COMPREHENSIVE ENERGY AUDIT REPORT

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

Royal International

G.T Road, Khurja

16-04-2015

Submitted to

ENERGY IS LIFE

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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. Atif Bhai, owner of the unit for showing keen interest in the energy audit and also thankful to the management of M/s Royal International 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 was really admirable.

Last but not the least, the interaction and deliberation with Mr. Tariq Anwar, President, Khurja Pottery Manufacturers Association (KPMA), Mr. Dushyant K. Singh, Secretary, Khurja Pottery Manufacturers Association (KPMA), Dr. L.K.Sharma, Scientist-in-charge, Central Glass and Ceramic Research Institute (CGCRI), Khurja, 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 based on the products that they manufacture– pottery works, insulator works and crockery works. The production process of all these three types of units are almost similar in nature and the main difference is in the amount of ceramic material ratios mixed in the ball mill 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 Royal International
Constitution	Private Limited
MSME Classification	Small
No. of years in operation	NA
Address: Registered Office	G.T Road, Khurja – 203131
Administrative Office	G.T Road, Khurja – 203131
Factory	G.T Road, Khurja – 203131
Industry-sector	Ceramics
Products Manufactured	Decorative stoneware
Name(s) of the Promoters / Directors	Mr. Atif Bhai

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

The production process of the unit

The main process equipment in the unit includes the following:

- The unit is having very wide potential of saving as the process involved is heat energy in the range of 1150 - 1200^{o}C where the input fuel is PNG in the kilns.
- There are other equipments, viz. ball mills, filter presses, pug mills, jigger jollies which also contribute to the production process involving electrical energy.
- The raw material is a mixture of clay, feldspar and quartz which is mixed along with water to form a slurry after which the water and air are removed from it and provided required shaped and then fired 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. Kilns consume most of the energy in the unit, accounting for more than 86% of the total energy usage. The identified energy performance improvement in the kilns include skin loss reduction by proper insulation, excess air control for firing by using PID control and replacement of kiln car material in order to reduce the dead weight of the trolley. This will help in reducing the fuel consumption by absorbing very less useful heat. VFD application was recommended in the pug mill to control the speed of rotation of the mill. It is also proposed to implement energy efficient fans for cooling and drying of plastic mould and energy efficient led lights in place of tube lights, increasing contract demand to reduce the billing penalty, DG frequency reduction and installing energy monitoring system. Reduction in compressed air pressure is also suggested, as it is used only for cleaning purposes. The details of energy improvement actions are given in Table – 2.

Table 2: Summary of EPIA

Sl. No	Name of the project	Estimated energy savings				Monetary savings	Estimated investment	Simple payback period	Annual emission reduction
		PNG	Electricity	HSD	Material Saving				
		SCM/y	kWh/y	litre/y	Rs./y	Rs.lakh/y	Rs.lakh	y	tCO2/y
1	Skin loss reduction from the kiln	4189.3				1.2	0.7	0.6	4.5
2	Excess air control	9046.8	-4834			4.3	7	1.6	12.8
3	Installation of energy efficient fan instead of conventional fan		24570			2.3	3.9	1.7	21.9
4	Installation of LED lighting instead of tube light and CFL		49864			4.8	4.56	2.9	44.4
5	VFD installation on pug mill		10026			1	1	1	8.9
6	DG frequency optimization up to 49.5 Hz			1407.5		0.8	0.05	0.1	3.6
7	Energy monitoring system	2307.7	2878			1.2	0.45	0.4	6.9
8	Increasing contract demand				0.3	0.3	0	0	0
9	Replacement of kiln car	7339.5				3.9	4.8	1.2	13.8
10	Compressed air pressure reduction		611			0.1	0.05	0.9	0.5
	Total	**22883.3**	**83114.9**	**1407.5**	**0.3**	**19.8**	**22.5**	**1.1**	**116.8**

The implementation of above suggested projects in the unit will result in energy savings of up to 37.04% and energy cost savings of Rs.19.8 Lakh/y.

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
    - Current energy usage (month wise) for all forms of energy for the last 12-24 months (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
    - Data required for preliminary environmental and social screening

- 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 maintenance, 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 combustion efficiencies with an intent to optimize thermal operations, steam and hot water systems (including hot water lines tracing, pipe sizes, insulation, redundant lines, distribution loss), heat recovery systems, etc.
    - Water usage and pumping efficiencies (including water receipt, storage, distribution, utilization, etc.), pump specifications, break-down maintenance.
- Evaluate the energy consumption vis-à-vis the production levels and to identify the potential for energy savings/energy optimization (both short term requiring minor investments with attractive payback, and mid to long terms system improvement areas needing moderate investments and with payback of 2.9 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 and “energy monitoring system” for effective monitoring and analysis of energy consumption, energy efficiency.

1.3 Methodology

1.3.1 Boundary parameters

Following boundary parameters were set on coverage of the audit.

- Audit covered all possible energy intensive areas & equipments which were in operation 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

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

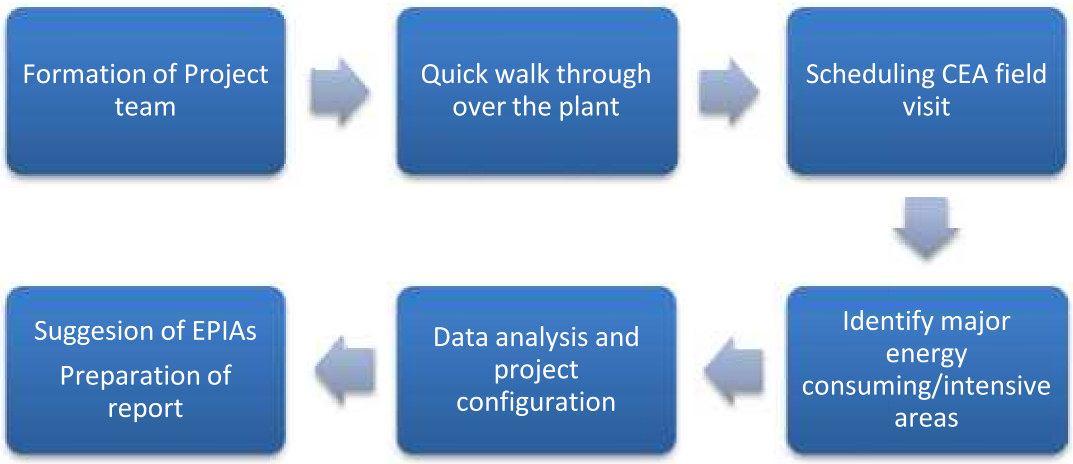


Figure 1: General methodology

The study was conducted in 3 stages:

- **Stage 1:** Walk through energy audit of the plant to understand the process, energy drivers, assessment of the measurement system ,assessment of scope, measurability, formulation of audit plan and obtaining required information
- **Stage 2:** Detailed energy audit-testing & 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 walk through was carried out before the audit with a view to:

- Understand the manufacturing process and collect historical energy consumption data
- Obtain cost and other operational data for understanding the impact of energy cost on the units financial performance
- Assess the energy conservation potential at 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 the process
- Fans and lighting loads

The 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) and then finding solutions to minimize the same. This entailed data collection, measurements/ testing of the system using calibrated, portable instruments analyzing the data/ test results and identifying the approach to improve the efficiency. The 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

Sl. No.	Instruments	Make	Model	Parameters Measured
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 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 Royal International
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. Atif owner +91 5738 231372 ceo@royalexpo.com
5	Address of the unit	Baroli road, Murari Nagar, G.T road, Khurja – 203131
6	Industry / sector	Ceramic
7	Products manufactured	Decorative stonewares
8	No. of operational hours	12
9	No. of shifts / day	1
10	No. of days of operation / year	300
11	Whether the unit is exporting its products (yes / no)	Yes
12	No. of employees	50

3 DETAILED TECHNICAL FEASIBILITY ASSESSMENT OF THE UNIT

3.1 Description of manufacturing process

3.1.1 Process & Energy flow diagram

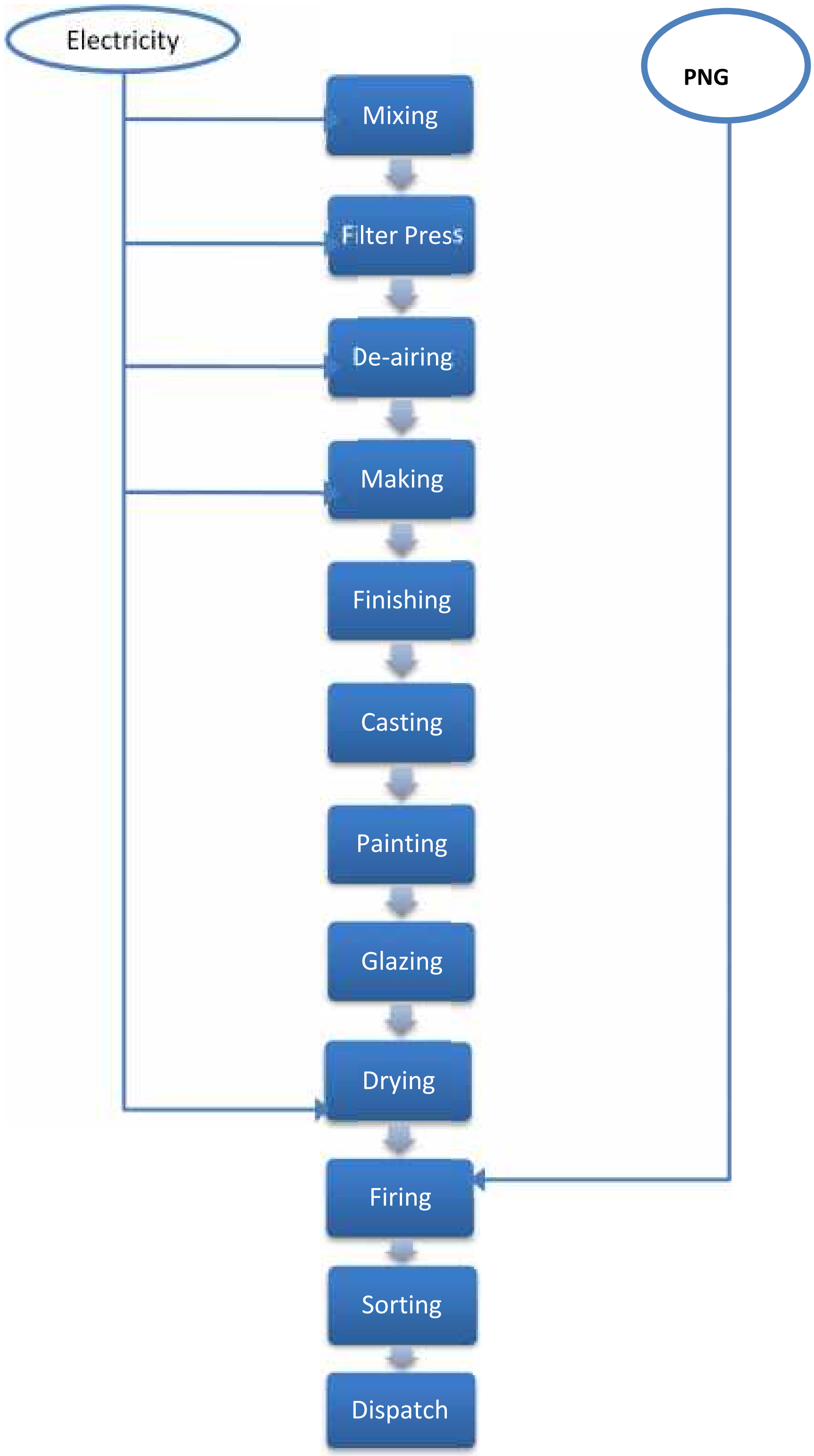


Figure 2: Process flow diagram

3.1.2 Process description

M/s Royal International is a manufacturer of ceramic decorative stonewares like ceramic knobs, hangers, etc. The process description is as follows:

- The raw materials clay, feldspar and quartz are mixed 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 diaphragm pump, the mixture is then transferred to the filter press to remove water.
- The filtered cakes formed are then put in to pug mill for removal of air bubbles by means of vacuum pump connected to it.
- Output from pug mill is cut down to smaller sizes and given shapes as per requirement using jigger jollies after which it they are dried 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 1200^{o}C.
- After firing, the products are quality checked, packed and dispatched.

