.55	0.4
8	Power factor improvement		0		0.19	0.2	0.08	0.2
9	Replacement with energy efficient kiln car	10097.7				4.8	4.80	1.0
10	Replacement of present burner with energy efficient burner	4230.0				2.0	0.73	0.4
	Total	21554.7	13437.3	11103.5	0.2	17.6	18.0	1.0

The projects proposed may result in energy savings of up to 27.15% and energy cost saving of up to Rs. 17.6 lakh/y 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:

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

1.2 Scope of work for Comprehensive Energy Audit

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

- Data Collection
  - Present energy usage (month wise) for all forms of energy from July-2014 to June-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 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 to long terms requiring moderate investments and with payback of 5.1 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 obvious and essential environmental and social improvement enhancement measures as part of overall implementation of EE Measures and integrate as part of investment proposals.
- Design an "energy monitoring system" for effective monitoring and analysis of energy consumption, energy efficiency.
- Correlate monthly production data with electricity and fuel consumption for a period of 18-24 months of normal operation for individual sections of the overall plant.

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 in operation during the field study
- All appropriate measuring systems including portable instruments were used
- The identified measures normally fall under short, medium and long-term measures

1.3.2 General methodology

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

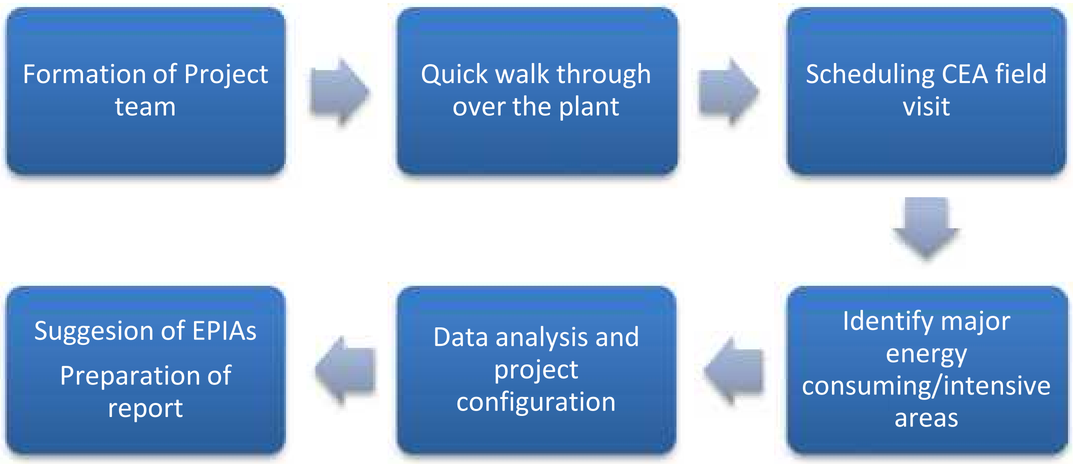


Figure 1: General methodology

The study was conducted in 3 stages:

- **Stage 1:** Walk through energy audit of the plant to understand the process, energy drivers, assessment of the measurement system, assessment of scope, measurability and formulation of audit plan and obtaining required information
- **Stage 2:** Detailed 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 the unit and freezing of projects for implementation and preparation of energy audit report

1.3.3 Comprehensive energy audit – field assessment

A quick walk through was carried out on 15th July, 2015 before the start of audit with a view to:

- Understand the manufacturing process and collect historical energy consumption data
- Obtain cost and other operational data for understanding the impact of energy cost on the 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:

- Diesel blend 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 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 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	Testo	925	Liquid and Surface temperature

Sl. No.	Instruments	Make	Model	Parameters Measured
	Temperature Meter			
12	High touch probe Temperature Meter	CIG		Temperature upto 1300℃
13	Lux Meter	Kusum Meco (KM-LUX-99) and Mastech		Lumens
14	Manometer	Comark	C 9553	Differential air pressure in duct
15	Pressure Gauge	Wika		Water pressure 0 to 40 kg

1.3.4 Comprehensive energy audit – desk work

Post audit off-site work carried out included:

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

2 ABOUT THE MSME UNIT

2.1 Particulars of the unit

Table 5: General particulars of the unit

Sl. No.	Particulars	Details
1	Name of the unit	M/s Nawal Ceramics
2	Constitution	Private
3	Date of incorporation / commencement of business	NA
4	Name of the contact person Designation Mobile/Phone No. E-mail ID	Mr. Rakesh Aggarwal Director
5	Address of the unit	Industrial Area, G.T Road, Khurja – 203131
6	Industry / sector	Ceramic
7	Products manufactured	Pots
8	No. of operational hours/day	24
9	No. of shifts / day	3
10	No. of days of operation / year	180
11	Whether the unit is exporting its products (yes / no)	No
12	No. of employees	35

3 DETAILED TECHNICAL FEASIBILITY ASSESSMENT OF THE UNIT

3.1 Description of manufacturing process

3.1.1 Process & Energy flow diagram

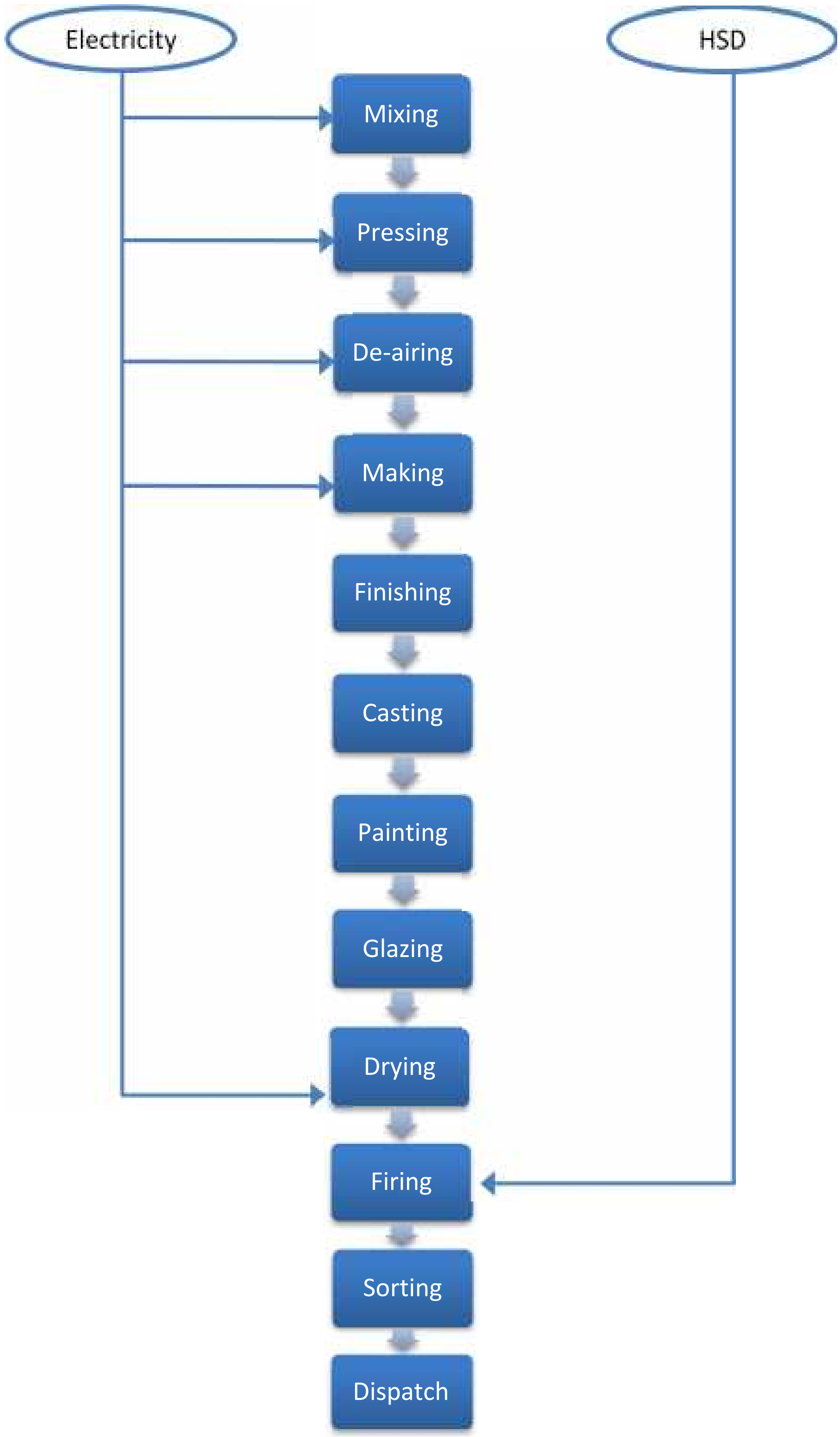


Figure 2: Process flow diagram

3.1.2 Process description

M/s Nawal Ceramics is a manufacturer of porcelain insulators.

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 8 hours.
- This mixture is then transferred to the agitator tank for thorough mixing. With the help of the diaphragm pump, the mixture is transferred to the filter press for water removal.
- The filtered cakes formed are then put into pug mill for removal of air bubbles by means of vacuum pump connected to it.
- Output from pug mill is cut down into smaller sizes and provided shapes as required using jigger jollies after which they are simply dried under fans for a few days.
- Then the materials are glazed and stacked on the kiln cars for firing to obtain strength. The firing zone temperature in the kiln is maintained at 1120 – 1150^{o}C.
- After firing, the products are quality checked, packed and dispatched.

3.2 Inventory of process machines/equipments and utilities

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 slurry.
- **Agitator:** The slurry after getting mixed in the ball mill is poured into a sump where an agitator is fitted for thorough mixing of materials and for preventing them to settle at the bottom.
- **Filter press with diaphragm pump:** The slurry is pumped from the sump to the filter press by means of a diaphragm pump. The filter press contains a number of filter plates to remove water from the mixture. About 40% of water is removed in this process.
- **Pug mill with vacuum pump:** The cakes that are taken out from the filter press are then introduced into the pug mill, which has a positive displacement conveyor connected with the vacuum pump to remove air bubbles in order to avoid pores and formation of cracks during firing. The output from the pug mill is cut in to small pieces and transferred to the shaping section. The moisture content is reduced by 20% in this process.
- **Jigger jollies:** The required shapes of the final product are made by the jigger jollies along with moulds and then dried for complete removal of moisture.
- **Tunnel Kiln:** The shaped materials are glazed and then stacked on the kiln car. They are then sent for firing in the tunnel kiln with the help of pusher motor kept at a specified rpm. The tunnel is about 16 feet long and the temperature gradually increases up to firing zone and then decreases (in the cooling zone) with the highest temperature being 1150^{o}C. Once the kiln car comes out of the cooling zone, the materials are further cooled, quality tested and packed for dispatch.

