COMPREHENSIVE ENERGY AUDIT REPORT

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

SCK Insulators

Industrial Area, G.T Road, Khurja

17-04-2015

Submitted to

BUREAU OF ENERGY EFFICIENCY

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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. S C Khanna, MD & CEO for showing keen interest in the energy audit and also thankful to the management of M/s SCK Insulators for their wholehearted support and cooperation for the preparation of this comprehensive energy audit Report, without which the study would not have steered to its successful completion. Special thanks to other members of the unit for their diligent involvement and cooperation.

It is well worthy to mention that the efforts being taken and the enthusiasm shown by all the plant personnel towards energy conservation and sustainable growth are really admirable.

Last but not the least, the interaction and deliberation with Mr. 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
	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 with respect to types of 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 main 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 equipment / process, 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 SCK Insulators
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	Porcelain Insulators
Name(s) of the Promoters / Directors	Mr. S C Khanna

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 and 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 approx. 1220-1230^{0}C (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 are mixed along with water to form slurry.T Water and air are removed from this slurry in various process machines and the material are given shapes as per requirement using dies and 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 equipments which were operational during the field study. Kilns consume most of the energy in the unit, accounting for more than 70% of the total energy used.

The identified energy performance improvement actions in the kilns include proper insulation to reduce radiation and convection heat loss from the surface, excess air control and replacement of the kiln car material. VFD application is recommended in 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						
		Fuel mix	Electricity	HSD	Material Saving	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	9026.8				4.2	0.32	0.1
2	Excess air control with separate blower for cooling and combustion air supply	28125	8101.3			13.9	7.00	0.5
3	Installation of energy efficient fan instead of conventional fan		14112.0			1.2	1.68	1.4
4	Installation of LED fixture instead of T8 tube light system		30002.4			2.5	1.81	0.7
5	VFD installation on Pug mill		8187.1			0.7	0.70	1.0
6	DG frequency optimization			136.1		0.1	0.05	0.7
7	Energy monitoring system	7232.1	8436.7			4.1	0.55	0.1
8	Power factor improvement		0		2.87	2.9	0.50	0.1
9	Replacement with energy efficient kiln car	22878.0				10.8	4.80	0.4
10	Replacement of existing burner with energy efficient burner	12053.6				5.7	1.94	0.3
	Total	79315.5	68839.5	136.1	2.9	46.0	19.4	0.4

The projects proposed may result in energy savings of approximately 30% and cost saving of Rs. 46 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 April-2014 to March-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 1.4 years.
- Classify parameters related to EE enhancements such as estimated quantum of energy saving, investment required, time frame for implementation, payback period, re-skilling of existing man power, etc. and to classify the same in order of priority.
- Identify and recommend proper "energy monitoring system" for effective monitoring and analysis of energy consumption, energy efficiency.

1.3 Methodology

1.3.1 Boundary parameters

Following boundary parameters were set on coverage of the audit:

- Audit covered all possible energy intensive areas & equipments which were operational during the field study
- All appropriate measuring systems including portable instruments were used
- The identified measures normally fall under short, medium and long-term measures

1.3.2 General methodology

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

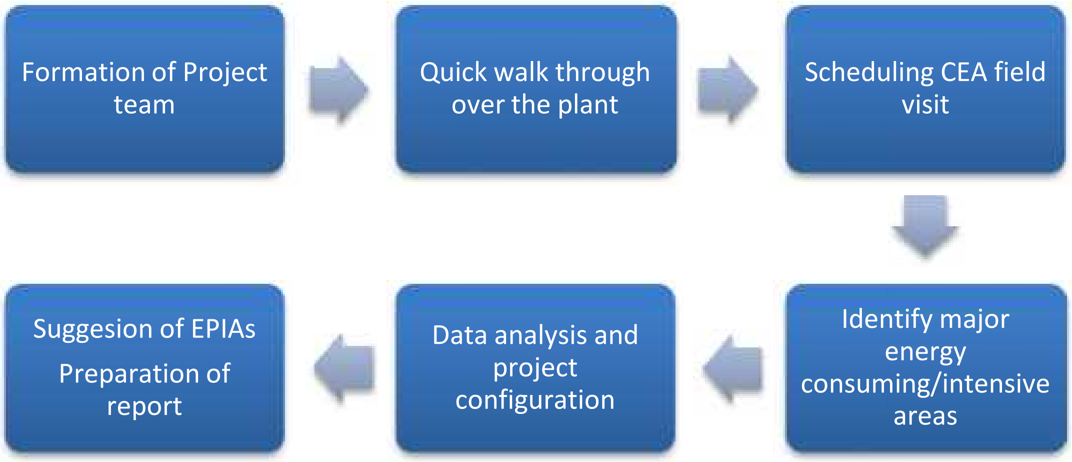


Figure 1: General methodology

The study was conducted in 3 stages:

- **Stage 1:** Walk through energy audit of the plant to understand the process, energy drivers, assessment of the measurement system, assessment of scope, measurability, formulation of audit plan and obtaining required information
- **Stage 2:** Detailed energy audit - testing & measurement for identification of saving potential, technology assessment and understanding of project constraints
- **Stage 3**: Desk work for data analysis, initial configuration of projects, savings quantification, vendor consultation, interaction with 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 to understand the impact of energy cost on the financial performance of the unit
- Assess the energy conservation potential at a macro level
- Finalize the schedule of equipment's and systems for testing and measurement

The audit identified the following potential areas of study

- 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 the site

Audit methodology involved system study to identify the energy losses (thermal / electrical) followed by finding solutions to minimize the same. This entailed data collection, measurements / testing of the system using calibrated, portable instruments, analyzing the data / test results and identifying the approach to improve the efficiency. The following instruments were used during the energy audit.

Table 4: Energy audit instruments

Sl.No.	Instruments	Make	Model	Parameters Measured
01	Power Analyzer – 3 Phase (for un balanced Load) with 3 CT and 3 PT	Enercon and Circutor	AR-5	AC Current, Voltage, Power Factor, Power, Energy, Frequency, Harmonics and data recording for minimum 1 sec interval
02	Power Analyzer – 3 Phase (for balance load) with 1 CT and 2 PT	Elcontrol Energy	Nanovip plus mem	AC Current, Voltage, Power Factor, Power, Energy, Frequency, Harmonics and data recording for minimum 2 sec interval
03	Digital Multi meter	Motwane	DM 352	AC Amp, AC-DC Voltage, Resistance, Capacitance
04	Digital Clamp on Power Meter – 3 Phase and 1 Phase	Kusam - Meco	2745 and 2709	AC Amp, AC-DC Volt, Hz, Power Factor, Power
05	Flue Gas Analyzer	Kane-May	KM-900	O2%, CO2%, CO in ppm and Flue gas temperature, Ambient temperature
06	Digital Temperature and Humidity Logger	Dickson		Temperature and Humidity data logging
07	Digital Temp. & Humidity meter	Testo	610	Temp. & Humidity
08	Digital Anemometer	Lutron and Prova	AM 4201 And AVM-03	Air velocity
09	Vane Type Anemometer	Testo	410	Air velocity
10	Digital Infrared Temperature Gun	Raytek	Minitemp	Distant Surface Temperature
11	Contact Type Temperature Meter	Testo	925	Liquid and Surface temperature
12	High touch probe Temperature Meter	CIG		Temperature upto 1300℃

Sl.No.	Instruments	Make	Model	Parameters Measured
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 S C K Insulators
2	Constitution	Private
3	Date of incorporation / commencement of business	NA
4	Name of the contact person Mobile/Phone No. Designation E-mail ID	Mr. S C Khanna +91 5738 232498 Managing Director nareshpott@gmail.com
5	Address of the unit	Industrial Area, G.T Road, Khurja – 203131
6	Industry / sector	Ceramic
7	Products manufactured	Porcelain insulators
8	No. of operational hours/day	24
9	No. of shifts / day	3
10	No. of days of operation / year	300
11	Whether the unit is exporting its products (yes / no)	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