3.2 Inventory of process machines/equipment and utilities

Major energy consuming equipments in the plants are:

- **Ball mill:** Here the raw materials like clay, feldspar and quartz are mixed in the ratio of 2:1:1 along with water to form a slurry.
- **Agitator:** The slurry after getting mixed in the ball mill is poured into a sump where the 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 the water is removed in this process.
- **Pug mill with vacuum pump:** The cakes that are taken out from the filter press operation 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 given to shaping zone. The moisture content is reduced by 20% in this process.
- **Jigger jollies:** The required shapes 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 with the help of pusher motor kept at a specified rpm. The tunnel is about 14 feet long and the temperature gradually increases up to firing zone and then decreases with the highest temperature being 1200^{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 being sought from two different sources:
  - From the Utility, PVVNL (Paschimanchal Vidyut Vitran Nigam Limited)
  - Captive backup diesel generator sets for the whole plant
- Thermal energy is used for following applications :
  - PNG (Piped Natural Gas) for kiln

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

Table 6: Energy cost distribution

Particulars	Energy cost distribution		Energy use distribution	
	Rs. Lakhs	% of total	MTOE	% of total
Grid – Electricity	8.29	16	8.3	9.52
HSD – DG	1.87	4	3.4	3.91
Thermal – PNG	40.52	80	75	86.57
Total	**50.68**	**100**	**86.6**	**100**

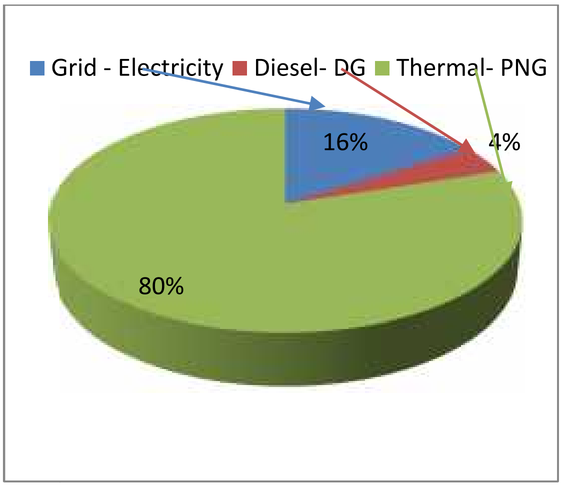


Figure 3: Energy cost share (Rs. Lakh)

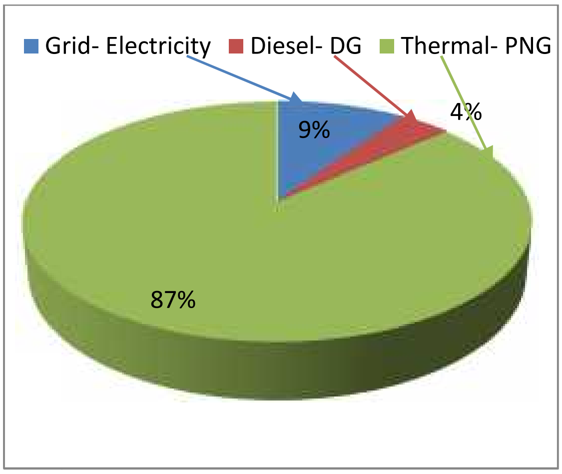


Figure 4: Energy use share (MTOE)

The major observations are as under:

- The unit uses both thermal and electrical energy for carrying out manufacturing operations. Electricity is sourced from the grid and self generated through DG sets when the grid power is not available. Thermal energy consumption is in the form of PNG, which is used for firing in the kiln.
- PNG used in kilns account for 85% of the total energy cost. HSD used in DG sets account for 4% of total energy cost and electricity used in plant process account for 16% of total energy cost.
- HSD used in kilns account for 87% of overall energy consumption. HSD used in DG sets account for 4% of overall energy consumption and electricity used in plant account for 9% of overall energy consumption.

3.4 Analysis of electricity consumption by the unit

3.4.1 Baseline parameters

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

Table 7: Baseline parameters

Electricity Rate (Excluding Rs./kVA)	6.20	Rs./ KVAH inclusive of taxes
Weighted Average Electricity Cost	9.55	Rs./ kWh for 2014-15
Percentage of total DG based Generation	10%	
Average Cost of PNG	52.68	Rs./SCM
Annual Operating Days per year	300	Days/yr
Annual Operating Hours per day	24	Hr/day
Production	324	MT

GCV of HSD	11840	kCal/ Litre
Density of HSD	0.826	kg/litre
Density of PNG	0.700	kg/SCM

3.4.2 Electricity load profile

Following observation has been made from the utility inventory:

- The plant and machinery load is 43.4 kW
- The utility load (fans & lighting) is about 29.6 kW including the single phase load
- The plant total connected load is 73 kW

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

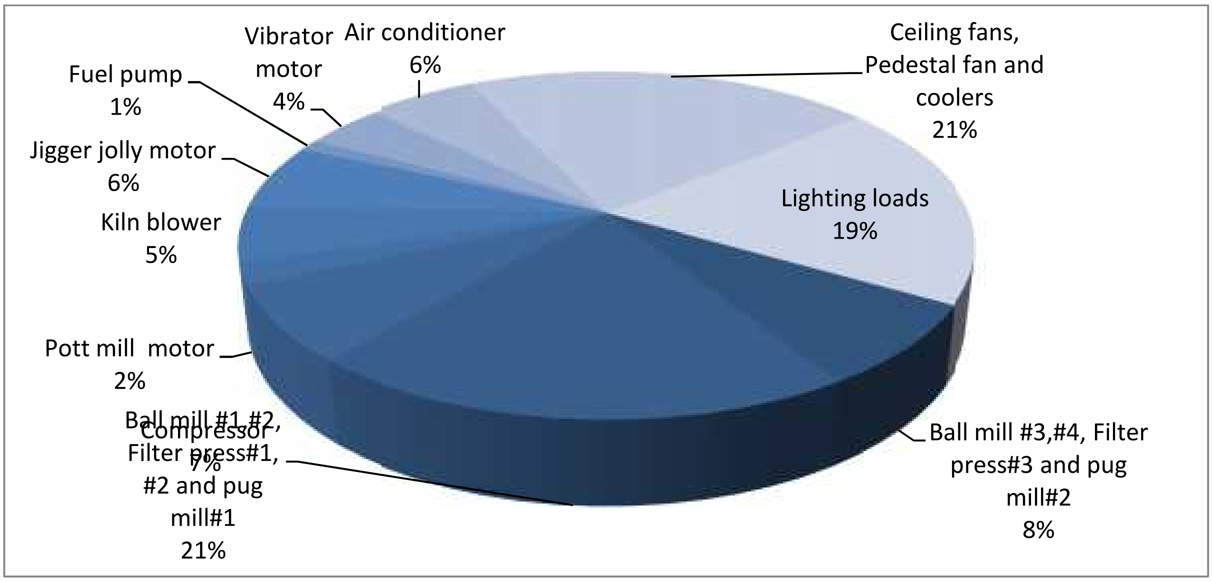


Figure 5: Details of connected load

As shown in the pie chart of connected load, the maximum share of connected load is for the ball mill, pug mill and filter press of 17% each, vacuum pump and kiln blower of 3% each. Other plant and machinery including jigger jolly motor – 4%, vibrator motor – 3%, fuel pump – 1%, fans and cooling loads – 13% and lighting load accounts for 12% of the connected load.

An analysis of area wise electricity consumption has been computed to quantify the electricity consumption in the individual processes. The electricity consumption by the machineries in the units is shared by two connections obtained from PVVNL. 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 #3,#4, Filter press#3 and pug mill#2	2.2	4028	3.8%
Ball mill #1,#2, Filter press#1, #2 and pug mill#1	6.0	8952	8.4%
Compressor	2.1	6266	5.9%

Pot mill motor	0.6	2865	2.7%
Pug mill motor	3.3	14167	13.3%
Vacuum pump motor	1.8	5371	5.0%
Kiln blower	0.4	1934	1.8%
Jigger jolly motor	1.5	4476	4.2%
Fuel pump	1.7	1512	1.4%
Vibrator motor	6.2	29760	28.0%
Air conditioner	5.6	27062	25.4%
Ceiling fans, Pedestal fan and coolers	2.2	4028	3.8%
Lighting loads	6.0	8952	8.4%
Total	**31.4**	**106393.6**	**100%**

This is represented graphically in the figure below:

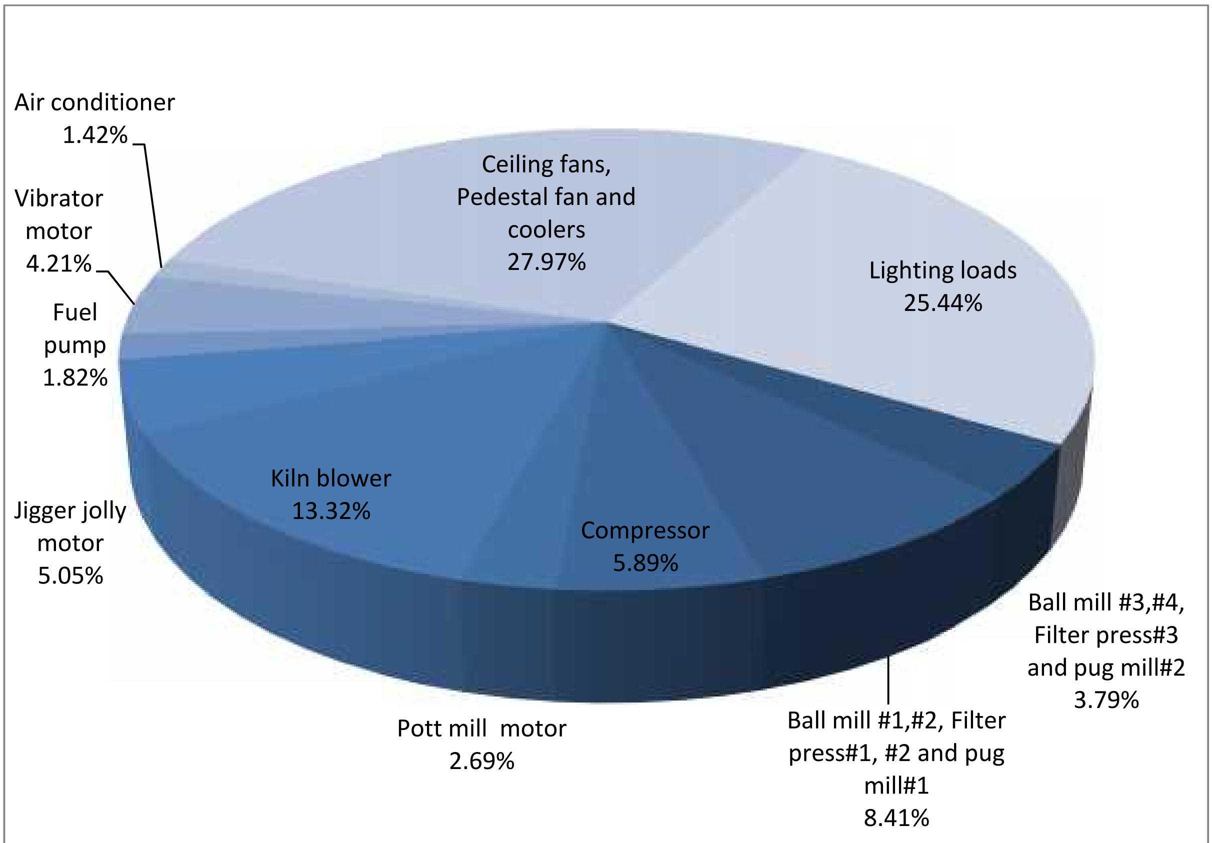


Figure 6: Area wise electricity consumption

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

3.4.3 Sourcing of electricity

The unit is drawing electricity from two different sources:

- Utility (PVVNL) through regulated tariff

- Captive DG sets which are used as backup source and supply 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	95,947	90%	8.3	82%
Self Generation	10,381	10%	1.9	18%
Total	106,327.96	100%	10.2	100%

This is graphically depicted as follows:

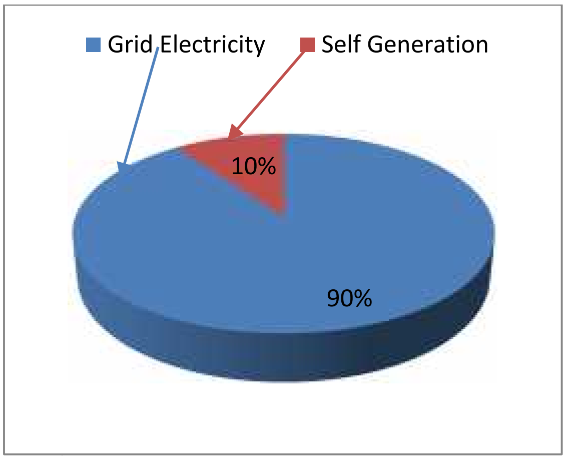


Figure 7: Share of electricity by source

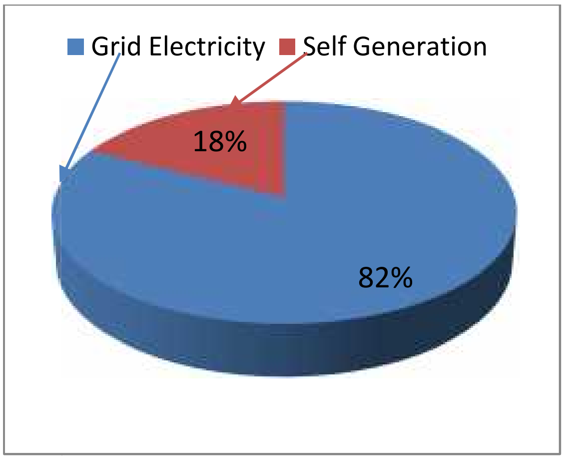


Figure 8: Share of electricity by cost

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 back-up source, i.e. DG sets is about 10% of total power which is not very high. Although the share of DG power in terms of kWh is just 10% of the total electrical power, but it is about 18% in terms of total cost of electrical power. It indicates high cost of DG power due to rise in the price of HSD. For economical operation, the utilization of DG sets need to be minimized, but it will depend upon the supply condition of grid as well as the job requirement of the plant.

3.4.4 Supply from utility

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

1. a) Meter K No. : 823352000
   b) Power Supply : 0.42 kV line
   c) Contract Demand : NA
   d) Sanctioned Load : 15.41 kW
   e) Nature of Industry : LT – G

2. a) Meter K No. : 267895070
   b) Power Supply : 0.415 kV line
   c) Contract Demand : NA
   d) Sanctioned Load : 15.41 kW
   e) Nature of Industry : LT – G

The tariff structure is as follows:

Table 10: Tariff structure

Particulars	Tariff structure	
Energy Charges	6.20	Rs./kWh
Regulatory	0.00	Rs./kVA
Fuel Surcharge	0.00	Rs./kWh
Electricity duty	1.79	Rs./kWh
Municipality tax	0.00	Rs./kWh

(As per bill for February – 15)

The electricity tariffs for both the connection were found to be same.

Electricity Bill Analysis																	
Month	Sanction Load	Contract Demand	Bill Demand	Recorded Maximum	PF	Electricity Consumption		Tariff	Energy Charges	Fixed Demand Charge	Electricity duty charge	Electricity Duty Charge	MD Penalty	LT Surcharge	Credit/Debit Amount	Late payment Surcharge	Total Charges
	kW	kVA	kVA	kVA		kWh	kVAh	Rs./kWh	Rs.	Rs.	Rs./kWh	Rs.	Rs	Rs.	Rs.	Rs.	Rs.
14-Mar	15	17	16	16	0.96	2281	2376	6	13686	3600	1.8	1296	0	641	0	28	19252
14-Apr	15	17	16	15	0.96	2992	3117	6	17952	3600	1.9	1616	0	284	0	29	23481
14-May	15	17	16	11	0.96	2552	2658	6	15312	3600	1.8	1418	0	0	0	35	20365
14-Jun	15	17	16	12	0.96	3097	3226	6	18582	3600	1.9	1664	0	0	0	264	24110
14-Jul	15	17	16	11	0.96	2640	2750	6	15840	3481	1.8	1498	0	642	0	220	21681
14-Aug	15	17	16	11	0.96	1593	1659	6	9558	3600	1.6	987	0	374	-13	0	14506
14-Sep	15	17	16	14	0.96	2833	2951	6	16998	3600	1.8	1545	0	585	0	181	22909
14-Oct	15	17	16	10	0.96	2072	2158	6	12432	3600	1.7	1202	0	455	0	442	18131
14-Nov	15	17	16	11	0.96	2640	2750	6	15840	3481	1.8	1498	0	642	0	220	21681
14-Dec	15	17	12	10	0.96	5534	5765	7	36431	5288	1.8	3129	0	2178	0	542	47567
15-Jan	15	17	12	9	0.96	1992	2075	7	13546	2644	1.6	1214	0	845	70	71	18389
15-Feb	15	17	12	7	0.96	1963	2045	7	13348	2643	1.8	1103	0	931	0	247	18273
Max	15		16	16	1	5534	5765	7	36431	5288	1.9	3129	0	2178	70	542	47567
Min	15		12	7	1	1593	1659	6	9558	2643	1.6	987	0	0	-13	0	14506
Avg	15		15	11	1	2682	2794	6	16627	3561	1.8	1514	0	631	4.8	190	22529
Total						32189	33530	74	199525	42736	21.2	18170	0	7577	57	2280	270346

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

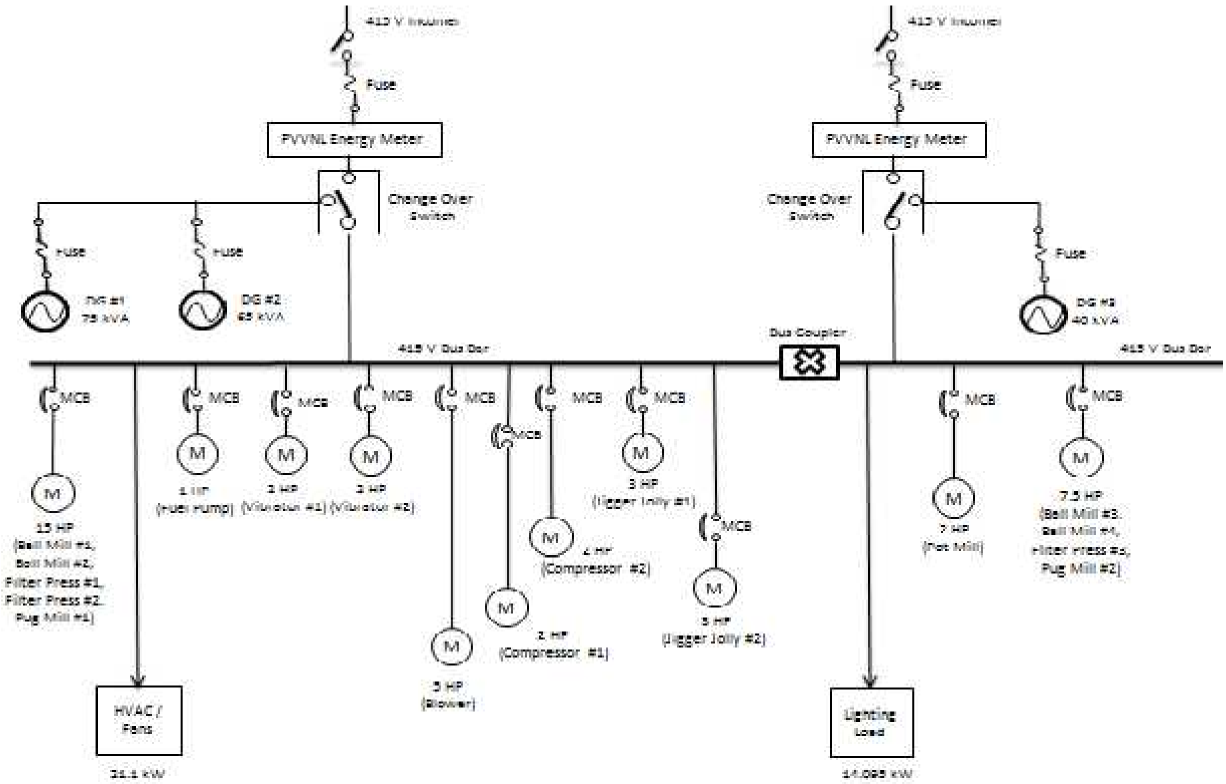


Figure 9: SLD of electrical load

Power factor

The utility bills of the unit reflect the power factor, however, the study was made by logging the power analyzer to one of the main incomers. The power factor was found to be 0.68.