3.3 Types of energy used and description of usage pattern

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

- Electricity is supplied from two different sources:
  - From the Utility, PVVNL (Paschimanchal Vidyut Vitran Nigam Limited)
  - Captive backup DG sets for the whole plant
- Thermal energy is used for following applications :
  - Diesel blend for tunnel kiln

Total energy consumption pattern for the period June-14 to July-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	1.00	2%	2.0	1.98
HSD– DG	8.25	17%	14.9	14.94
Thermal – Diesel Blend	39.82	81%	83.1	83.08
Total	49.07	100%	100.0	100.00

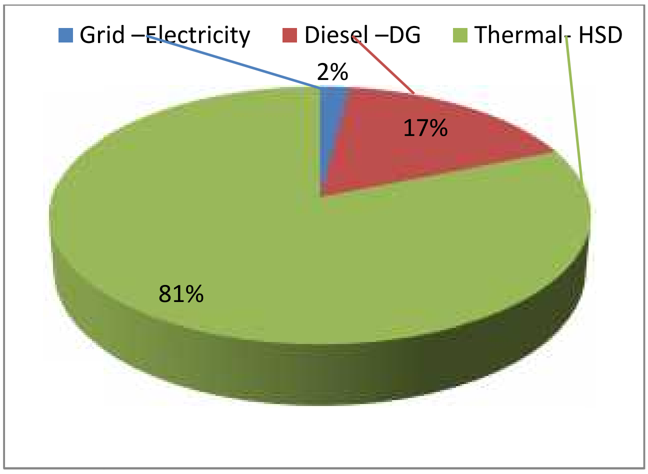


Figure 3: Energy cost share (Rs. Lakh)

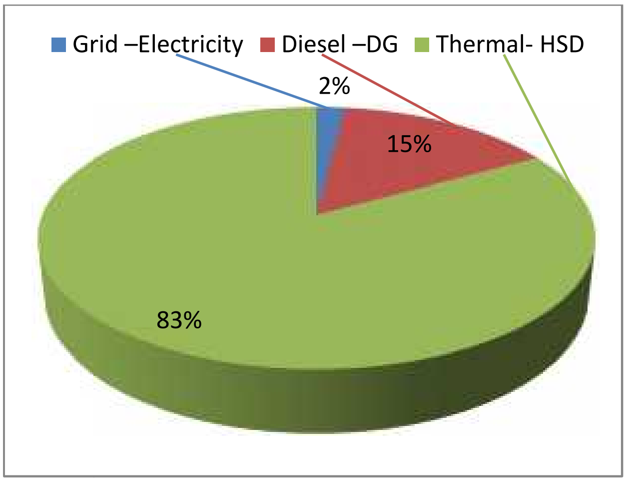


Figure 4: Energy use share (MTOE)

Major observations are as under:

- The unit uses both thermal and electrical energy for manufacturing operations. Electricity is sourced from the grid as well as self generated by a DG set when the grid power is not available. Thermal energy consumption is in the form of Diesel blend, which is used for firing in the kiln.
- HSD used in kilns account for 81% of the total energy cost. HSD used in DG sets account for 15% of total energy cost and electricity used in plant process account for 2% of total energy cost.
- HSD used in kilns account for 83% of overall energy consumption. HSD used in DG sets account for 15% of overall energy consumption and electricity used in plant account for 2% of overall energy consumption.

3.4 Analysis of electricity consumption by the unit

3.4.1 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 the landed costs.

Table 7: Baseline parameters

Electricity cost (Excluding Rs./kVA)	9.05	Rs./ KVAH inclusive of taxes
Percentage of total DG based Generation	39%	
Average Cost of Diesel blend	47.07	Rs./litre
Annual Operating Days per year	180.00	Days/yr
Annual Operating Hours per day	24.00	Hr/day
Production	380	MT

GCV of Diesel blend	11840	kCal/ Litre
Density of Diesel blend	0.853	kg/litre

3.4.2 Electricity load profile

Following observation have been made from the utility inventory:

- The plant and machinery load is 31.0 kW
- The utility load (fans & lighting) is about 5.6 kW including the single phase load
- The plant total connected load is 36.6 kW

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

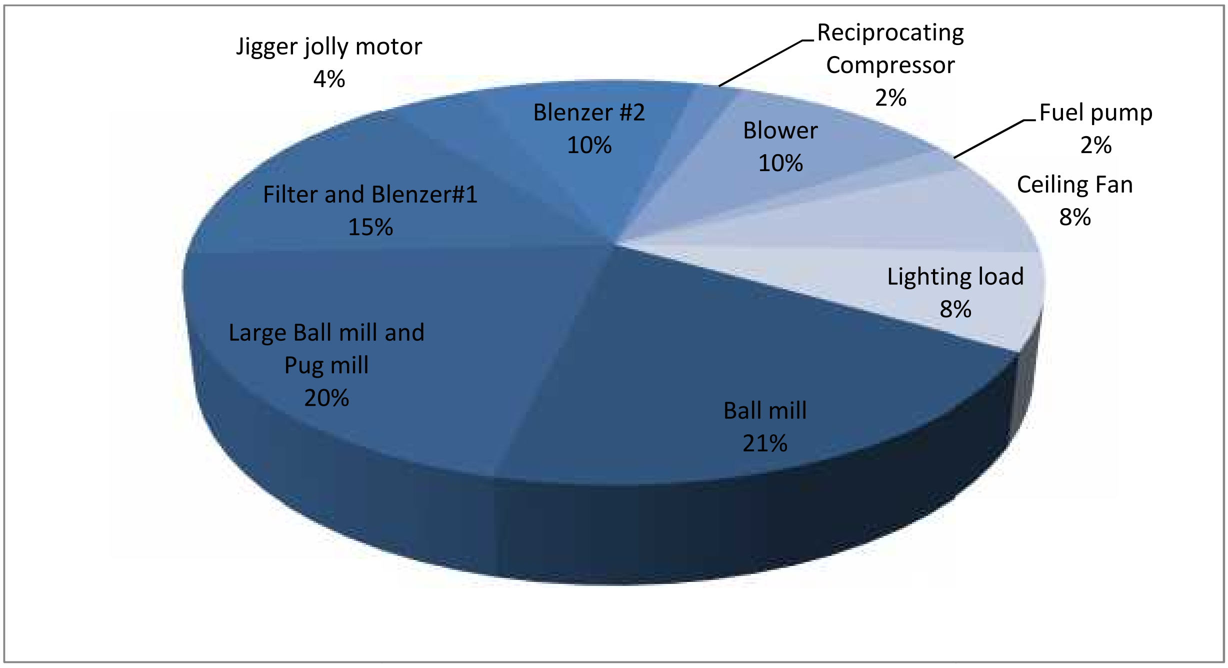


Figure 5: Details of connected load

As shown in the pie chart of connected loads, the maximum share of connected electrical load is for the ball mill – 20%, followed by motor connecting large ball mill and pug mill – 20%, motor connecting filter and Blenzer#1 – 15%, Blenzer#2 and Blower of 10% each. Other machinery including jigger jolly motor and reciprocating compressor – 4% and 2% respectively, fuel pump – 2%, fans – 8% and lighting load accounts for 8% of the connected load.

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

Table 8: Area wise electricity consumption (estimated)

Consumption	kW	kWh/year	% of Total
Ball mill	7.5	3357.00	9.2%
Large Ball mill and Pug mill	7.5	3357.00	9.2%
Filter and Blenzer#1	5.6	2517.75	6.9%
Jigger jolly motor	1.5	671.40	1.8%
Blenzer #2	3.7	1342.80	3.7%
Reciprocating Compressor	0.7	268.56	0.7%
Blower	5.6	12085.20	33.2%
Fuel pump	0.7	2127.00	5.8%
Ceiling Fan	2.8	5322.24	14.6%
Lighting load	2.8	5360.26	14.7%
Total	38.4	36409.2	100%

This is represented graphically in the figure below:

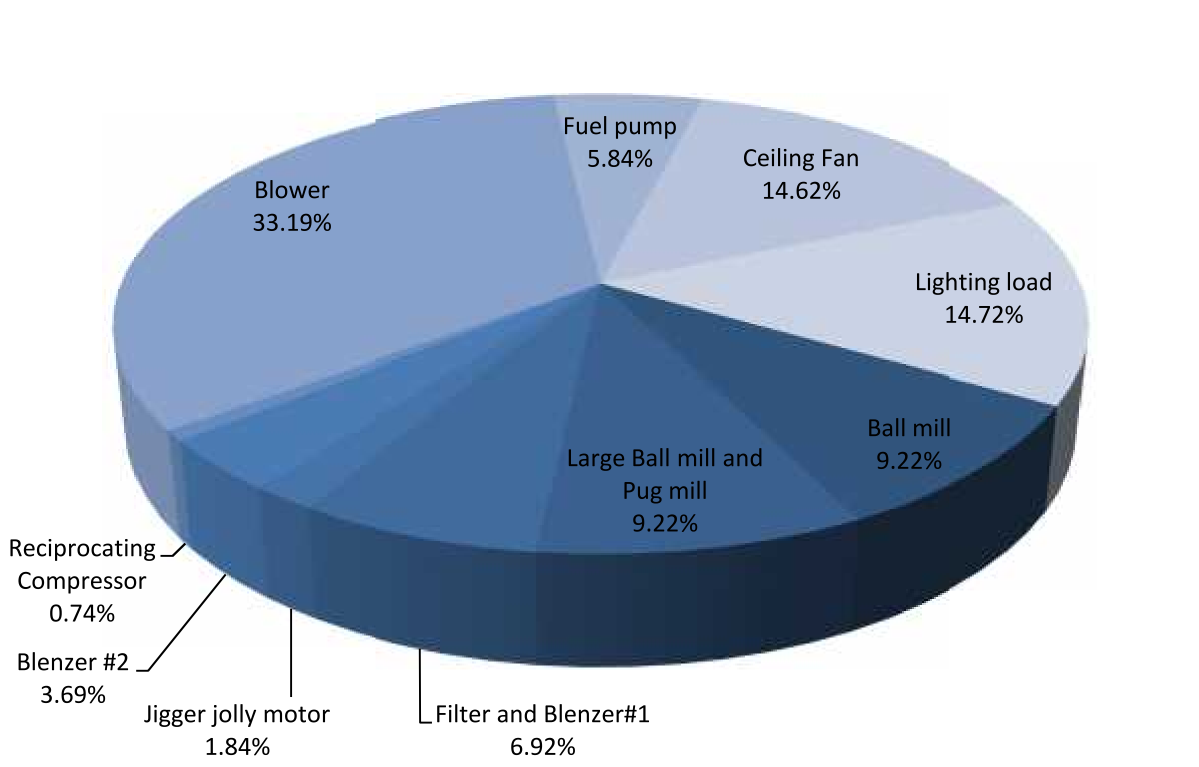


Figure 6: Area wise electricity consumption

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

3.4.3 Sourcing of electricity

The unit is drawing electricity from two different sources:

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

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

Table 9: Electricity share from grid and DG

	Consumption (kWh)	%	Cost (Lakh Rs.)	%
Grid Electricity	22,973	61%	1.0	11
Self Generation	14,602	39%	8.2	89
Total	37,574.74	100%	9.2	100

This is graphically depicted as follows:

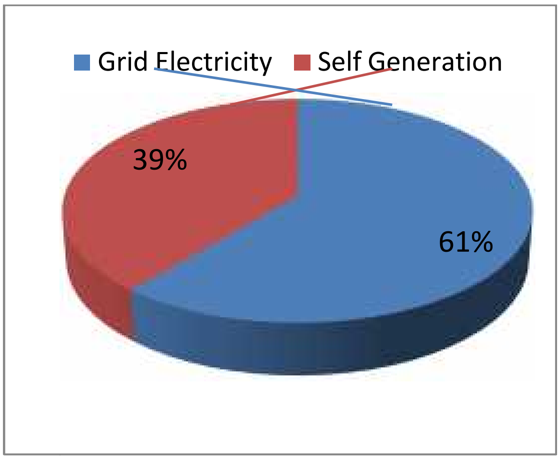


Figure 7: Share of electricity by source

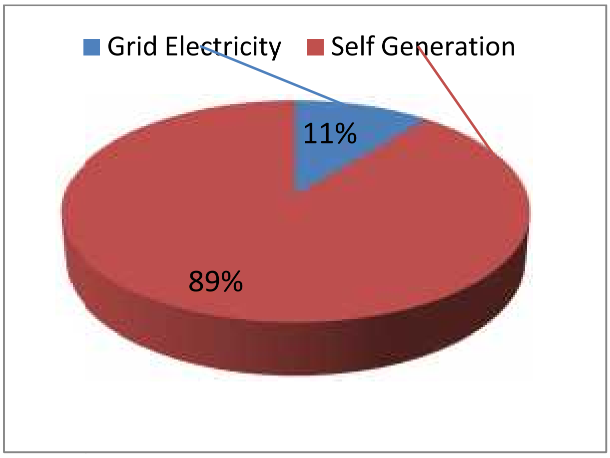


Figure 8: Share of electricity by cost

The share of electrical power as shown in the above chart indicates the condition of power supply from the utility. The requirement of power supply from backup source, i.e. the DG set is about 17% of the total power which is not very high. Although the share of DG power in terms of kWh is just 39% of the total electrical power, but it accounts for about 89% in term of total cost of electrical power. This indicates the high cost of DG power due to rise in the price of HSD. For economical operation, the utilization of DG set needs to be minimized, but it will depend upon the supply condition of the grid as well as power requirement of the plant.

3.4.4 Supply from utility

Electricity is supplied by the Paschimanchal Vidyut Vitran Nigam Ltd. (PVVNL). The unit has one HT energy meter provided by the distribution company in the premise. Details of the supply are as follows:

a)	Meter K No.	:	UP102102
b)	Power Supply	:	0.44 kV line
c)	Contract Demand	:	22 kVA
d)	Sanctioned Load	:	NA
e)	Nature of Industry	:	LT – G

The tariff structure is as follows:

Table 10: Tariff structure

Particulars	Tariff structure	
Energy Charges	5.13	Rs./kVAh
Regulatory	0.41	Rs./kVA
Fuel Surcharge	0.00	Rs./kVAh
Electricity duty	0.00	Rs./kVAh
Municipality tax	0.00	Rs./kVAh

(As per bill for June – 15)

Table 11: Electricity bill analysis

Month	Contract Demand	Bill Demand	Recorded Maximum	PF	Electricity Consumption					Energy - TOD Charges	Demand Charge	Demand Penalty @ (202.5*2)/kVA	Regulatory charges @ 2.84% Energy Amount	Charge due to old meter	Electricity Duty Charge@7.5% of (Demand +Energy Charges)	Total Arrears	Total Charge
	kVA	kVA	kVA		kWh	TOD-1 (kVAh)	TOD-2 (kVAh)	TOD-3 (kVAh)	Total (kVAh)	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Jul-14	22	16	19	0.88					1618	9597	3341.3	0.0	675	0.0	970	58	14643
Aug-14	22	16	18	0.88					1261	7480	3341.3	0.0	564	0.0	811	58	12257
Sep-14	22	16	14	0.88					1651	9793	3341.3	0.0	685	0.0	985	58	14863
Oct-14	22	16	16	0.88					1629	9659	3341.3	0.0	678	0.0	975	58	14713
Nov-14	22	16	13	0.88					1234	7320	3341.3	0.0	556	0.0	799	58	12076
Dec-14	22	16	10	0.90	1432	514	700	375	1590	9232	3341.3	0.0	656	0.0	943	65	14238
Jan-15	22	16	16	0.85	1152	442	601	301	1345	7702	3341.3	0.0	576	0.0	828	52	12501
Feb-15	22	16	14	0.88					2304	13662	3341.3	0.0	887	0.0	1275	58	19225
Mar-15	22	26	26	0.75	3106	1321	1797	1042	4161	25207	5412.8	1915	1598	0.0	2296	78	36509
Apr-15	22	16	20	0.88					3040	18029	3341.3	0.0	1115	0.0	1602	58	24148
May-15	22	23	23	0.88					3463	20537	4787.1	664	1321	0.0	1899	58	29269
Jun-15	22	35	35	0.76	3061	1021	1819	1206	4047	24807	7235.3	5560	1672	0.0	2403	58	41737
Max	22	16	26	0.90	1432	514	700	375	2304	13662	3341.3	0.0	887		1275	65	19225
Min	22	16	10	0.74	1152	442	601	301	1234	7320	3341.3	0.0	556		799	52	12076
Avg	22	16	14	0.87	1292	478	651	338	1579	9264	3341.3		658		945	58	14267
Total					2584	957	1302	676	12634	64850	23388	0.0	4606		6617	412	99875

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

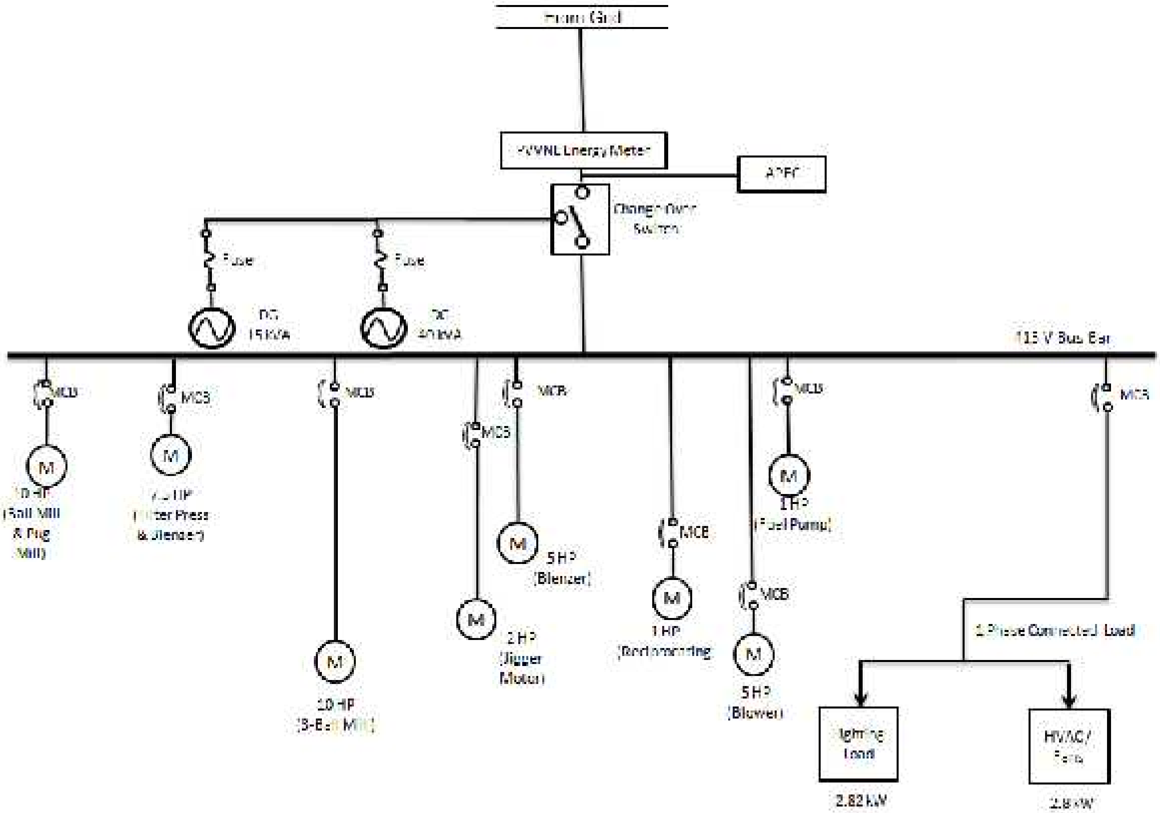


Figure 9: SLD of electrical load

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. The average power factor was found to be 0.57 with the minimum being 0.56 and the maximum being 0.57.

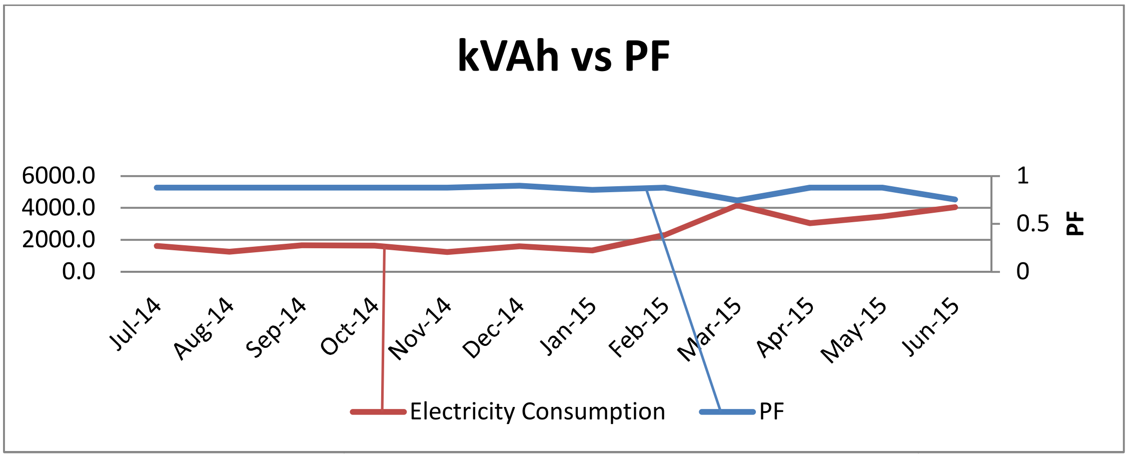


Figure 10: Monthly trend of PF

Maximum demand

Maximum demand as reflected in the utility bill is 26.7 kVA from the bill analysis.

3.4.5 Self – generation

The unit has one DG set of 15 kVA. The unit does not have a system for monitoring the energy consumption and fuel usage in DG. HSD purchase records are, however, maintained by the unit. In order to evaluate the month wise energy contribution by the DG set, the results of performance testing of the DG set carried out during the detailed energy audit was used.

Performance testing was done of the 15 kVA DG set and the specific energy generation ratio (SEGR) was calculated as 0.96 kWh/litre. HSD consumption by the DG sets is 15,275 litres annually costing Rs. 8.24 lakh with a power generation of 14,602 kWh.

Note: Since only month consumption was given by operating person verbally, hence the average value is taken for the evaluation which is correspondingly computed annually too.