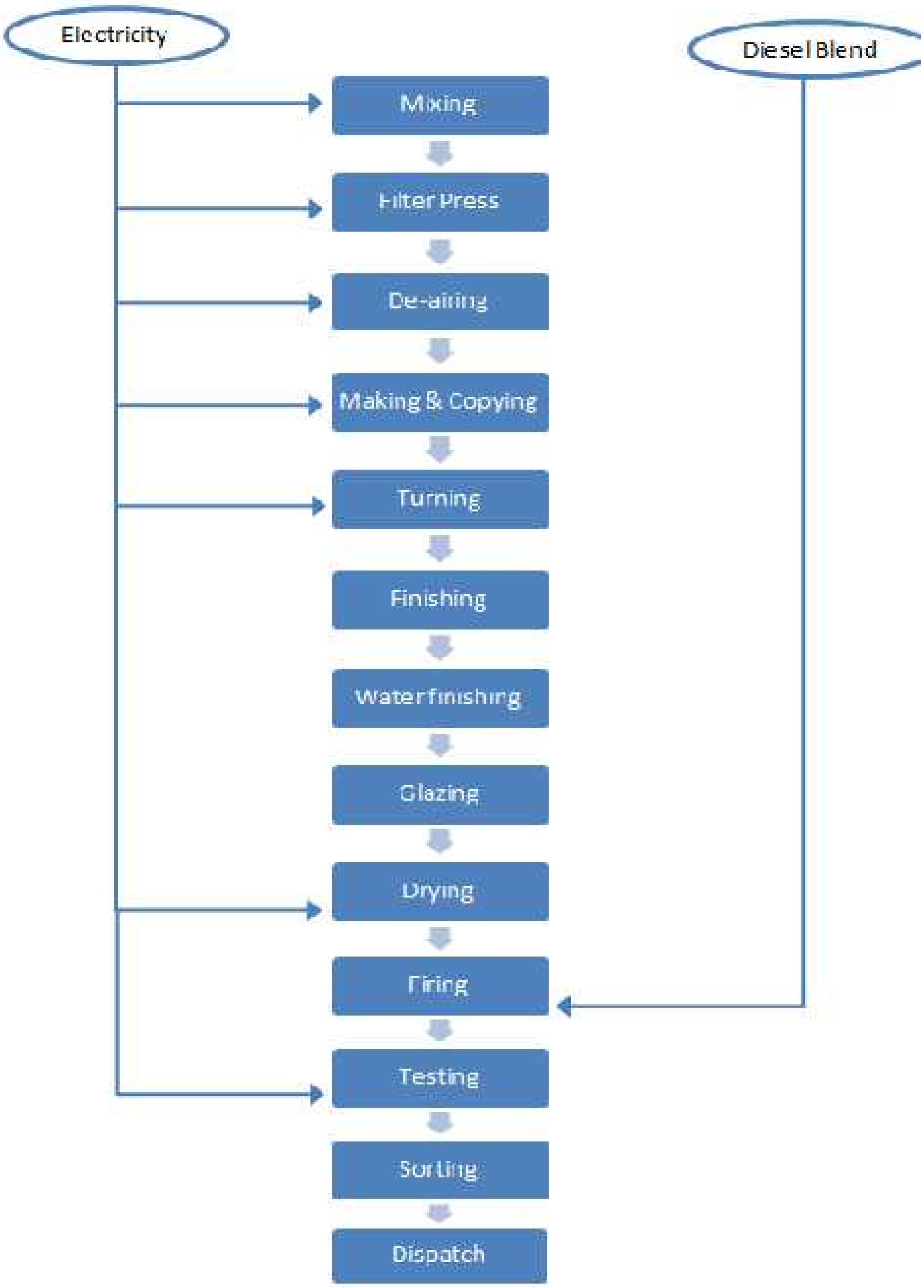


Figure 2 Process flow diagram

3.1.2 Process description

M/s S C K Insulators 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 diaphragm pump, the mixture is further transferred to the filter press to remove water.
- The filter cakes formed are then placed in a pug mill for de-airing by a 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 they are simply dried under fans for a few days.
- The dried materials are glazed, and stacked on the kiln cars for firing to obtain the requisite strength. The firing zone temperature in the kiln is maintained at 1220 – 1230^{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 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 the 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 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 are then introduced into the pug mill, which has a positive displacement conveyor connected with the vacuum pump for de-airing in order to avoid formation of pores and cracks during firing. The output from the pug mill is cut in to small pieces and transferred to 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.
- **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 1230^{o}C. Once the kiln car comes out of the cooling zone the materials are further cooled, quality tested and packed for dispatch.