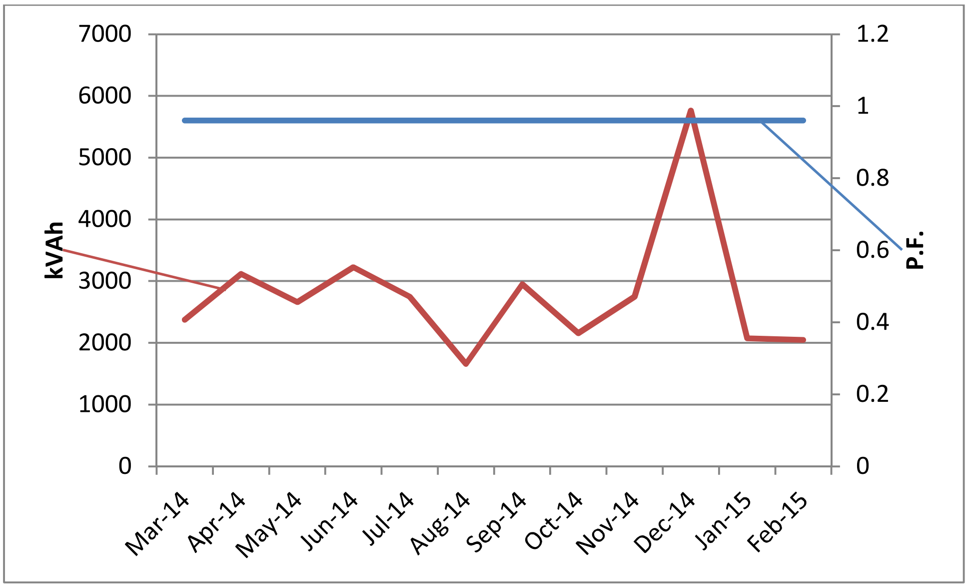


Figure 10: Monthly trend of PF

Maximum demand

Maximum demand as reflected in the utility bill is 16 kW and 27.5 kW for two connections from the bill analysis.

3.4.5 Self-generation

The unit has three DG sets of 40, 65 and 75 kVA each. The DG set with capacity of 40 kVA was studied during the CEA as others were not in operation. 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 find the month wise energy contribution by DG, the results of performance testing of the DG sets, carried out during the detailed energy audit was used.

Performance testing was done for the 40 kVA DG set and the specific energy generation ratio (SEGR) was calculated as 3 kWh/litre. HSD consumption by DG sets is Rs. 1.86 lakh .

Note: Since only monthly 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 11: Electricity consumption & cost

Months	Electricity Used (kWh)			Electricity Cost, Rs.		
	Grid	DG	Total	Grid	DG	Total
	kWh	kWh	kWh	Rs.	Rs.	Rs.
Apr-14	7,545	865	8,410	62,391	15,571	77,962
May-14	8,825	865	9,690	70,165	15,571	85,737
Jun-14	7,736	865	8,601	66,494	15,571	82,066
Jul-14	8,746	865	9,611	73,075	15,571	88,646
Aug-14	7,788	865	8,653	65,730	15,571	81,301
Sep-14	5,420	865	6,285	51,282	15,571	66,853
Oct-14	9,045	865	9,910	77,544	15,571	93,115
Nov-14	5,998	865	6,863	54,517	15,571	70,088
Dec-14	7,788	865	8,653	65,730	15,571	81,301
Jan-15	15,337	865	16,202	134,190	15,571	149,761
Feb-15	5,981	865	6,846	55,347	15,571	70,918
Mar-15	5,738	865	6,603	52,193	15,571	67,764
Total	**95,947**	**10,381**	**106,328**	**828,657**	**186,857**	**1,015,514**

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

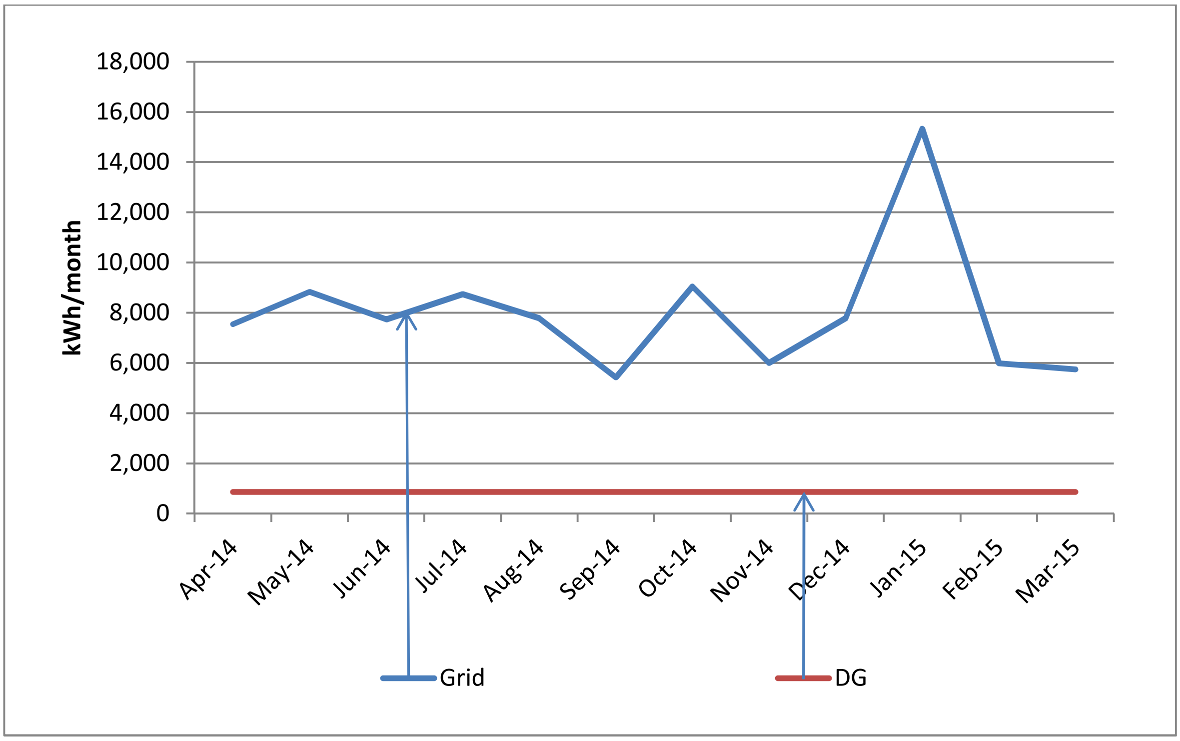


Figure 11: Month wise variation in electricity consumption from different sources

As shown in figure above, the consumption of electrical energy is on higher side during the month of January 2015 and its fluctuating over the remaining period. However, it was noticed that electricity consumption during September 2014 was low because the plant was running on partial load. In January 2015, the electricity consumption was at peak due to seasonal operation of plant. The corresponding month wise variation in electricity cost is shown graphically in the figure below.

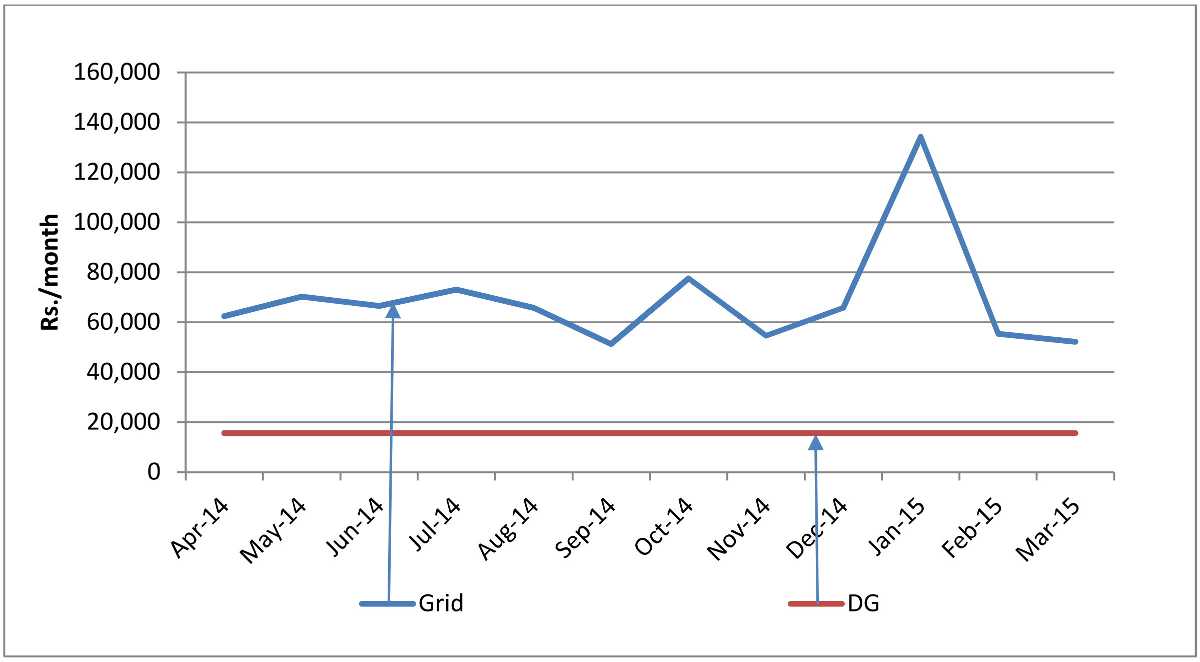


Figure 12: Month wise variation in electricity cost from different sources

From the utility bill analysis, it is clear that the cost per unit of kWh consumption goes down with the rise in consumption. As the consumption goes high 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:

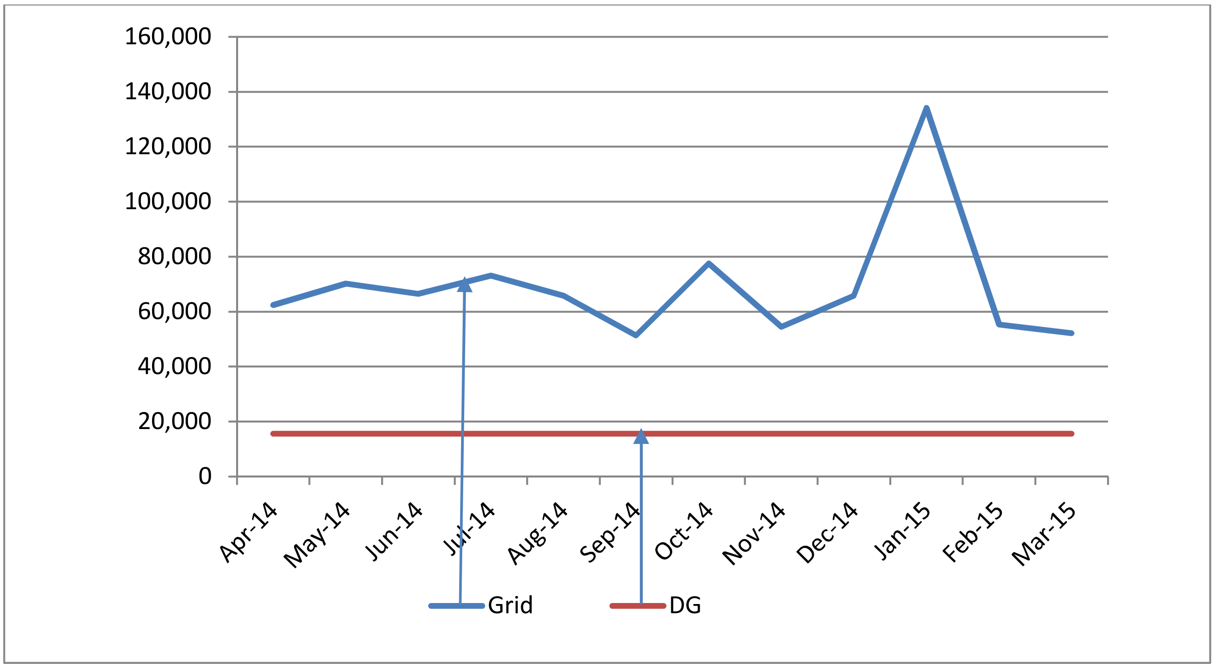


Figure 13: Average cost of power (Rs./kWh) from different sources

3.5 Analysis of thermal consumption by the unit

PNG is used as the fuel for firing of the ceramic materials. PNG is supplied through pipeline from Adani Gas Limited and the average landed rate is Rs. 54/SCM. There is a meter installed for the flow of gas through the pipe which will give the fuel consumption for kiln. PNG consumption by kiln is 6,410 SCM monthly costing Rs. 3.46 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