3.4.6 Month wise electricity consumption

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

Table 12: Electricity consumption & cost

Months	Electricity Used (kWh)			Electricity Cost (Rs.)		
	Grid	DG	Total	Grid	DG	Total
	kWh	kWh	kWh	Rs.	Rs.	Rs.
Jul-14	1,421	1,217	2,638	14,643	68,740	83,383
Aug-14	1,108	1,217	2,324	12,257	68,740	80,997
Sep-14	1,450	1,217	2,667	14,864	68,740	83,604
Oct-14	1,430	1,217	2,647	14,713	68,740	83,453
Nov-14	1,084	1,217	2,301	12,077	68,740	80,816
Dec-14	1,431	1,217	2,648	14,238	68,740	82,978
Jan-15	1,152	1,217	2,369	12,501	68,740	81,241
Feb-15	2,023	1,217	3,240	19,225	68,740	87,965
Mar-15	3,104	1,217	4,321	36,509	68,740	105,249
Apr-15	2,670	1,217	3,886	24,148	68,740	92,888
May-15	3,041	1,217	4,258	29,269	68,740	98,009
Jun-15	3,060	1,217	4,276	41,738	68,740	110,477
Total	**22,973**	**14,602**	**37,575**	**246,183**	**824,876**	**1,071,059**

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

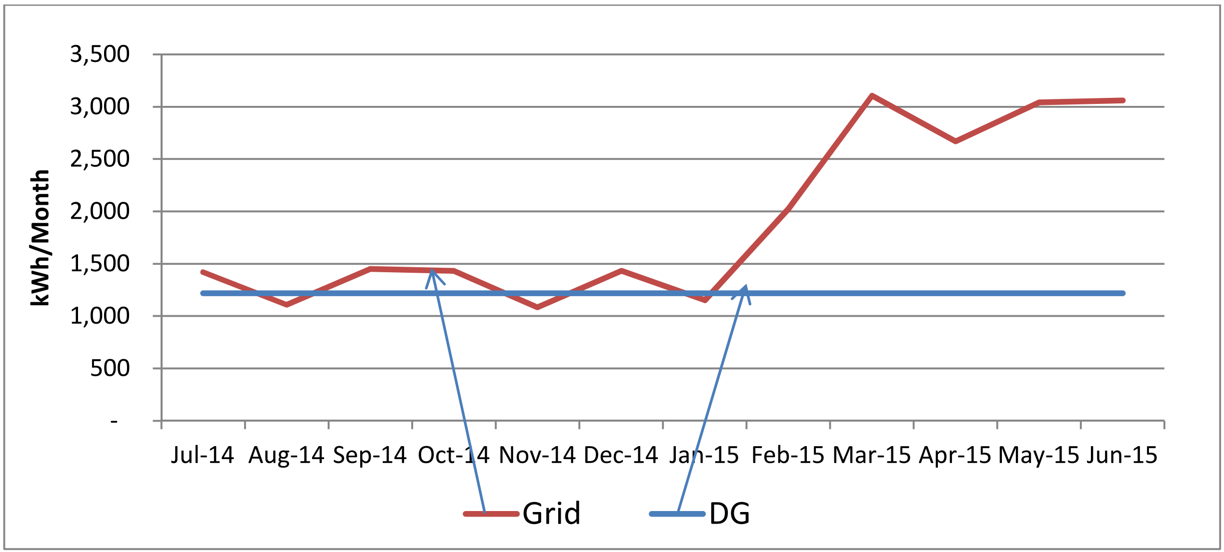


Figure 11: Month wise variation in electricity consumption from different sources

As shown in the figure above, the consumption of electrical energy was on higher side during the months of March, May and June 2015, and it kept on fluctuating over the remaining period. However, it was noticed that electricity consumption during November 2014 was very less because the plant was shut down during that time for maintenance. The corresponding month wise variation in electricity cost is shown in the figure below.

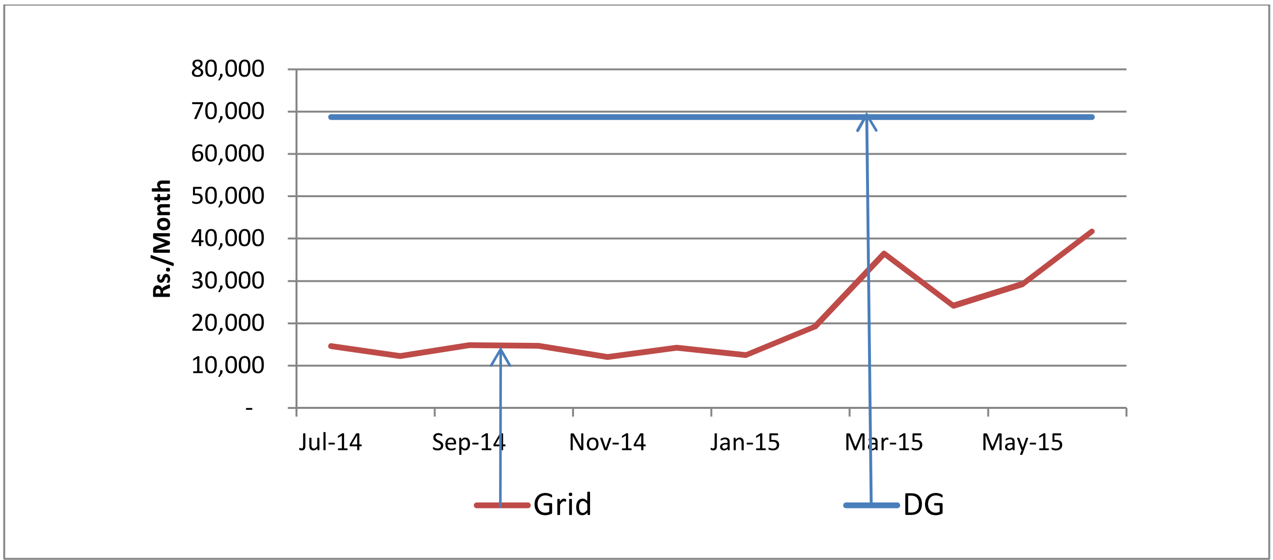


Figure 12: Month wise variation in electricity cost from different sources

From the utility bill analysis, the cost per unit of kWh consumption goes down with the rise in consumption. As the consumption increases, the share of fixed charge goes low and vice versa.

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

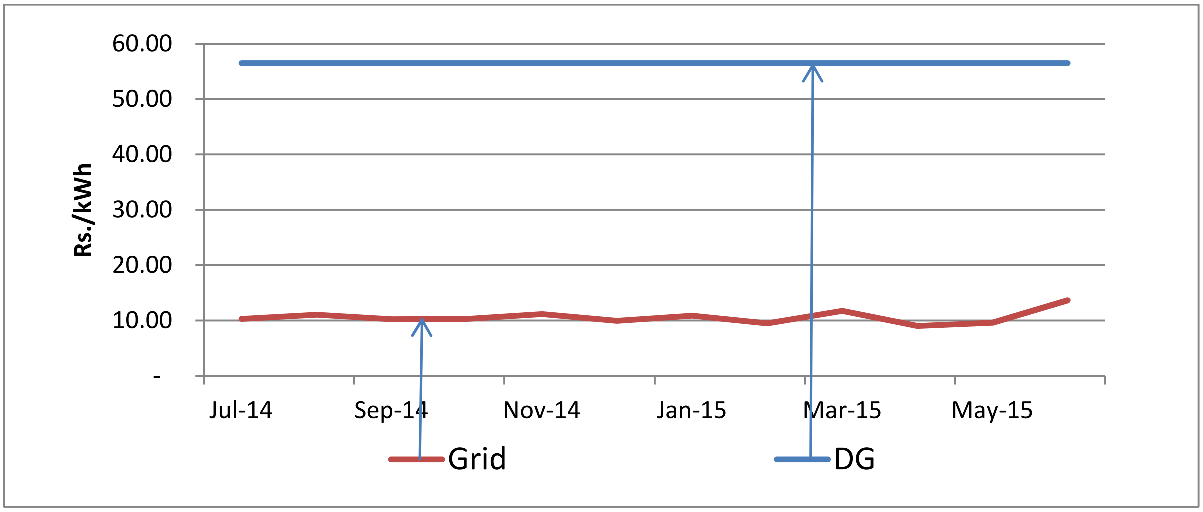


Figure 13: Average cost of power (Rs./kWh) from different sources

The above graph clearly indicates that the cost of electrical energy from DG set is very high, which is nearly 4.5 times the cost of utility power.

3.5 Analysis of thermal consumption by the unit

HSD + tire oil mixture was used as the fuel for firing in the kiln. HSD is procured from local suppliers and the average landed rate is Rs. 47.07/liter. There was no meter installed for the measurement of fuel consumption for kiln. Diesel blend consumption by kilns is 7,050 liter monthly costing Rs. 3.32 lakh.

Note: Since only monthly consumption of diesel blend in kiln was given by the operating person verbally, hence the average value is taken for the evaluation which is correspondingly computed annually too.

3.6 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 13: Overall specific energy consumption

Parameters	Value	UoM
Annual Grid Electricity Consumption	22,973	kWh
Annual DG Generation Unit	14,602	kWh
Annual Total Electricity Consumption	37,575	kWh
HSD Consumption for Electricity Generation	15275	Litres
Annual fuel consumption in kiln (Diesel blend)	84,600	Litres
Annual Energy Consumption; MTOE	100	MTOE
Annual Energy Cost	49.07	Lakh Rs

Annual Production	380	MT
SEC; Electricity from Grid	99	kWh/MT
SEC; Thermal	223	Litre/MT
SEC; Overall	0.263	MTOE/MT
SEC; Cost Based	12907	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
  - 1kg of oil equivalent : 10,000 kCal
- GCV of Diesel blend : 11,840 kCal/ kg
- Density of Diesel blend : 0.8263 kg/litre
- CO_2 Conversion factor
  - Grid : 0.89 kg/kWh
  - HSD : 3.07 tons/ ton

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 PVVNL of the unit were recorded for 1 hour using portable power analyzer. Following observations were made:

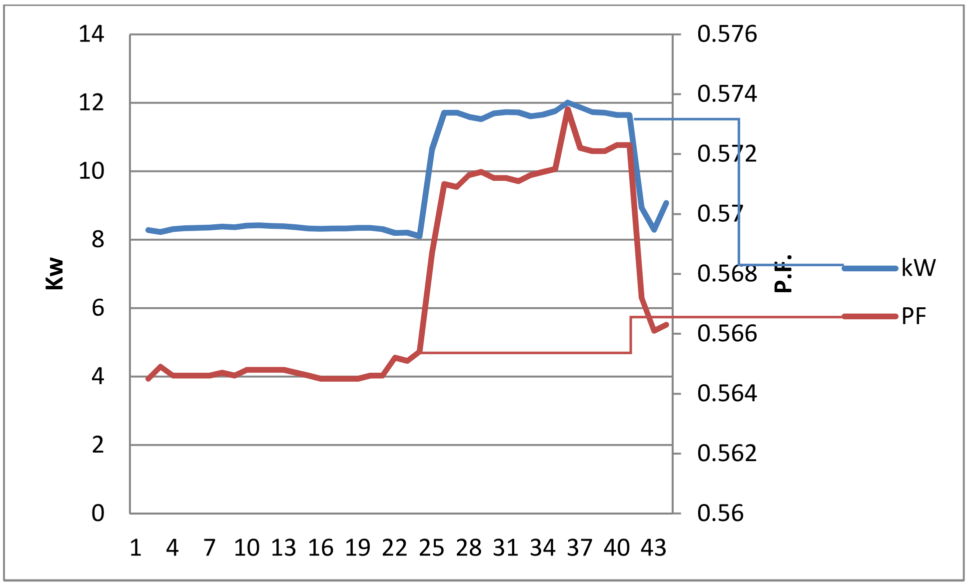


Figure 14: Lad profile and power factor

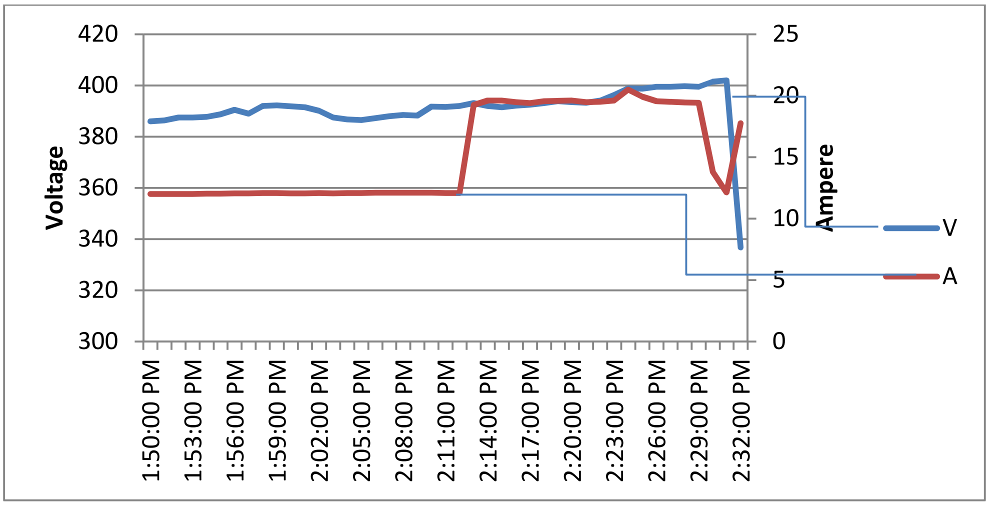


Figure 15: Voltage and current profile

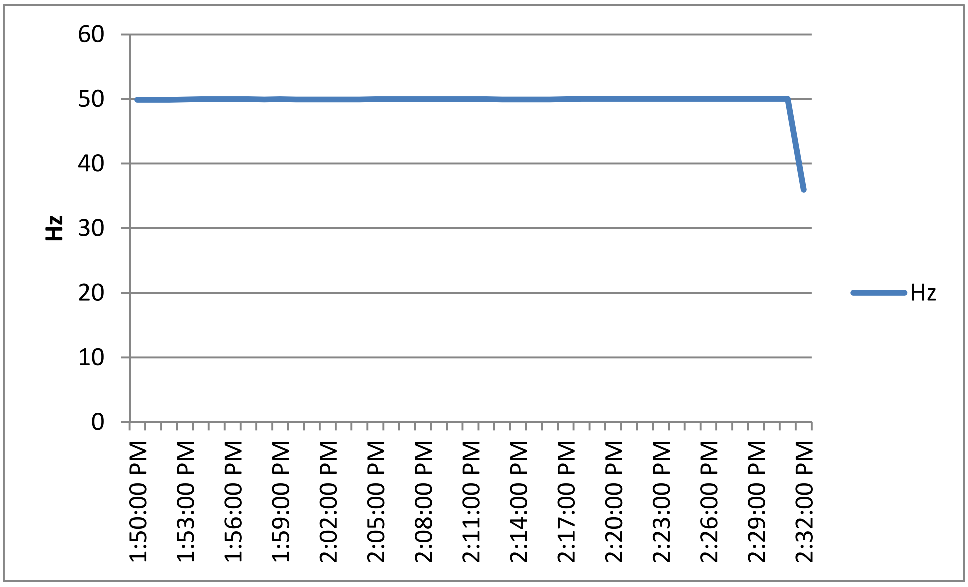


Figure 16: Harmonic Profile

Table 14: 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 PVVNL through a separate transformer. The unit has a HT connection. The contract demand of the unit is 22 kVA.	The maximum kVA recorded during study period was 14.6 kVA. As per utility bill; the MD was 26.7 KVA which is less than the contract demand.	No EPIAs were suggested.

Power Factor	Unit has an HT connection and billing is in kVAh. The utility bills reflect the PF of the unit. The unit has an APFC panel installed to control the power factor.	The average PF found during the measurement was 0.57. It varied between 0.56 and 0.57 where the difference was very large.	Power factor improvement is suggested in the same APFC by adding or changing the de-rated capacitors.
Voltage variation	The unit has no Servo stabilizers for voltage regulation.	The voltage profile of the unit was satisfactory and average voltage measured was 390.9 V. Maximum voltage was 402.0 V and minimum was 336.7 V.	No EPIAs recommended.

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

3.7.2 DG Performance

The unit has one DG set of 15 kVA. Performance testing was conducted for the DG set during the comprehensive energy audit. As part of the performance testing, measurements were conducted on the DG set by keeping track of the HSD consumed (by measuring the top up to the diesel tank) and recording of kWh generated during the same period. The key performance indicators of the DG set are evaluated as follows:

Table 15: Analysis of DG set

Particulars	DG
Rated KVA	15
Specific Energy Generation Ratio (kWh/Litre)	0.96

The observations made are as under:

- The SEGR of DG set was 0.96 kWh/litre
- The power factor was 0.78.
- The present average frequency of the DG set is 47.64 Hz

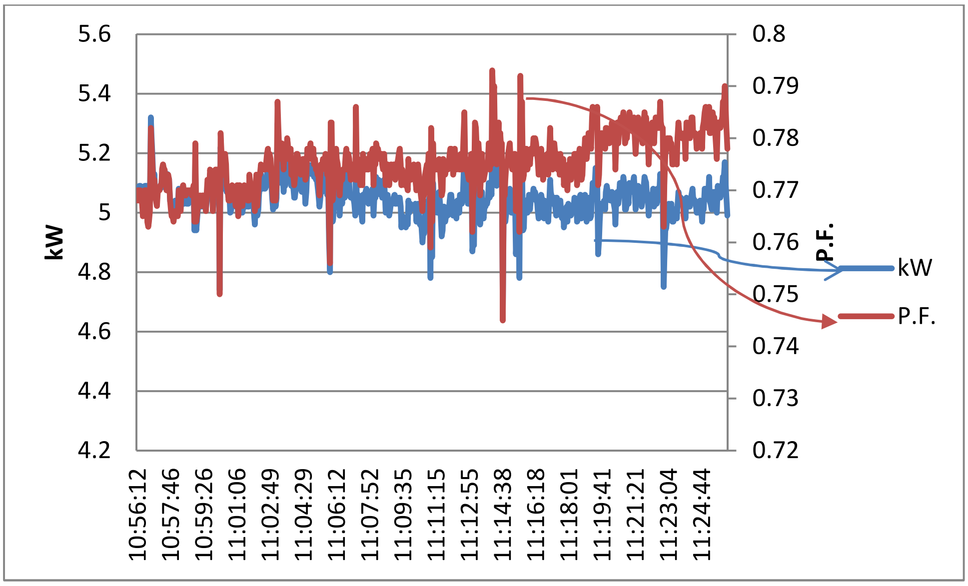


Figure 17: Load and power factor profile of DG set

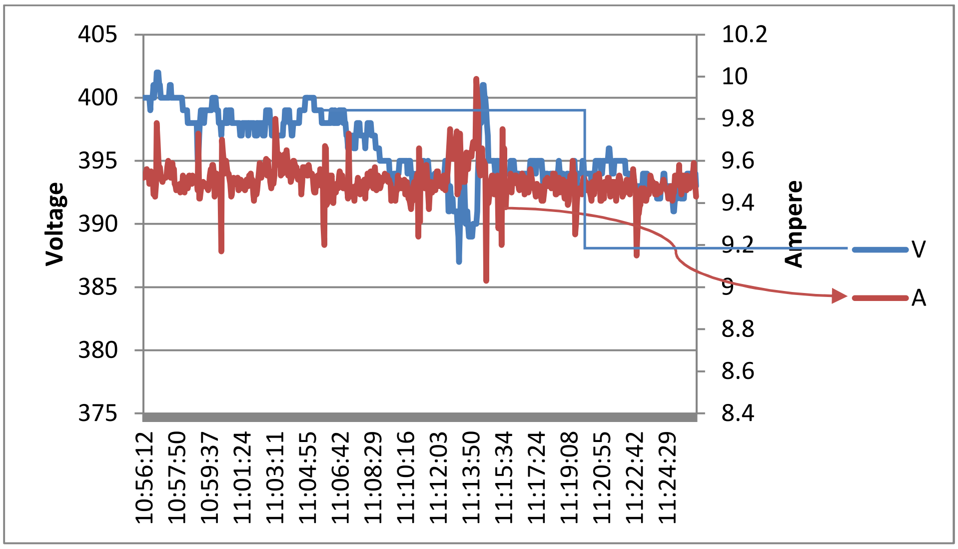


Figure 18: Voltage and current profile of DG set

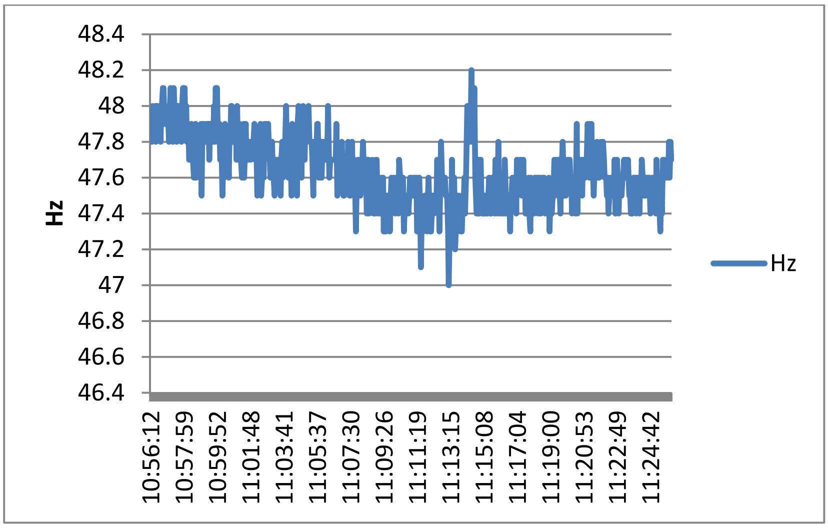


Figure 19: Harmonic profile of DG set

Based on the above observation, it is recommended to replace the DG set.

3.7.3 Electrical consumption areas

The section-wise consumption of electrical energy is shown in Table 6. Over 90% of energy consumption is in the manufacturing operations, while about 5% is in utilities.

The details of measurements conducted, observations 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 4 ball mills in the unit out of which 3 are connected with 10 HP motors and 1 with a 10 HP motor accompanied by pug mill respectively. Ball mills account for 8.9% of overall energy consumption.	Ball mills were not in operation.	No EPIAs were suggested for the ball mill.
DG Set	There are 2 DG sets with rating as 15 kVA and 40 kVA respectively in the unit out of which only 15 kVA DG set was	15 KVA DG set was studied during the CEA. The results of the study are as below:	As SEC is 0.96 kWh/litre, hence an EPIA was suggested for D G replacement.