3.3 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 diesel generator sets for the whole plant
- Thermal energy is used for following applications :
  - Diesel blend for tunnel 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	29.31	20	24.2	8.86
Diesel – DG	6.56	4	11.9	4.35
Thermal – DIESEL BLEND	113.47	76	236.8	86.78
Total	149.34	100	272.9	100

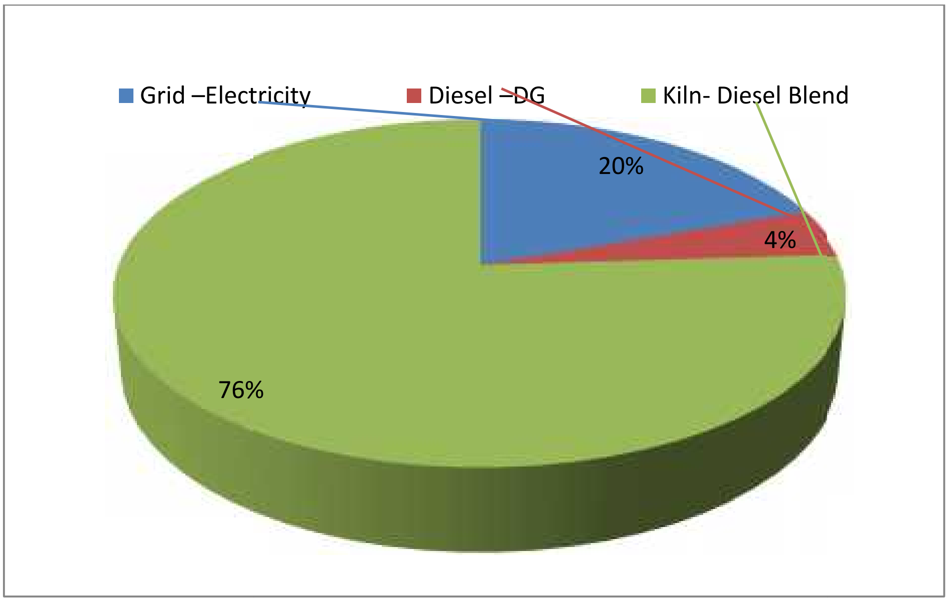


Figure 3: Energy cost share (Rs. Lakh)

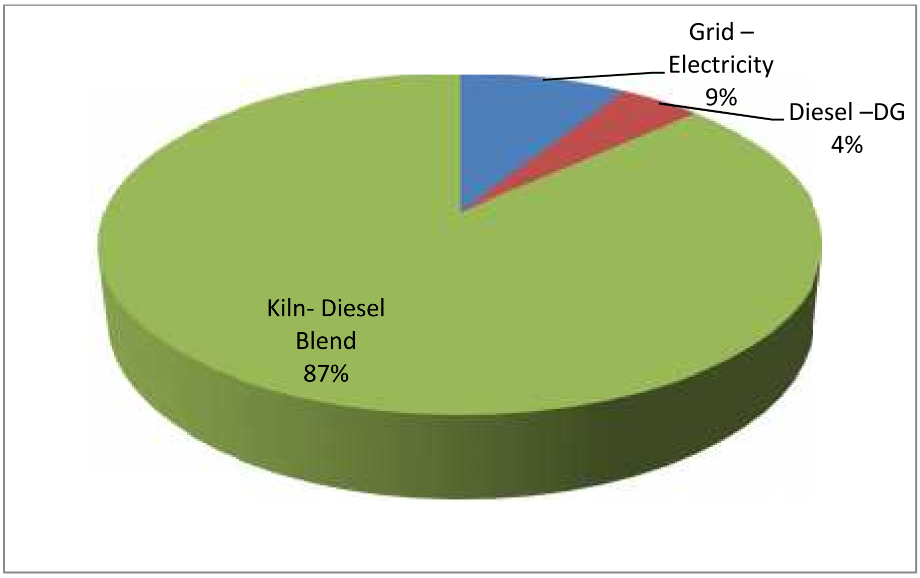


Figure 4: Energy use share (MTOE)

Major observations are as under:

- The unit uses both thermal and electrical energy for manufacturing operations. Electricity is supplied by the grid as well as self generated through DG sets 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.
- Diesel blend used in kilns account for 76% of the total energy cost. Diesel blendused in DG sets account for 4% of total energy cost and electricity used in plant process account for 20% of total energy cost.
- Diesel blend used in kilns account for 87% of overall energy consumption. Diesel blend 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

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

Table 7: Baseline parameters

Electricity cost (Excluding Rs/kVA)	6.26	Rs./ KVAH inclusive of taxes
Weighted Average Electricity Cost	8.23	Rs./ kWh for 2013-14
Percentage of total DG based Generation	12%	
Average Cost of Diesel Blend	47.07	Rs./litre
Average cost of HSD	54.00	Kg/liter