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 12: Overall specific energy consumption

Parameters	Value	UoM
Annual Grid Electricity Consumption	95,947	kWh
Annual DG Generation Unit	10,381	kWh
Annual Total Electricity Consumption	106,328	kWh

HSD Consumption for Electricity Generation	3460	Litres
Annual Fuel Consumption in kiln (PNG)	76,924	SCM
Annual Energy Consumption; MTOE	86.63	MTOE
Annual Energy Cost	50.68	Lakh Rs
Annual Production	324	MT
SEC; Electricity from Grid	328	kWh/MT
SEC; Thermal	237	Litre/MT
SEC; Overall	0.267	MTOE/MT
SEC; Cost Based	15641	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
  - 1kgoe : 10000 kCal
- GCV of HSD : 11840 kCal/ kg
- Density of HSD : 0.8263 kg/litre
- GCV of PNG : 9000 kCal/scm
- Density of PNG : 0.7 kg/scm
- 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 made during CEA in the unit and some observations were made along with a few ideas of EPIAs for the same. Summary of key observations is as follows:

3.7.1 Electricity Supply from Grid

Further, the electrical parameters at the main electrical incomer feeder from PVVNL supply of the unit was recorded for 8 hours using the portable power analyzer instrument. Following observations were made:

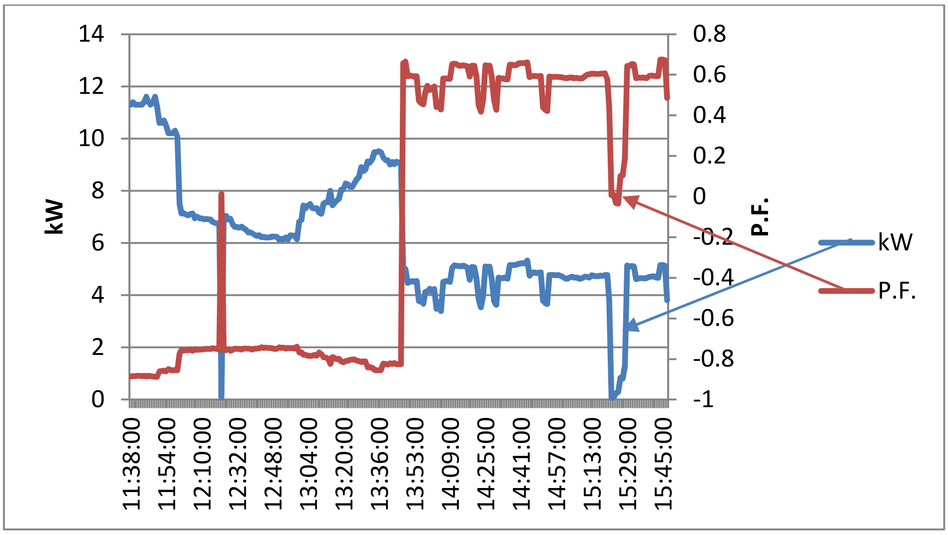


Figure 14: Load profile and power factor

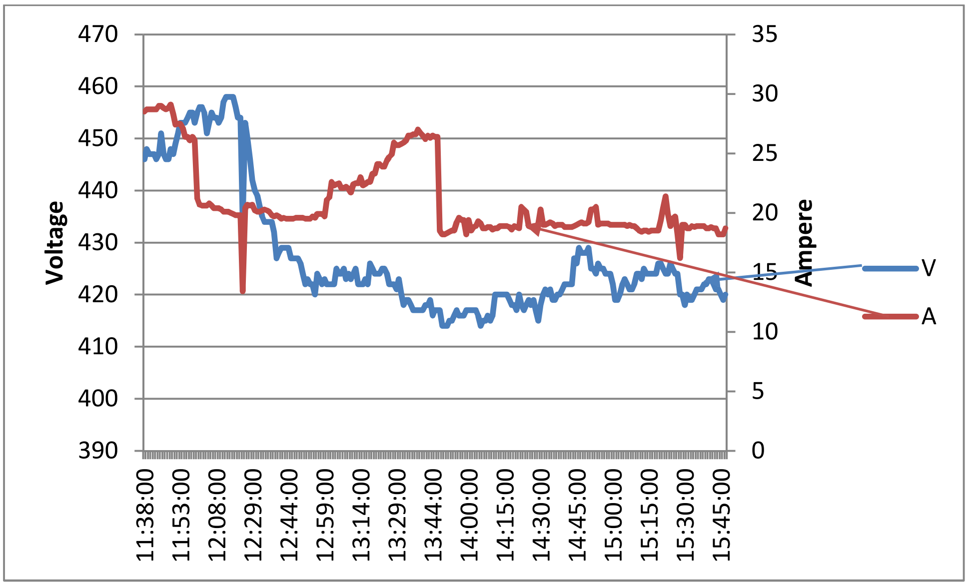


Figure 15: Voltage and current profile

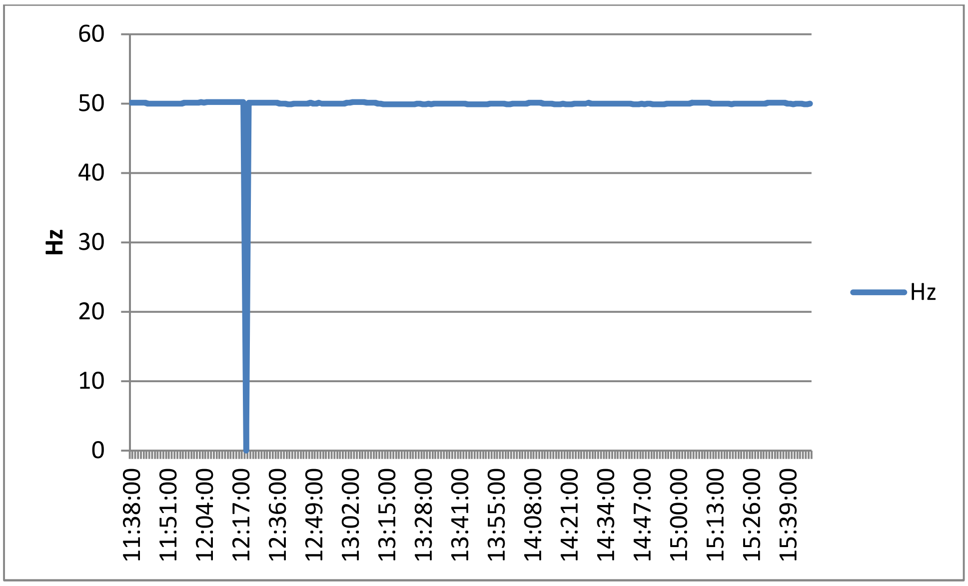


Figure 16: Harmonic profile

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	The power is fed to this unit by PVVNL through a separate transformer. The unit has two LT connections. The contract demand of the unit is 17.12 kVA	The maximum kW recorded during study period was 11.6 kW. As per utility bill; the MD was 16 and 27.5 KVA.	Increasing the contract demand has been suggested.
Power Factor	Unit has two LT connections and billing is in kW. The utility bills do not reflect the PF of the unit. The unit has installed capacitors on the mains to maintain PF but the capacitors are worn out.	The average PF found during the measurement was 0.78. And, it varied between 0.67 and 0.88.	No EPIAs were recommended.
Voltage variation	The unit has no servo stabilizers for voltage regulation.	The voltage profile of the unit was satisfactory and average voltage measured was 427.5 V. Maximum voltage was 458 V and minimum was 414 V.	No EPIA's were recommended.

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

3.7.2 DG Performance

The unit has three DG sets of 40, 65 and 75 kVA. Performance testing was done for 40 kVA DG set during the detailed energy audit as others were not in operation. 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 in the same period. The key performance indicators of the DG sets are evaluated as follows:

Table 14: Analysis of DG set

Particulars	DG
Rated KVA	40
Specific Energy Generation Ratio (kWh/Litre)	3

The observations made are as under:

- The SEGR of DG set is 3 kWh/litre
- The present average frequency of the DG Set is 50.3 Hz