<table>
<tr><td></td><td>studied during the CEA. The DG set accounts for an estimated 15% of overall energy.</td><td><table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>DG Set</td><td>5.05</td><td>0.78</td></tr></table></td><td></td></tr>
<tr><td>Pug mill</td><td>There is 1 pug mill installed in the unit which is connected with a large ball mill on same 10 HP motor. They account for about 8.9% of total energy consumption.</td><td>Data logging was done on it to establish the power profile.

The results of the study are as below:<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Pug mill</td><td>3.45</td><td>0.65</td></tr></table></td><td>Application of VFD has been suggested on the pug mill based on the loading and unloading profile of power consumption observed.</td></tr>
<tr><td>Kiln blower</td><td>The unit has a kiln blower which is used for supplying combustion and cooling air in the tunnel kiln. The blower account for 21.4% of the total electricity consumption.</td><td>Data logging was carried out on the blower to establish the power profile.

The results of the study are as below:<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Blower</td><td>4.60</td><td>0.87</td></tr></table></td><td>Excess air control by PID controller was suggested as an EPIA.</td></tr>
</table>

3.6.4 Thermal consumption areas

As discussed in the earlier section, kiln accounts for about 81% of energy cost and 83% of the energy use.

Tunnel kilns are steady state continuous kilns. On an average, about 24 to 27 trolleys travel through the kiln in 24 hours. In ceramic industries, kiln is one of the main energy consuming equipment. In Naval Ceramics Diesel blend is used as a fuel in the tunnel kiln to heat the ceramic material to the required temperature. The kiln has three zones as below:

- **Pre-heating zone**: Ceramic material mounted on trolley kiln cars enters the kiln at close to ambient temperature through the preheating zone. Here the ceramic material is preheated by the hot flue gases emanating from the firing zone. The temperature of hot flue gases in pre-heating zone decreases gradually from approximately 800 °C (near the firing zone) to 200°C (near the chimney). This flue gas pre-heats the ceramic material before it enters the main firing chamber. The pre-heating zone acts as waste heat recovery equipment.

- **Firing Zone**: Where fuel is fed and combustion happens. The temperature in firing zone is around 1000°C to 1200°C.

- **Cooling Zone:** Here, fired material is cooled by air blowing through the air curtains. Temperature in cooling zone varies from 800°C (near the firing zone) to 170°C (near the outlet).

There are four burners installed in the kiln, two main burners and two auxiliary burners. The main burners are at the back side and the auxiliary burners are installed at the side walls. There is only one blower which supplies combustion air to all the burners as well as supplies cooling air through air curtains.

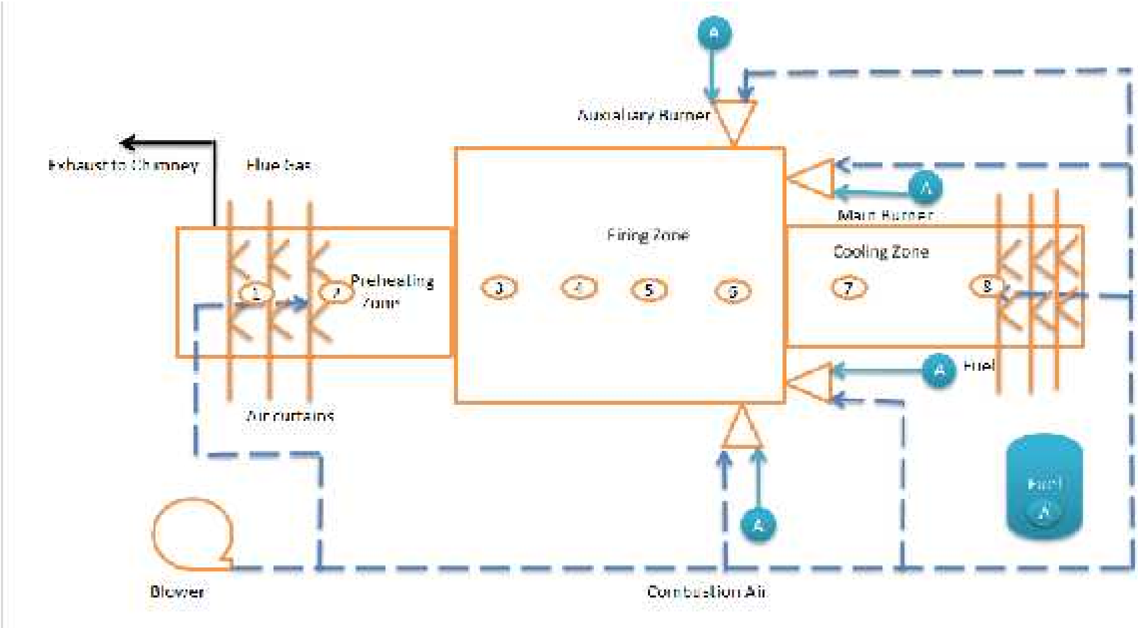


Figure 20: Tunnel Kiln

The details of present set-up, key observations made and potential areas for energy cost reduction have been mentioned in the table below:

Table 16: Temperatures at various sections of tunnel kiln

Section of kiln	Temperature
1	230°C
2	670°C
3	1143°C
4	1130°C
5	1141°C
6	1135°C
7	680°C
8	270°C

Table 17: Dimensions of kiln

Zone	Length	Width	Height
Pre-heating	920 cm	102 cm	148 cm
Firing	486 cm	230 cm	148 cm
Cooling	1518 cm	102 cm	148 cm

Table 18: Observations in kiln during field study and proposed EPIA

<table>
<tr><th>Observations during field Study & measurements</th><th>Proposed Energy performance improvement actions</th></tr>
<tr><td>The fuel consumption of kiln was 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>7.46%</td><td>32.07°C</td><td>197°C</td></tr></table>
From the above table, it is clear that the oxygen level measured in flue gas was high.</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 kiln.

Reducing opening losses in the kiln is recommended.</td></tr>
<tr><td>The inlet temperature of raw material in kiln was in the range of 35 – 42°C, which was the ambient air temperature.

The exhaust temperature of flue gas in the kiln through chimney after the effect of air curtains was in the range of 198 - 205°C whereas at the exit of firing zone it was found to be 926 – 1012°C during CEA study.

The kiln car is made up of fire clay bricks, pillars and tiles to stack the materials. All these materials have different Cp values. It is to be noted that the kiln car takes away lot of useful heat.</td><td>It is recommended to change the kiln car material with other materials of lower Cp values.</td></tr>
</table>

4 EE TECHNOLOGY OPTIONS AND TECHNO – ECONOMIC FEASIBILTY

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

Based on the analysis, Energy Performance Improvement Actions (EPIAs) have been identified; each of which are described below:

4.1 EPIA 1: 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 the roof. These losses are substantially higher in 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 the roof to maintain the skin temperature of the furnace at around 45-50°Cto 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 the 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 the kiln walls.

Study and investigation

There are three different zones in the kiln, i.e. pre- heating, firing and cooling zones in which the skin temperatures of all the three zones were observed. The average surface temperature of kiln body in the firing zone has to be in the range of 45-50°C, but it was measured to be 97.96°C. Therefore, proper insulation needs to be done to keep the surface temperature within the specified range.

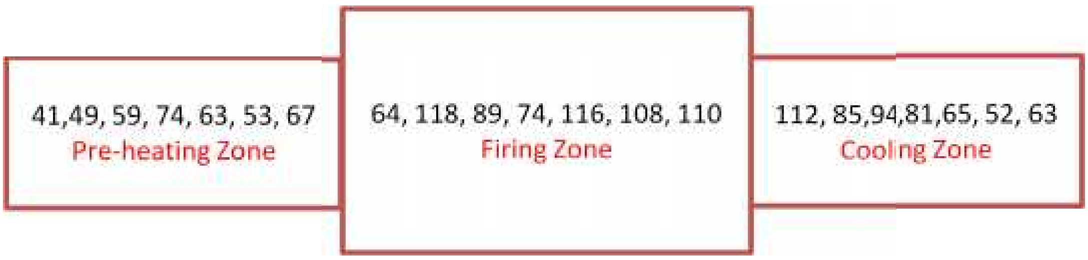


Figure 21: Measured Skin temperatures of kiln (deg C)

Recommended action

Recommended surface temperature of the firing zone to be brought to 50°Cto reduce the heat loss due to radiation and convection and utilize the useful heat.

In the below table, amount of heat lost through radiation and convection in each zone is given.

Table 19: R & C losses

Total radiation and convection heat loss per hour	Units	Value
Pre-Heating Zone	kCal / hr	1,383
Firing Zone	kCal / hr	3,936
Cooling Zone	kCal / hr	5,741
Total R&C loss	kCal / hr	11,060

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

Table 20: Cost benefit analysis (EPIA 1)

Parameters	UoM	Value
Present average skin temperature of Firing zone	deg. C	97.96
Recommended skin temperature of Firing Zone	deg. C	50.00
Present heat loss due to Radiation & Convection from Work side wall	kCal / hr	3,936
Recommended heat loss due to Radiation & Convection from Firing zone	W / m2	112.78
	kCal / m2	96.99
	kCal / hr	768
Total reduction in heat loss due to Radiation & convection by limiting skin temperature at Firing zone	kCal / hr	3,167
Calorific value of Fuel	kCal / kg	11,517
Equivalent savings in Fuel	kg / hr	0.28
	Nm3 / hr	
Plant running time	days / year	180
	hrs / day	24
Annual savings in Fuel	litre/y	1,438
Cost of fuel	Rs. / litre	47
Annual Monitory savings	Rs. / Year	67,680
	Rs. Lakhs / Year	0.68
Estimated investment	Rs. Lakhs	0.10
Simple Payback	year	0.14

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 the fuel. The excess air levels are calculated based on oxygen content in the flue gases. The theoretical air required for combustion of any fuel can be known from the ultimate analysis of the fuel. All combustion processes require a certain amount of excess air in addition to the theoretical air supplied. Excess air supplied needs to be maintained at optimum levels, as too much of excess air results in excessive heat loss through the flue gases. On the other hand, too little excess air results in incomplete combustion of fuel and formation of black colored 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, will measure 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) can be regulated. Subsequently, proper temperature and optimum excess air for combustion can be attained in the kiln.

Study and investigation

At the time of CEA, 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 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 21: Cost benefit analysis (EPIA 2)

Parameters	UOM	Present	Proposed
Oxygen level in flue gas	%	7.46	3.00
Excess air control	%	55.10	16.67
Dry flue gas loss	%	7.26	

Saving in fuel	With every 10% reduction in excess air leads to a saving in specific fuel consumption by 1%		
Specific fuel consumption	Liter/t	158.96	152.85
Saving in specific fuel consumption	Liter/h		0.75
Savings in fuel cost	Rs. Lakh/y		1.53
Installed capacity of blower	kW	5.60	5.97
Running load of the blower	kW	4.60	4.18
Operating hours	hrs/y	4320.00	4320.00
Electrical energy consumed	kWh/y	24170.40	25781.76
Savings in electrical energy	kWh/y		-1611.36
Cost of increased electrical energy	Rs. Lakh/y	2.19	2.33
Savings in terms of energy cost	Rs. Lakh/Y		1.38
Estimated investment	Rs. lakh		7.00
Simple payback	y		5.06

4.3 EPIA 3: Replacing conventional ceiling fans with Energy efficient fans

Technology description

Replacing old fans of conventional types installed in various sections of the plant with energy efficient fans will 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 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 35 conventional ceiling fans which are very old and can be replaced with energy efficient fans.