Annual Operating Days per year	300	Days/yr
Annual Operating Hours per day	24	Hr/day
Production	2376	MT
GCV of Diesel Blend	11517	kCal/ Litre
Density of Diesel blend	0.853	kg/litre

3.4.2 Electricity load profile

Following observation has been made from the utility inventory:

- The plant and machinery load is 94.7 kW
- The utility load (fan and lighting) is about 5.3 kW including the single phase load
- The plant total connected load is 100 kW

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

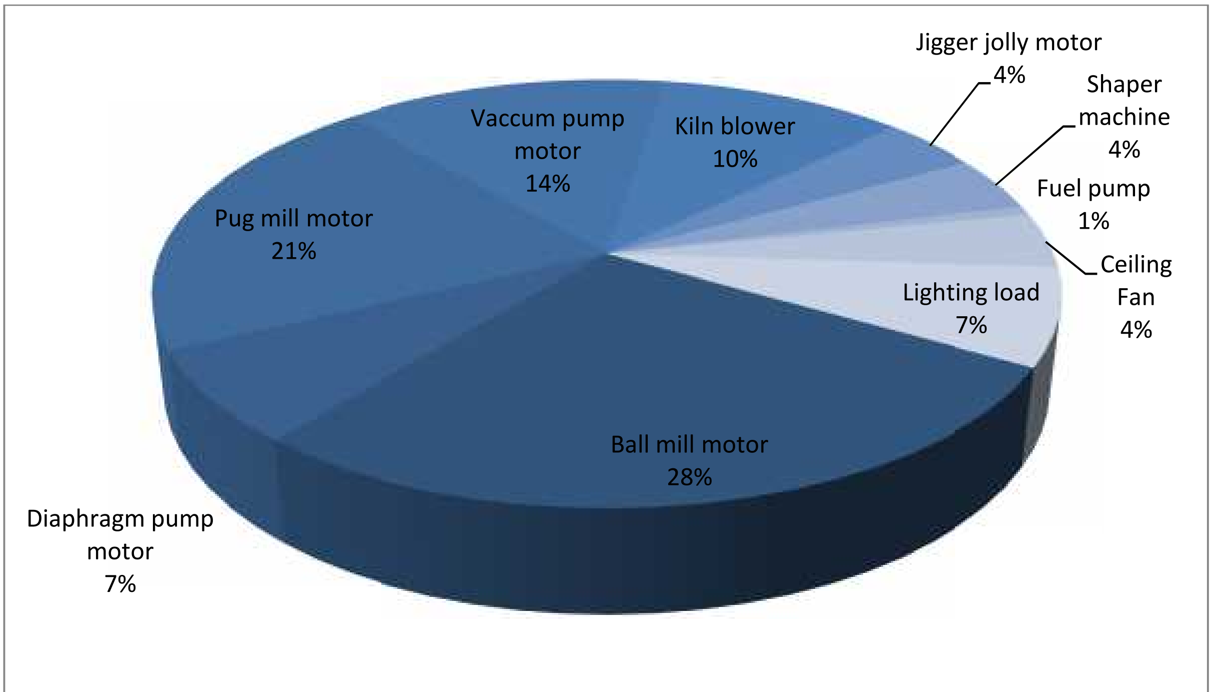


Figure 5: Details of connected load

As shown in the pie chart of connected loads, the maximum share of connected electrical load is for the ball mill – 28%, followed by pug mill – 21%, vacuum pump – 14%, kiln blower - 10%, diaphragm pump – 7%. Other loads are jigger jolly motor and shaper motor – 4% each, fuel pump – 1%, fans – 4% and lighting load accounts for 7% of the connected load.

An analysis of area wise electricity consumption has been computed to quantify the electricity consumption in the individual processes; the details of the same are shown in table below:

Table 8: Area wise electricity consumption (estimated)

Consumption	kW	kWh/year	% of Total
Ball mill motor	9.4	33989	10.8%
Diaphragm pump motor	7.5	35808	11.4%
Pug mill motor	9.3	55723	17.7%
Vacuum pump motor	6.8	20468	6.5%
Kiln blower	8.6	49450	15.7%
Jigger jolly motor	3.1	15039	4.8%
Shaper machine	3.6	20625	6.6%
Fuel pump	0.7	5371	1.7%
Ceiling Fan	4.5	21696	6.9%
Lighting load	7.9	56707	18.0%
Total	**61.5**	**3,14,877**	**100%**