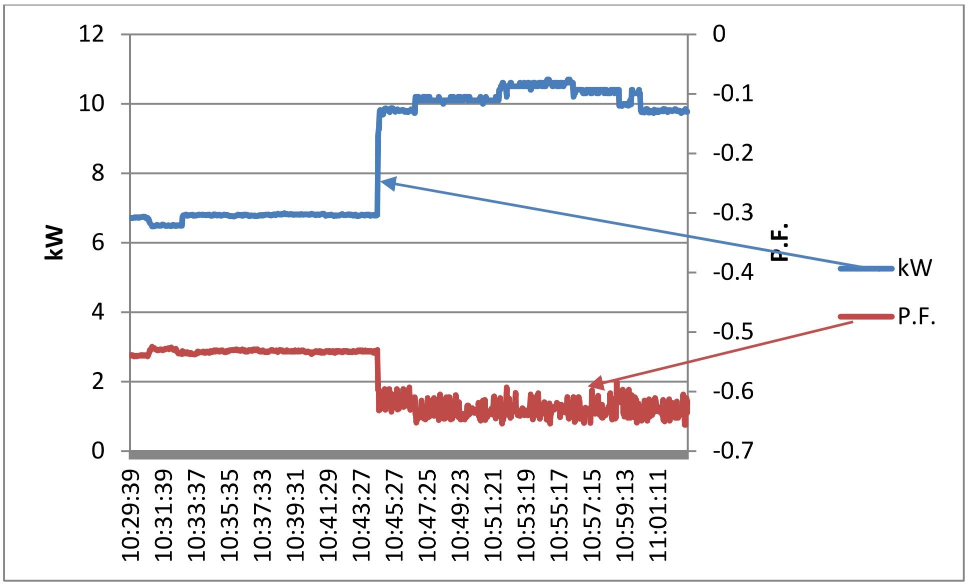


Figure 17: Load profile and power factor of DG set

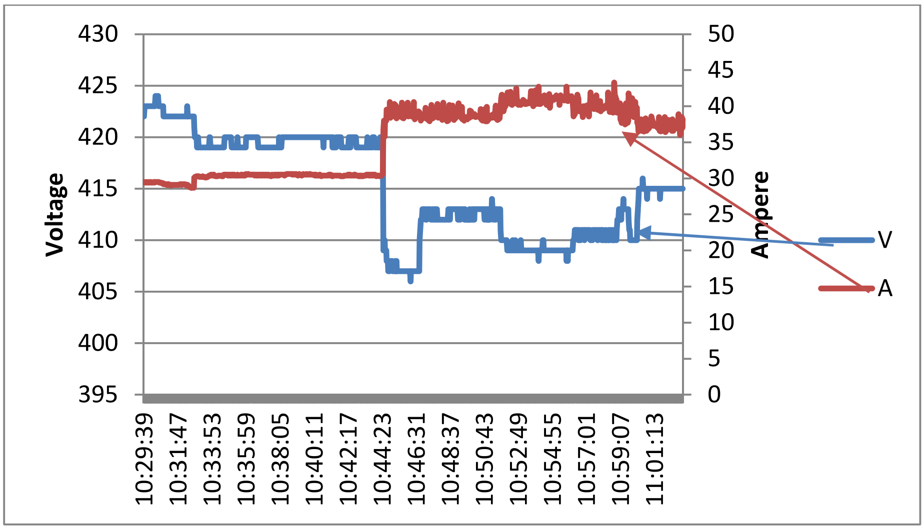


Figure 18: Voltage and current profile of DG set

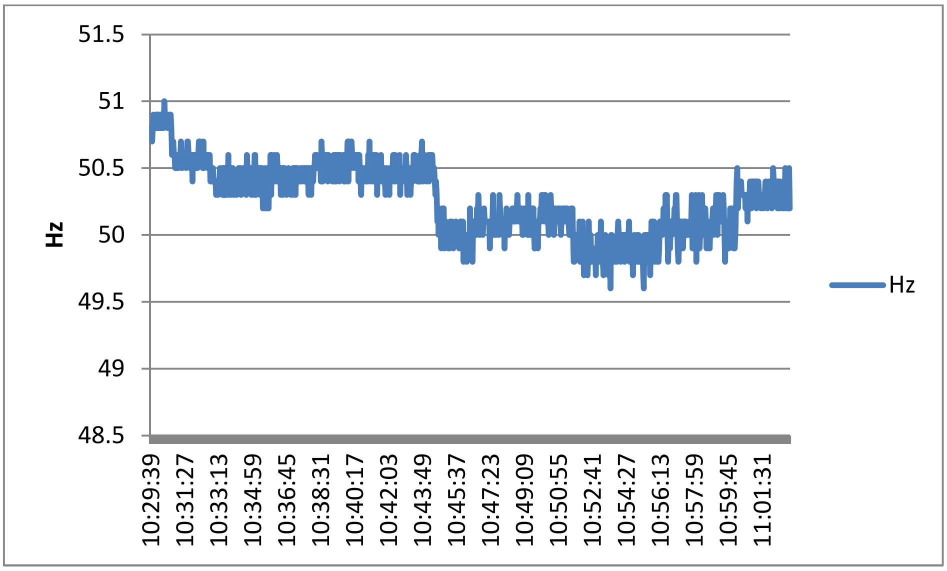


Figure 19: Harmonics profile of DG set

Based on the above observation, it is recommended to set DG frequency @ 49.5 Hz.

3.7.3 Electrical consumption areas

The section-wise consumption of electrical energy, developed in consultation with the unit. This is indicated in Table 6. Over 90% of energy consumption is the manufacturing operations and about 5% is in the utilities.

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

<table>
<tr><th>Name of Area</th><th>Present Set-up</th><th>Observations during field Study & measurements</th><th>Proposed Energy performance improvement actions</th></tr>
<tr><td>Ball mill</td><td>There are 4 ball mills in the unit in which 2 are connected to the same motor of 7.5 HP and other two to the motor of 20 HP. Ball mills account for an estimated 17% of overall energy consumption.</td><td>Out of the 5 ball mills 2 were operational during CEA and were studied.

The results of the study are as below:<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Ball Mill (2T)</td><td>4</td><td>0.96</td></tr><tr><td>Ball Mill (0.8T)</td><td>4</td><td>0.97</td></tr></table></td><td>No EPIA has been proposed since the loading is fine and power factor is maintained.</td></tr>
<tr><td>Pug mill</td><td>There are 2 pug mills installed in the unit, out of which only one could be studied during CEA. This section accounts for about 17% of total energy consumption.</td><td>Only one pug mill was operating during the time of CEA. Data logging was carried out on the machine 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>4</td><td>0.36</td></tr></table></td><td>Application of VFD has been suggested as an EPIA based on the loading and unloading operation power consumption.</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 machine accounts for 3% 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>3.28</td><td>0.95</td></tr></table></td><td>Excess air control by PID controller has been suggested as EPIA.</td></tr>
</table>

3.7.4 Thermal consumption areas

As discussed in the earlier section, about 76 % of energy cost and 85% of the energy use in the kiln.

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

Royal International PNG 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.

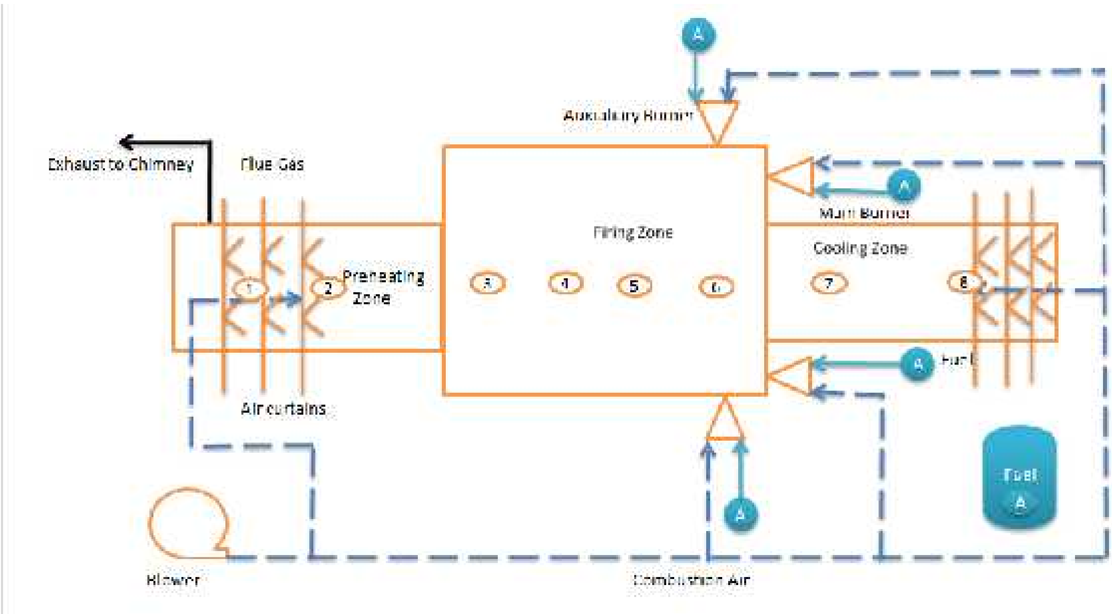


Figure 20: Tunnel kiln

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

Table 15: Temperatures at various sections of tunnel kiln

Section of kiln	Temperature
1	224 °C
2	780 °C
3	1110 °C
4	1168 °C
5	1180 °C
6	1185 °C
7	830 °C
8	255 °C

Table 16: Dimensions of kiln

Zone	Length	Width	Height
Pre-heating	1097 cm	135 cm	139 cm
Firing	487 cm	230 cm	139 cm
Cooling	1280 cm	135 cm	139 cm

Table 17: 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 has been identified by the gas meter provided by AGL.
<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>12%</td><td>33.5°C</td><td>197°C</td></tr>
</table>
From the above table, it is very clear that the oxygen level measured in flue gas is in excess.
The inlet temperature of raw material in all the four furnaces is 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 is in the range of 195 - 200°C whereas near the firing zone it is found to be 860 – 926°C during CEA study.
</td><td>
No recommendation has been suggested, as the exit flue gas temperature is minimum and cannot be used for waste heat recovery.
Reducing the skin losses by improving insulation is recommended in firing zone of the kiln.
Reducing opening losses in the kiln is recommended.
</td></tr>
</table>

4 EE TECHNOLOGY OPTIONS AND TECHNO – ECONOMIC FEASIBILTY

During CEA of the plant, all energy consuming equipment and processes were studied. The analysis of all major energy consuming equipment and appliances were carried out and the same has been discussed in the 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: Skin loss reduction

Technology description

A significant portion of the losses in a kiln occurs as radiation 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 in some of the kilns. Ideally, optimum amount of refractory and insulation should be provided in the kiln walls and the roof to maintain the skin temperature of the furnace at around 50-60°C to avoid minimum heat loss due to radiation. Refractories are heat-resistant materials that constitute the linings for high-temperature furnaces and other processing units. In addition to being resistant to thermal stress and other physical phenomena induced by heat, refractories must also withstand physical wear and corrosion by chemical agents.

Thermal insulations are used to get reduction of heat transfer (the transfer of thermal energy between objects of differing temperature) 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 due to 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 temperature of all the three zones were observed. The average temperature has to be in the range of 50 - 60°C, however, it was observed to be 80.31°C. Hence, proper insulation has to be done to keep the surface temperature within the specified range.

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

Recommended action

Recommended skin temperature of the firing zone to be brought to 50°C to reduce the heat loss through radiation and convection and utilize much of the useful heat.

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

Table 18: R & C losses

Total radiation and convection heat loss per hour	Units	Value
Pre-Heating Zone	kCal / hr	2,046
Firing Zone	kCal / hr	4,402
Cooling Zone	kCal / hr	2,352
Total R&C loss	kCal / hr	8,801

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

Table 19: Cost benefit analysis (EPIA 1)

Parameters	UoM	Value
Present average skin temperature of Firing zone	deg. C	80.31
Recommended skin temperature of Firing Zone	deg. C	50.00
Present heat loss due to Radiation & Convection from Work side wall	kCal / hr	4,402
Recommended heat loss due to Radiation & Convection from Firing zone	W / m2	101.71
	kCal / m2	87.47
	kCal / hr	1192
Total reduction in heat loss due to Radiation & convection by limiting skin temperature at Firing zone	kCal / hr	3210
Calorific value of Fuel	kCal / SCM	13,928
Equivalent savings in Fuel	kg / hr	0.23
	Nm3 / hr	
Plant running time	days / y	300
	hrs / day	24
Annual savings in Fuel	kg/y	1660
Cost of fuel	Rs. /kg	75.254
Annual Monitory savings	Rs./y	124896
	Rs. Lakhs/y	1.25
Estimated investment	Rs. Lakhs	0.7
Simple payback	y	0.56

4.2 EPIA 2: Excess air control

Technology description

It is necessary to maintain the optimum oxygen level for complete combustion of the fuel. Generally, in most of the tunnel kilns, the fuel is fired with excess oxygen supply i.e. excess supply of 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. The excess air effects the formation of ferrous oxide resulting in increasing the burning loss. The primary air is required for atomization and secondary air for combustion. Also here the air curtains are present which will also carry away the useful heat. So, the control of air is very much necessary for combustion.

Study and investigation

The firing zone of kiln is not equipped with automation and control system to maintain the optimum excess air and the fuel is fired from the existing burner arrangement. Also the air for combustion and cooling through air curtains are provided by the same blower.

Recommended action

Two separate blowers have been recommended for combustion and cooling purposes. It has been also proposed to install control system to regulate the supply of excess air for complete combustion. As a thumb rule, reduction in every 10% of excess air will save 1% in specific fuel consumption.