Recommended action

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

Table 22: Cost benefit analysis (EPIA 3)

Data & Assumptions	UOM	Present	Proposed
Number of fans in the facility	Nos	35	35
Run hours per day	H/d	24.00	24
Power consumption at Maximum speed	kW	0.07	0.04

Number of working days/year	days	180.00	180
Tariff for Unit of electricity	Rs./kWh	9.05	9.05
Fan unit price* (use '0' for ordinary fan if replaced)	Rs./piece	1500	3000
Electricity consumption:			
Electricity demand	kW	2.45	1.23
Power consumption by fans in a year	kWh/y	10584	5292
Savings in terms of power consumption	kWh/y	5292	
Savings in terms of cost	Rs. Lakh/y	0.48	
Estimated investment	Rs. Lakh/y	1.05	
Payback period	y	2.19	

4.4 EPIA 4: Energy efficient light fixture

Technology description

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

Study and investigation

The unit is having 35 T12 tube light and 10 incandescent lamps (GLS bulbs).

Recommended action

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

Table 23: Cost benefit analysis (EPIA 4)

Parameters	UoM	Present	Proposed
Fixture		T-12 & Incandescent	16 Watt LED tube light
Power consumed by T12 tubes	W	40	16
Power consumed by Ballast	W	12	0
Total power consumption (by T12)	W	52	16
Total power consumption (by incandescent)	W	100	16
Operating Hours/day	Hr	18	18
Annual days of operation	Day	180	180
Energy Used per year/fixture	kWh/y	9,137	2,333
Electricity tariff	Rs./kWh	9.05	9.05
No. of Fixtures – T12	Unit	35	35

No. of fixtures – incandescent lamps	Unit	10	10
Operating cost per year	Rs. Lakh/Year	1	0.21
Saving in terms of electrical energy	kWh/Year		6804
Savings in terms of cost	Rs. Lakh/Year		0.62
Investment per fixture of LED	Rs. Lakh		0.0125
Investment of project	Rs. Lakh		0.5625
Payback period	Years		0.91

4.5 EPIA 5: VFD on pug mill motor

Technology description

For fluctuating loads, it is always recommended to install a variable frequency drive (VFD) to control the speed of the motor. A VFD will reduce the power consumption according to the load variation in the motor. During loading periods, the current drawn by the pug mill is high. During no load / unloading periods, the pug mill motor draws higher current than required. Installation of a VFD will help in regulating speed of the broaching machine's motor thus resulting in lower current drawn and reduction in power consumption during no load / under loading.

Study and investigation

The existing pug mill draws more current even during unloading period.

Recommended action

It is recommended to install VFD with the pug mill motor. This will ensure that the machine draws minimal current during unloading by sensing the required power. The cost benefit analysis of the energy conservation measure is given below:

Table 24: Cost benefit analysis (EPIA 5)

Parameters	Unit	Present	Proposed
Installed capacity of motor	kW	7.46	7.46
Estimated energy saving by installing VFD on (Pug-Mill motor)	%		20.0
Average power consumption	kW	3.5	3
No of operating hrs per day	Hrs	20	20
Operating Days per Year	Days	180.00	180
Average electricity consumption per year	kWh	12437	9950
Annual electricity savings	kWh/y		2487
Average electricity tariff	Rs/kWh	9.05	9.05
Annual saving in terms of cost	Lakhs Rs.		0.23
Estimated investment	Lakh Rs		0.7
Simple Payback	Y		3.1

4.6 EPIA 6: DG Replacement

Technology description

DG set is a power generating unit which is used as a self generating power source. However, it provides a higher per unit cost generation to the supply as compared to the available grid source.

Study and investigation

The DG present in the unit delivers power with HSD consumption, which is found to be higher than the desired amount.

Recommended action

Specific energy consumption of DG set 15 kVA is 0.96 which is very low as compared to the standard SEC of a DG set; hence an EPIA is suggested for replacement of the present DG set with a new DG set. The cost benefit analysis for this project is given below:

Table 25: Cost benefit analysis (EPIA 6)

Parameters	UOM	Present	Proposed
Rated kVA	kVA	15.00	15
Operating Hours	hr	1440	1440
No of Units generated	kWh/yr	14602.12	14602.12
Annual HSD Consumption	litres	15275.49	4172.03
Specific Energy Consumption	kWh/litre	0.96	3.5
Annual HSD savings	litre/yr		11103
Diesel Cost	Rs/l		54
Investment	Lakh Rs.		2.48
Monetary Savings	Lakh Rs.		6.00
Simple Payback	year		0.41

4.7 EPIA 7: Electrical 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

As per the analysis, online data measurement was 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 the 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. It is also recommended to install online flow-meters on the individual DG set and kilns to measure the oil flow. This measure will help in reduction in energy consumption by approximately 3% from its present levels. The cost benefit analysis for this project is given below:

Table 26: Cost benefit analysis (EPIA 7)

Parameters	Unit	Present	Proposed
Energy monitoring savings	%		3.00
Energy consumption of major machines per year	kWh/Yr	2,585	2,507
Annual electricity savings per year	kWh/Yr		78
Electricity Tariff	Rs./kWh		9.05
Annual monetary savings	lakh Rs./yr		0.01
Estimate of Investment	Lakh Rs.		0.35
Simple Payback	Months		598.28
Energy monitoring savings	%		3.00
Current Diesel blend consumption	Litre/y	84,600	82062
Annual fuel savings per year	Litre/y		2,538
Unit Cost	Rs./Litre		47.07
Annual monetary savings	Lakhs Rs./year		1.19
Estimate of Investment	Lakhs Rs.		0.20
Simple Payback	Y		0.17

4.8 EPIA 8: Power factor improvement

Technology description

Power factor plays an important role in electricity system of industries. If proper power factor is not maintained, it may lead to penalty in the electricity billing. Present system of billing in Rs. / kVAh has the power factor component in-built in the tariff structure. Poor power factor will result in higher electricity bill for the unit, hence, it is necessary to maintain high power factor. To maintain high power factor, properly sized capacitors needs to be connected in the electricity line. The value of capacitors to be connected will vary with respect to load and the existing PF and can be controlled using APFC panels.

Study and investigation

An APFC panel is already installed in the unit and the power factor was found to be deviating beyond 0.90 due to unhealthy condition of a few capacitors. It is recommended to replace the de-rated capacitors. The average power factor maintained in the unit was found to be 0.88 during the study.

Recommended action

A high power factor of 0.99 needs to be maintained to avoid higher electricity bills as the billing structure in kVAh already factors the effect of power factor into the total amount billed. To maintain high power factor, proper sizing of capacitors needs to be made which is given in the table:

Table 27: Sizing of capacitor banks

Parameters	Unit	Value
Present Minimum PF	Cos ø	0.75
Present Maximum PF	Cos ø	0.90
Present Average PF	Cos ø	0.88
Minimum Load	kW	8.1
Maximum Load	kW	12.0
Average Load	kW	9.7
Target Average Power Factor		0.99
Capacitor Bank Capacity at Average Load and Average PF	kVAR	3.6
Capacitor Bank Capacity at Maximum Load and Average PF	kVAR	4.5
Capacitor Bank Capacity at Maximum Load and Minimum PF	kVAR	8.0
Capacitor Bank Capacity at Minimum Load and Minimum PF	kVAR	5.4
Required capacitor bank for PF at Unity	kVAR	8
APFC Panel (Rating) for maintaining optimum PF	kVAR	8

The cost benefit analysis for installation of APFC panels in the unit is given below in the table:

Table 28: Cost benefit analysis (EPIA 8)

Parameters	Unit	Present	Proposed
Minimum PF	Cos ø	0.75	0.99
Maximum PF	Cos ø	0.90	0.99
Average PF	Cos ø	0.88	0.99
Maximum Load	kW	12.0	12.01
Average Load	kW	9.7	9.66
Capacitor Bank	kVAR	70.0	78.0
Annual Grid Electricity Consumption	kVAh/y	18951.8	16807.7
	kWh/y	16639.6	16639.6
Annual Grid Electricity Savings	kVAh/y	-	2144.04

Electricity Tariff	Rs./kVAh	9.1	9.1
Annual Monetary Savings	Lakh Rs./y	-	0.19
Investment	Lakh Rs.	-	0.08
Payback Period	years	-	0.41

4.9 EPIA 9: 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, thus carrying away the useful heat supplied to the kilns. This reduces the kiln efficiency. Instead the material called ultralite[1] can be used in the kiln car construction, which will reduce its dead weight. This will also help in reducing kiln losses due to useful heat carried away by the kiln car, as this material has lesser specific heat.

Study and investigation

Presently, the kiln car used in the unit is made up of HFK bricks, quadrite tiles and pillars. These materials contribute to a dead weight (of kiln car) of 477 kg. The ceramic materials to be fired 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. . However, this wastage is inevitable, as the materials have to be placed on the kiln cars to travel along the kiln. So, in order to reduce this wastage, it is recommended to select kiln car material that will absorb as minimum heat as possible so that most of the heat supplied is gained by the ceramic materials. This will also help in reducing 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. This will help reduce the dead weight of the kiln car besides reducing the heat gained by the same, and also help in reducing in fuel consumption in the kiln by approximately 30%. The cost benefit analysis for the EPIA is given in the table below:

Table 29: Cost benefit analysis (EPIA 10)

Parameters	UoM	Present	Proposed
Present Production of kiln	tph	0.09	0.09
Weight of existing kiln car	kg	377	269
Total number of kiln cars inside kiln	Nos.	24	24
Initial temperature of kiln car	Deg c	32.08	32.08

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

Final temperature of kiln car	Deg c	1135.75	1135.75
Estimated percentage savings by replacing present kiln car with new EE kiln car	%		30
Heat carried away by the kiln material	kcal/h	89,735	62,815
Reduction in the heat carried by the new EE kiln car	kcal/h		26,921
Operating hours of kiln	h	4320	4320
Savings in terms of fuel consumption	Litre/y		10,098
Savings in terms of cost	Rs. lakh/y		4.8
Estimated investment of kiln car material	Rs. lakh/y		4.80
Payback period	y		1.0

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

Technology description

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

Study and investigation

The present fuel firing for the given production was high. It was monitored during the DEA.