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

Table 20: Cost benefit analysis (EPIA 2)

Parameters	UOM	Present	Proposed
Oxygen level in flue gas	%	13.00	3.00
Excess air control	%	162.50	16.67
Dry flue gas loss	%	13.44	
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	134.03	114.48
Saving in specific fuel consumption	kg/h		0.88
Saving in fuel consumption per year	kg/y		6333
Savings in fuel cost	Rs. Lakh/y		4.77
Installed capacity of blower	kW	3.73	5.22
Running load of blower	kW	2.98	3.66
Operating hours	hrs/y	7200.00	7200.00
Electrical energy consumed	kWh/y	21484.80	26318.88
Savings in electrical energy	kWh/y		-4834.08

Cost of electrical energy	Rs. Lakh/y	2.05	2.51
Savings in terms of energy cost	Rs. Lakh/Y		4.30
Estimated investment	Rs. lakh		7.00
Simple payback	y		1.63

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 it will increase the dead weight of the car carrying away the useful heat required in the kilns. This will reduce the kiln efficiency. Instead the material called ultralite[1] can be used in the kiln car construction which will reduce the dead weight of the kiln thereby reducing the fuel consumption as the material has lesser specific heat.

Study and investigation

The dead weight of the kiln with materials of HFK bricks, quadrite tiles and pillars alone contribute to the weight of 271 kg in a kiln car. These materials have different Cp values and each gains certain amount of height which becomes waste heat, as it is not utilized for useful firing of materials stacked in the kiln. This results in more fuel consumption.

Recommended action

The present kiln car material has to be replaced with ultralite with some modification in the arrangement of refractories which will reduce the dead weight of the kiln, thereby reducing the fuel consumption to the considerable level.

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

Table 21: Cost benefit analysis (EPIA 3)

Parameters	UoM	Present	Proposed
Present Production of kiln	tph	0.05	0.05
Weight of existing kiln car	kg	271	190
Total number of kiln cars inside kiln	Nos.	24	24
Initial temperature of kiln car	Deg c	33.5	33.5
Final temperature of kiln car	Deg c	1119	1119
Estimated percentage saving by replacing present kiln car with new EE kiln car	%		30
Heat carried away by the kiln material	kcal/h	33,128	23,190
Reduction in the heat carried by the new EE kiln car	kcal/h		9,938

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

Operating hours of kiln	h	7200	7200
Savings in terms of fuel consumption	Litre/y		5,138
Savings in terms of cost	Rs. lakh/y		3.9
Estimated investment of kiln car material	Rs. lakh/y		4.80
Payback period	y		1.2

4.4 EPIA 4: VFD on pug mill motor

Technology description

The variable frequency drive will always reduce the power consumption accordingly to the load variation in the pug mill. During loading periods, the current will be very high as the external force is also applied for the process to take place. During no load periods, the current drawn by the equipment is very less and this can be obtained by installing a variable frequency drive if a device draws more current during unloading.

Study and investigation

The existing pug mill draws more current even during unloading.

Recommended action

The proposed condition is that installation of VFD will allow the pug mill to draw minimal current during unloading by sensing the required parameter, for e.g. weight of raw material introduced in to the pug mill for de-airing.

The cost benefit analysis for installation of VFD on pug mill is given below:

Table 22: Cost benefit analysis (EPIA 4)

Parameters	Unit	Present	Proposed
Installed capacity of motor	kW	15	14.92
Estimated energy saving by installing VFD on (Pug-Mill motor)	%		20.0
Average power consumption	kW	10.4	8
No of operating hrs per day	Hrs	16	16
Operating Days per Year	Days	300	300
Average electricity consumption per year	kWh	50131.2	40105
Annual electricity saving	kWh/y		10026
Average electricity tariff	Rs./kWh	9.55	9.55
Annual saving in terms of cost	Rs.lakh		0.96
Estimated investment	Rs.lakh		1.0
Simple Payback	y		1.0

4.5 EPIA 5: Increasing the contract demand

Technology description

Having a contract demand below the recorded maximum demand by the unit will incur penalty in its bills. Instead the actual contract demand can be increased for the unit which will result in immediate savings.

Study and investigation

From the electricity bills for a year, it is noted that the contract demand for the unit is only 17.12 kVA and the recorded maximum demand was found to be always higher with minimum value of 19.5 kVA and maximum value of 27.5 kVA for which demand penalty has been reflected in the utility bill by PVVNL. It is an additional cost incurred other than energy usage cost.

Recommended action

The maximum demand recorded is 27.5 kVA and it is advised to increase the demand to 30 kVA for which no investment will be required and the savings will be immediate. This is recommended for the connection of Royal International whereas the same can be implemented for the other connection.

EPIA analysis is given in the table below:

Table 23: Cost benefit analysis (EPIA 5)

Parameters	Unit	Present	Proposed
Contract Demand	kVA	17	30
Demand Charges	Rs./kVA		225
Demand Charges	Rs.		202.5
Maximum Demand Penalty	Rs.	66950.5	72900
Total Cost	Rs.	107797	0
Estimated Savings	Rs. lakhs		0.35
Estimated investment	lakh Rs.		0.0
Simple Payback	y		Immediate

4.6 EPIA 6 & 7: Energy efficient light fixture

Technology description

Lightings is very essential at places where hand painting and glazing are done. The hand painting should be very precise and it depends on the size of the crockery too. Good lights provide proper visibility to the workers involved in hand painting.

Study and investigation

The unit is having about 208 CFL lamps with its fittings.

Recommended action

The CFL light fixtures have to be replaced with energy saving LED lamps which can reduce the energy consumption immensely.

The cost benefit analysis of the LED fixtures is given below in the table:

Table 24: Cost benefit analysis (EPIA 6)

Parameters	UoM	Present	Proposed
Fixture		CFL	LED tube light
Power consumed by T8	W	40	16
Power consumed by Ballast	W	12	0
Total power consumption	W	52	16
Operating Hours/day	Hr	18	18
Annual days of operation	Day	300	300
Energy Used per year/fixture	kWh	281	86
Energy Rate	Rs./kWh	9.55	9.55
No. of Fixture	Unit	208	208
Power consumption per year	kWh/y	58406	17971
Operating cost per year	Rs. Lakh/y	5.58	1.72
Saving in terms of electrical energy	kWh/y		40435
Savings in terms of cost	Rs. Lakh/y		3.86
Investment per fixture of LED	Rs. Lakh		0.0125
Investment of project	Rs. Lakh		2.6
Payback period	y		0.67

Table 25 Cost benefit analysis (EPIA 7)

Particulars Fixture	Unit	Existing 45 watt and 23 watt CFL	Proposed 16 Watt LED light
Power consumed by CFL 45 watt	W	45	16
Total no. of 45 watt CFL	Nos.	10	10
Power consumed by the CFL 23 Watt	W	23	16
Total no. of 23 watt CFL	Nos.	208	208
Total power consumption	kW	5	3
Operating Hours/day	Hr	18	18
Annual days of operation	Day	300	300

Particulars Fixture	Unit	Existing 45 watt and 23 watt CFL	Proposed 16 Watt LED light
Energy Used per year/fixture	kWh	*28,264*	*18,835*
Energy Rate	Rs/kWh	**9.55**	**9.55**
Operating cost per year	Rs. Lakh/Year	2.70	1.80
Saving in terms of electrical energy	kWh/Year		9428
Savings in terms of cost	Rs. Lakh/Year		0.90
Investment per fixture of LED	Rs. Lakh		0.009
Investment of project	Rs. Lakh		1.96
Payback period	Years		2.18

4.7 EPIA 8: Energy efficient fans

Technology description

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

Study and investigation

The unit is having about 130 fans which are very old.

Recommended action

The existing fans have to be replaced with energy efficient fans.

The cost benefit analysis was made for this energy conservation measure and it is given below:

Table 26: Cost benefit analysis (EPIA 8)

Data & Assumptions	UOM	Present	Proposed
Number of Ceiling fans in the plant	Nos	130	130
Running hours per day (average) - for fans	hrs / day	18	18
Power consumption at Maximum speed	kW	0.07	0.04
Number of working days/year	days / year	300	300
Tariff for Unit of electricity	Rs. / kWh	9.55	9.55
Fan unit price	Rs./piece	1500	3000
Electricity consumption:			
Electricity demand	kW	9.10	4.55

Power consumption by fans in a year	kWh/y	49140	24570
Savings in terms of power consumption	kWh/y		24570
Savings in terms of cost	Rs. Lakh/y		2.35
Estimated investment	Rs. Lakh/y		3.90
Payback period	y		1.66

4.8 EPIA 9: DG frequency optimization

Technology description

The fuel consumption in the DG set when it is observed to be higher than the desired amount that has to be consumed, change in operating frequency can be suggested where the fuel consumption can be minimized by reducing the speed of shaft rotation in DG, thereby reducing the operating frequency.

Study and investigation

The DG present in the unit delivers power with the frequency of 50 Hz and HSD consumption is found to be higher than the desired amount.

Recommended action

The set frequency can be changed to 49.5 Hz so that the fuel consumption in the DG set can be reduced which will result in fuel savings by 0.1 liter per hour.

The cost benefit analysis for this project is given below:

Table 27: Cost benefit analysis (EPIA 9)

Parameters	Unit	Present	Proposed
Present average frequency of the DG sets	Hz	50.27	49.5
Average load on DG	kW	9	8.6
Specific Fuel Consumption	Litre/kWh	3.00	3.00
Centrifugal Load	%	36.50	36.50
Possible power savings	kW	-	0.4
Possible savings	Litres/h	-	1.2
Operation hours per day	h/day	4	4
DG operating hours	h/y	1200	1200.0
Annual HSD savings	Litres/y	-	1407
HSD Cost	Rs./litre		
Annual Monetary savings	Lakh Rs/y	54.00	54.0
Investment	Rs Lakh	-	0.76
Payback Period	y	-	0.05

4.9 EPIA 10: Energy monitoring system

Technology description

Installation of energy monitoring system on a unit will monitor the energy consumed and production rate. This will help in setting the benchmark energy consumption, and if there is any increase in electrical energy consumption it can be noticed and proper maintenance actions can be taken.

Study and investigation

As per the analysis done by the team on the online data, measuring is not done on the main incomer as well as various electrical panels for energy consumption.

Recommended action

It is recommended to install energy monitoring online system for the fuel supply to reduce overall energy consumption by 3%.
The savings assessment has been given in the table below:

Table 28: Cost benefit analysis (EPIA 10 – fuel)

Parameters	Unit	As Is	To Be
Energy monitoring savings	%		3.00
Energy consumption of major machines per year	kWh/y	95,947	93,069
Annual electricity savings per year	kWh/y		2,878
W. Average Electricity Tariff	Rs./kWh		9.55
Annual monetary savings	Rs.lakh/y		0.27
Estimate of Investment	Rs.lakh		0.25
Simple Payback	Months		10.91
Current fuel mix consumption	kg/y	53,847	52,231
Annual fuel savings per year	kg/y		1,615
Unit Cost of PNG	Rs./kg		75.25
Annual monetary savings	Rs.lakh/y		1.22
Estimate of Investment	Rs.lakh		0.20
Simple Payback	y		0.16

4.10 EPIA 11: Pressure reduction in compressor

Technology description

It is advisable to have a certain pressure range for the required operation. In ceramic industry, compressors are used for the purpose of cleaning the materials before it is being glazed to remove dust particles from it. The pressure difference between cut-in and cut-out should be a maximum of

1.02 kg/cm2 to avoid burning out of compressor motor if the pressure difference is too low and the larger pressure difference will result in larger energy consumption.