Recommended action

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

Table 30 Cost benefit analysis (EPIA 11)

Sl. No.	Replacing present burners with energy efficient burners		Kiln	
	Parameters	Unit	Present	Proposed
1	Production rate of the kiln	kg/hr	123	123
2	Total number of main burner	Nos.	1.0	1.0
3	Total number of auxilary burner	Nos.	2.0	2
4	Total numbers of energy efficient burner required	Nos.	3.0	3.0
5	Estimated saving by energy effcient burner	%		5.0
6	Current fuel firing in kiln	kg/hr	17	16
7	Savings in fuel per hours	kg/hr		0.84
7	Number of operating days	days	180.00	180
8	Number of operating hours per day	hrs	24.00	24
9	Total savings per year into fuel firing	kg/yr		3608
10	Unit cost of fuel	Rs./kg		55.19

Sl. No.	Replacing present burners with energy efficient burners		Kiln	
	Parameters	**Unit**	Present	Proposed
11	Cost savings per year	Lakh Rs./yr		1.99
12	Estimated investment for all burners	Lakh Rs.		0.7
13	Payback period	Yr		0.4

5 ANNEXURE

Kiln efficiency calculations

Input parameters

Parameters	Value	UoM
Tunnel Kiln Operating temperature (Firing Zone)	1136	*Deg C*
Final temperature of material (at outlet of Firing zone)	1000	*Deg C*
Initial temperature of kiln car	32.08	*Deg C*
Avg. fuel Consumption	16.7	*Kg/hr*
Flue Gas Details		
Flue gas temp. after APH (in chimney; No APH installed)	197	*deg C*
Preheated air temperature/Ambient	32.075	*deg C*
O2 in flue gas	7.46	*%*
CO2 in flue gas	10.22	*%*
CO in flue gas	195.4	*ppm*
Atmospheric Air		
Ambient Temp.	32.075	*Deg C*
Relative Humidity	45.6	*%*
Humidity in ambient air	0.03	*kg/kgdry air*
Fuel Analysis		
C	*77.00*	**%**
H	*12.00*	**%**
N	*0.00*	**%**
O	*11.00*	**%**
S	*0.01*	**%**
Moisture	*0.00*	**%**
Ash	*0.00*	**%**
Weighted Average GCV of Fuel-mix	*11517*	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 (Dead weight of kiln car)	377	*Kg/Hr*
Weight of ceramic material (Raw material) being fired in Kiln	88	*Kg/Hr*
Weight of Stock	88	*kg/hr*
Specific heat of clay material	0.20	*Kcal/kgdegC*
Specific heat of kiln car material	0.22	*Kcal/kgdegC*
Avg. specific heat of fuel	0.417	*Kcal/kgdegC*

fuel temp[2]	32.075	*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 Convection from preheating zone surface	1383	*kcal/hr*
Radiation and Convection from heating zone surface	3936	*kcal/hr*
Radiation and Convection from firing zone surface	5741	*kcal/hr*
Heat loss from all zones	11060	*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	1	*Hr*
Area of opening in m2	0.672	*m2*
Coefficient based on profile of kiln opening	0.7	
Max operating temp. of kiln	335	*deg K*

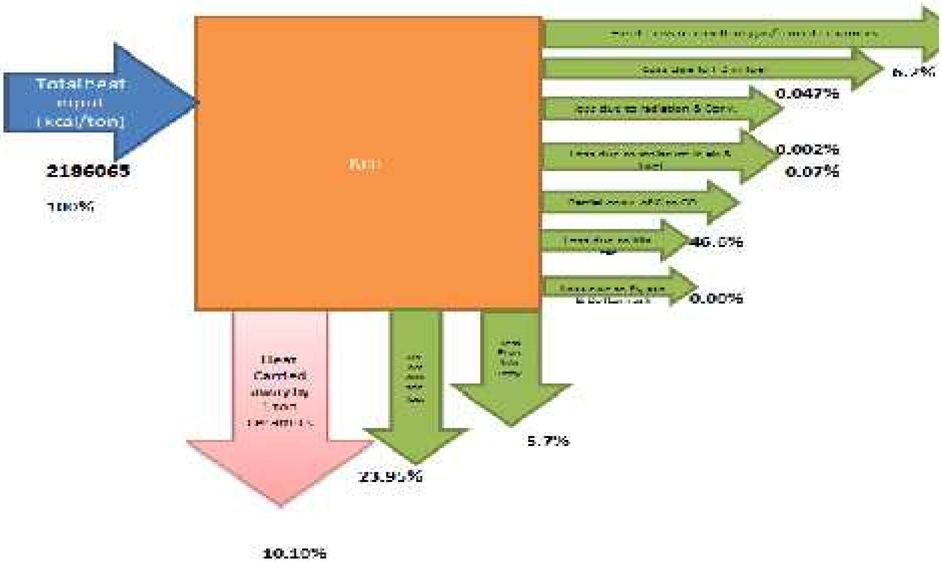
Efficiency calculations

Parameters	Value	UoM
Theoretical Air Required	12.63	*kg/kg of fuel*
Excess Air supplied	55.10	*%*
Actual Mass of Supplied Air	19.59	*kg/kg of fuel*
Mass of dry flue gas	19.51	*kg/kg of fuel*
Amount of Wet flue gas	20.59	*Kg of flue gas/kg of fuel*
Amount of water vapour in flue gas	1.08	*Kg of H2O/kg of fuel*
Amount of dry flue gas	19.51	*kg/kg of fuel*
Specific Fuel consumption	189.81	*kg of fuel/ton of ceramic material*
Heat Input Calculations		
Combustion heat of fuel	2,186,065	*Kcal/ton of ceramic material*
Sensible heat of fuel	-	*Kcal/ton of ceramic material*

[2] Pre-heating zone is already a waste heat recovery system. 3 nos. of air curtains are present in pre-heating zone which supplies ambient air to prevent thermal shock to ceramic material while it to travel through the pre-heating zone to firing zone. Due to effect of these air curtains which supplies ambient air the temp of flue gas at the chimney (exit of pre-heating zone) is around 190-210 °C. The O_2 % in flue gas at chimney was measured to be 17.4 % while at the exit of firing zone it was 12 %, which implies the quantity of flue gas increases in the pre-heating zone due to the effect of fresh air supplied through the air curtains. We had considered the feasibility of recovering waste heat from flue gas at the stack but it was not technically & economically viable because the temperature of flue gas at the stack was low.

Total heat input	2,186,065	*Kcal/ton of ceramic material*
Heat Output Calculation		
Heat carried away by 1 ton of ceramics (useful heat)	220,735	*Kcal/ton of ceramic material*
Heat loss in dry flue gas per ton of ceramics	158,782	*Kcal/ton of ceramic material*
Loss due to H2 in fuel	134,931	*Kcal/ton of ceramic material*
Loss due to moisture in combustion air	44	*Kcal/ton of ceramic material*
Loss due to partial conversion of C to CO	1,577	*Kcal/ton of ceramic material*
Loss due to convection and radiation (openings in kiln - inlet & outlet of kiln car)	1,026	*Kcal/ton of ceramic material*
Loss Due to Evaporation of Moisture Present in Fuel	-	*Kcal/ton of ceramic material*
Total heat loss from kiln (surface) body	125,686	*Kcal/ton of ceramic material*
Heat loss due to unburnts in Fly ash	-	*Kcal/ton of ceramic material*
Heat loss due to unburnts in bottom ash	-	*Kcal/ton of ceramic material*
Heat loss due to kiln car	1,019,720	*Kcal/ton of ceramic material*
Unaccounted heat lossess	523,564	*Kcal/ton of ceramic material*
Heat loss from Kiln body and ceilings		
Total heat loss from kiln	125,686	*Kcal/tons*
Furnace Efficiency	10.10	*%*

Sankey diagram



6 LIST OF VENDORS

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

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Morgan Advanced Materials - Thermal Ceramics	P.O. Box 1570, Dare House Complex, Old No. 234, New No. 2, NSC Bose Rd, Chennai - 600001, INDIA	T 91 44 2530 6888 F 91 44 2534 5985 M 919840334836	munuswamy.kadhirvelu@morganplc.com mmtcl.india@morganplc.com ramaswamy.pondian@morganplc.com
2	M/s LLOYD Insulations (India) Limited,	2,Kalka ji Industrial Area, New Delhi-110019	Phone: +91-11-30882874 / 75 Fax: +91-11-44-30882894 /95 Mr. Rajneesh Phone : 0161-2819388 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	# 1698, First Floor,	Office: +91-161-	Email: interautoinc@yaho

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
	Automation Inc Contact Person Sanjeev Sharma)	Canara Bank Building, Near Cheema Chowk, Link Road, Ludhiana	4624392, Mobile: +91-9815600392	o.com
3	Happy Instrument	Yogesh 20, Proffulit Society, Nr Navo Vas, Rakhial, Ahmedabad-380021	079-22771702 9879950702	yogesh@happyinstrument.com
4	Wonder Automation	Kulwinder Singh E-192, Sector 74, Phase 8-B, Industrial Area, SAS nagar Mohali	0172-4657597 98140 12597	info@wonderplctrg.com admn.watc@gmail.com hs@wonderplctrg.com

EPIA 3: Replacing conventional ceiling fans with energy efficient fans

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

EPIA 4: Energy efficient light

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Osram Electricals Contact Person: Mr. Vinay Bharti	OSRAM India Private Limited,Signature Towers, 11th Floor,Tower B, South City - 1,122001	Phone: 011-30416390 Mob: 9560215888	vinay.bharti@osram.com

Sl. No.	Name of Company	Address	Phone No.	E-mail
		Gurgaon, Haryana		
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
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: VFD on pug mill motor

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

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

EPIA 6: DG Replacement

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

EPIA 7: Energy Monitoring System

Sl. 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	Office: 011-30810229,	manjulpandey@aimil.com

Sl. No.	Name of Company	Address	Phone No.	E-mail
	Contact Person: Mr. Manjul Pandey	Industrial Estate, Mathura Road, New Delhi - 110 044	Mobile: +91-981817181	
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 8: Power Factor Improvement

PF Improvement				
Sl. No.	**Name of Company**	**Address**	**Phone No.**	**E-mail / Website**
1	Cummins Power Generation Contact Person: Rishi Gulati Senior Manager-Power Electronics	Cummins India Limited Power Generation Business Unit 35/A/1/2, Erandawana, Pune 411 038, India	Phone: (91) 020-3024 8600 , +91 124 3910908	cpgindia@cummins.com rishi.s.gulati@cummins.com
2	Krishna Automation System Contact Person: Vikram Singh Bhati	ESTERN CHAWLA COLONY, NEAR KAUSHIK VATIKA, GURGAON CANAL BALLBGARH FARIDABAD 121004	Mob: 9015877030, 9582325232	krishnaautomationsystems@gmail.com

EPIA 10: Installation of EE Burners

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

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
Automation				
1	ENCON Thermal Engineers (P) Ltd Contact Person: Mr V B Mahendra, Managing Director Mr. Puneet Mahendra, Director	297, Sector-21 B Faridabad – 121001 Haryana	Tel.: +91 129 4041185 Fax: +91 129 4044355 Mobile: +919810063702 +919971499079	sales@encon.co.in kk@encon.co.in www.encon.co.in
2	TECHNOTHERMA FURNACES INDIA PVT. LTD.	206, Hallmark Commercial Complex, Near Nirmal Lifestyles, L.B.S. Marg, Mulund West, Mumbai - 400 080. India.	T: 022-25695555	Furnace@technotherma.net
3	Therm process	Mr. Sanjay Parab B/1203-O2 Commercial Complex, Minerva Estate, Opp Asha Nagar, P.K.Cross Road, Mulund (W) Mumbai-400080	T: 022-25917880/82/83 M: 9967515330	thermprocess@yahoo.com sanjay@thermprocess.com

EPIA 9: Replacement of kiln car material

Sl. 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