This can bring energy savings of up to 6% for difference in 1.02 kg/cm2 and will increase if the pressure difference is even high.

Study and investigation

It was observed during the CEA that the cut-in pressure was 5 kg/cm2 and cut-out pressure was 7.5 kg/cm2.

Recommended action

As per thumb rule, the difference of 1.02 kg/cm2 has to be set in pressure so that minimum amount of energy is consumed. So, the existing 7.5 kg/cm2 cut-out pressure has to be lowered to 6 kg/cm2 which will reduce the energy consumption by 9% as per guidelines mentioned in energy management book by BEE.

The cost benefit analysis is given in the table below:

Table 29: Cost benefit analysis (EPIA 11)

Parameters	UoM	Present	Proposed
Operating Pressure Required	kg/cm^2	5	5
Cut off pressure	kg/cm^2	7.5	6
Reduction in pressure	kg/cm^2		-
% of energy savings	%	-	9.00
Average load	kW	1.3	1.14
Average working of compressor hours in a day	h	18	18
Average working days of compressor in a year	days	300	300
Energy Consumption	kWh	6,786	6,175
Energy Savings	kWh	-	611
W. Avg cost of electricity	Rs./kWh		9.55
Monetary savings	Lakh Rs/y	-	0.06
Investment	Lakh Rs	-	0.05
Payback	y		0.86

4.11 EPIA 12: 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 12)

Sl. No.	Replacing persent burners with energy efficient burners		Kiln	
	Parameters	Unit	Present	Proposed
1	Production rate of the kiln	kg/hr	45	45
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 efficient burner	%		5.0
6	Current fuel firing in kiln	kg/hr	6	6
7	Savings in fuel per hours	kg/hr		0.30
7	Number of operating days	days	300.00	300
8	Number of operating hours per day	hrs	24.00	24
9	Total savings per year into fuel firing	kg/yr		2171
10	Unit cost of fuel	Rs./kg		75.25
11	Cost savings per year	Lakh Rs./yr		1.63
12	Estimated investment for all burners	Lakh Rs.		0.7
13	Payback period	Yr		0.4

5 ANNEXURE

Participation of the unit in this project

Royal International

Manufacturers & Exporters of all kinds of Handicrafts

Ref. Date: 26/05/2015

Date:

To,
The President
[illegible]
[illegible]
[illegible]

Sub: Participation in BEE - [illegible] project on EE & RE in [illegible] Cluster

Dear Sir,

We wish to participate in the BEE - UNIDO energy efficiency project in Khurja Ceramic cluster. In this regard, we hereby offer our [illegible] unit where BEE-UNIDO team can undertake comprehensive energy audit. We shall provide all necessary co-operation required by the energy audit team to successfully conduct the comprehensive energy audit at our unit which shall result in identification of energy saving options for our unit.

Thanking you,

Royal International
Auth. Sign.

Name & signature of unit head

[illegible] Road, [illegible] Nagar, KHURJA 203131
Ph: [illegible]

TIN No. [illegible]
C.S.T. No. [illegible]

Client Name	Bureau of Energy Efficiency (BEE)	Project No.	9A0000005601
Project Name	Promoting energy efficiency and renewable energy in selected MSME clusters in India	Rev.	2
Prepared by: DESL	Date: 06-07-2015		Page 53 of 61

Kiln efficiency calculations

Input parameters

Parameters	Value	Units
Tunnel Kiln Operating temperature (Firing Zone)	1119	*Deg C*
Initial temperature of kiln car	33.5	*Deg C*
Avg. fuel Consumption	6.0	*kg/hr*
Flue Gas Details		
Flue gas temperature after APH	197	*deg C*
Preheated air temp./Ambient	33.5	*deg C*
O2 in flue gas	13	*%*
CO2 in flue gas	7.9	*%*
CO in flue gas	36	*ppm*
Atmospheric Air		
Ambient Temperature	33.5	*Deg C*
Relative Humidity	48.3	*%*
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	*13928*	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	135	*Kg/Hr*
Weight of ceramic material being fired in Kiln	45	*Kg/Hr*
Weight of Stock	45	*kg/hr*
Specific heat of clay material	0.22	*Kcal/kgdegC*
Specific heat of kiln car material	0.23	*Kcal/kgdegC*
Avg. specific heat of fuel	0.559	*Kcal/kgdegC*

fuel temp[2]	33.5	*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 zones		
Radiation and from preheating zone surface	2046	*kcal/hr*
Radiation and from heating zone surface	4402	*kcal/hr*
Radiation and from firing zone surface	2352	*kcal/hr*
Heat loss from all zones	8801	*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	1.232	*m2*
Coefficient based on profile of kiln opening	0.7	
Max operating temp. of kiln	353	*deg K*

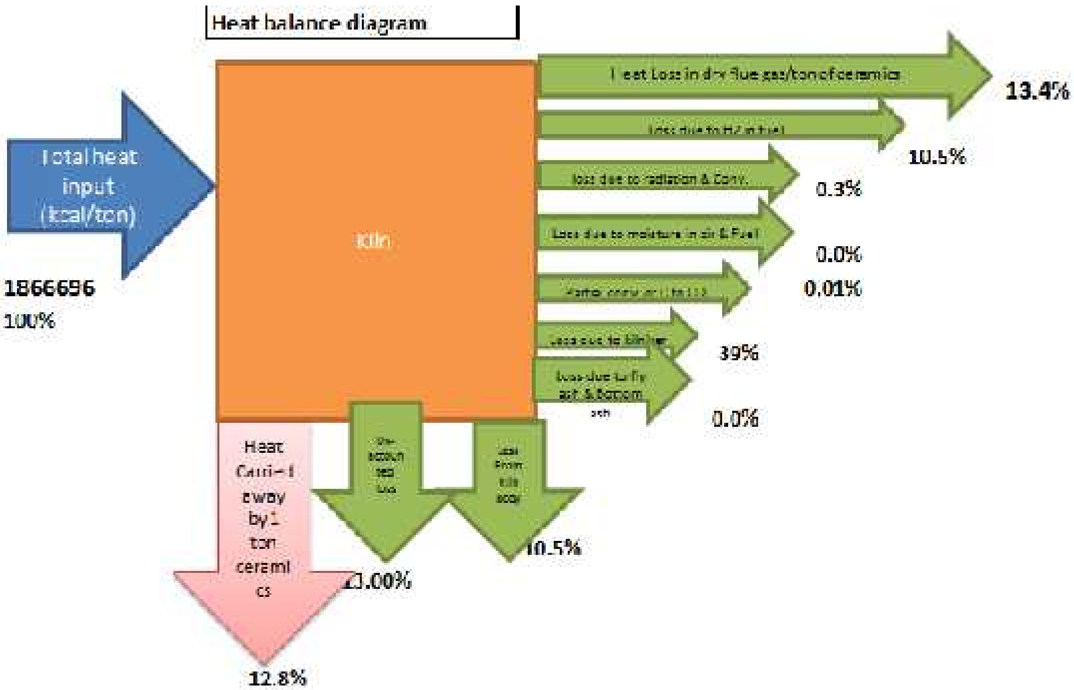
Efficiency calculations

Calculations	Values	Unit
Theoretical Air Required	17.25	*kg/kg of fuel*
Excess Air supplied	162.50	*%*
Actual Mass of Supplied Air	45.27	*kg/kg of fuel*
Mass of dry flue gas	44.05	*kg/kg of fuel*
Amount of Wet flue gas	46.27	*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	44.05	*kg/kg of fuel*
Specific Fuel consumption	134.03	*kg of fuel/ton of billet*
Heat Input Calculation		
Total heat input	1866696	*Kcal/ton of billet*
Heat Output Calculation		
Heat carried away by 1 ton of ceramics (useful heat)	238810	*Kcal/ton of billet*
Heat loss in dry flue gas per ton of ceramics	250963	*Kcal/ton of billet*
Loss due to H2 in fuel	195919	*Kcal/ton of billet*
Loss due to moisture in combustion air	100	*Kcal/ton of billet*
Loss due to partial conversion of C to CO	257	*Kcal/ton of billet*

[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.

Loss due to convection and radiation (openings in kiln - inlet & outlet of kiln car)	6,268	*Kcal/ton of billet*
Loss Due to Evaporation of Moisture Present in Fuel	0.0	*Kcal/ton of billet*
Total heat loss from kiln (surface) body	195572	*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	736178	*Kcal/ton of billet*
Unaccounted heat losses	242628	*Kcal/ton of billet*
Heat loss from kiln body and other sections		
Total heat loss from kiln	195572	*Kcal/tons*
Kiln Efficiency	**12.8**	*%*

Sankey Diagram



6 LIST OF VENDORS

EPIA 1: Skin Loss Reduction

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

EPIA 4: 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.	Electrical business group,32,Shivaji Marg,Near Moti	011(41419500),9582252422(Mr.Rajesh),7838299559(Mr.Vikra	Email: bhallar@lntebg.com, vikram.garg@lntebg.com,

Sl. No.	Name of Company	Address	Phone No.	E-mail
	Rajesh Bhalla	nagar,Delhi-15	m-sales),(PrIthvi power-technical)-9818899637,9810028865(Mr.Ajit),8510999637(Mr.Avinash Vigh)	prithvipowers@yahoo.com, rajesh.bhalla@lntebg.com,ajeet.singh@lntebg.com

EPIA 6 & 7: 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 Gurgaon, Haryana	Phone: 011-30416390 Mob: 9560215888	vinay.bharti@osram.com
2	Philips Electronics Contact Person: Mr. R. Nandakishore	1st Floor Watika Atrium, DLF Golf Course Road, Sector 53, Sector 53 Gurgaon, Haryana 122002	9810997486, 9818712322(Yogesh-Area Manager), 9810495473(Sandeep-Faridabad)	r.nandakishore@phillips.com, sandeep.raina@phillips.com
3	Bajaj Electricals Contact Person: Mr. Kushgra Kishore	Bajaj Electricals Ltd,1/10, Asaf Ali Road, New Delhi 110 002	9717100273, 011-25804644 Fax : 011-23230214 ,011-23503700, 9811801341(Mr.Rahul Khare), (9899660832)Mr.Atul Baluja, Garving Gaur(9717100273),9810461907(Kapil)	kushagra.kishore@bajajelectricals.com, kushagrakishore@gmail.com; sanjay.adlakha@bajajelectricals.com

EPIA 8: 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 10: 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 Contact Person: Mr. Manjul Pandey	Naimex House A-8, Mohan Cooperative Industrial Estate, Mathura Road, New Delhi - 110 044	Office: 011-30810229, Mobile: +91-981817181	manjulpandey@aimil.com
3	Panasonic India Contact Person: Neeraj Vashisht	Panasonic India Pvt Ltd Industrial Device Division (INDD) ABW Tower,7th Floor, Sector 25, IFFCO Chowk, MG Road,Gurgaon - 122001, Haryana,	9650015288	neeraj.vashisht@in.panasonic.com

EPIA 12: 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