This is represented graphically in the figure below:

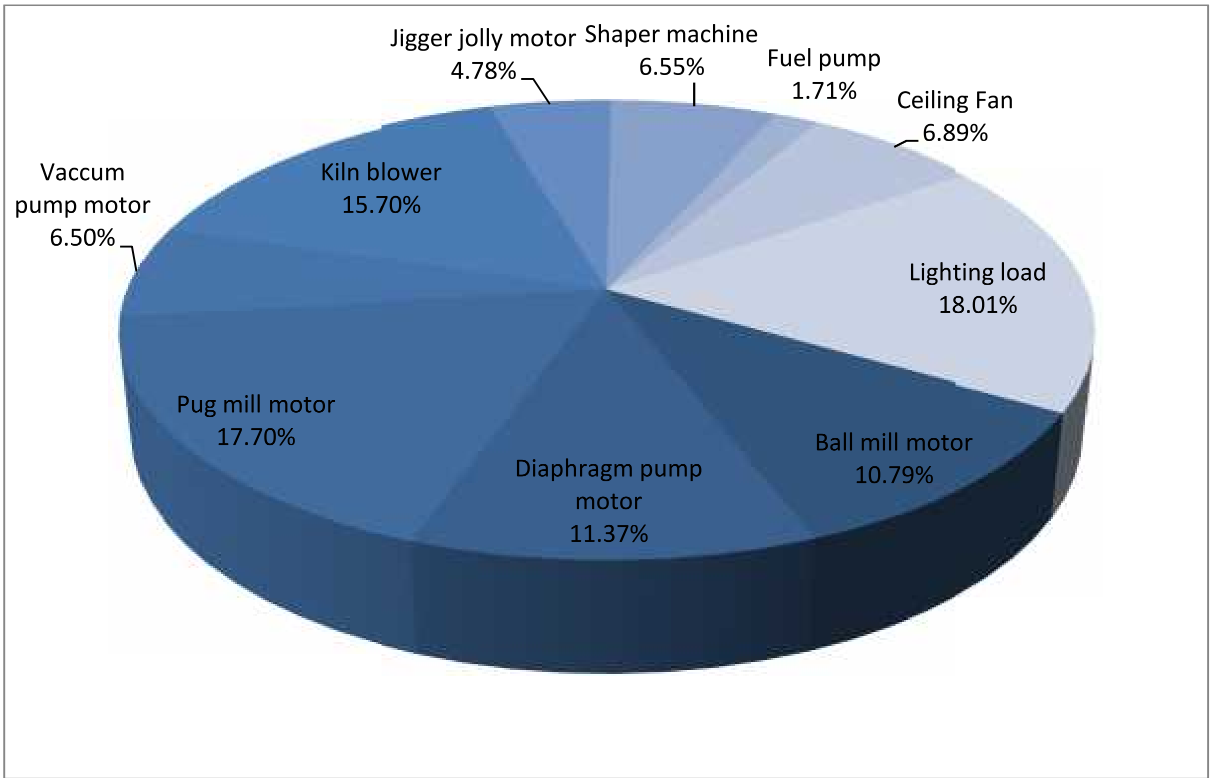


Figure 6: Area wise electricity consumption

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 set which is used as a backup source and supplies electricity 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	281,224	88	29.3	82
Self Generation	37,824	12	6.6	18
Total	319,048	100	35.9	100

This is graphically depicted as follows:

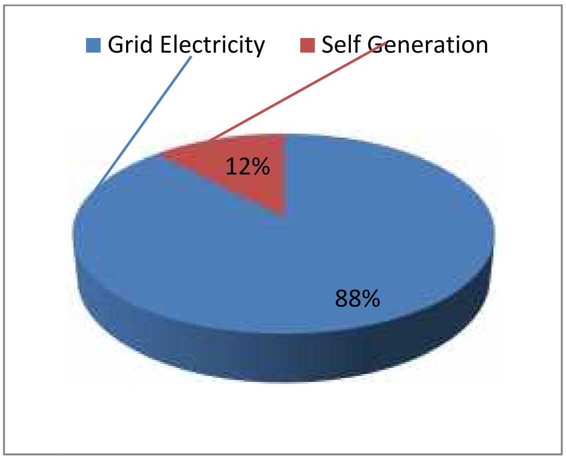


Figure 7: Share of electricity by source

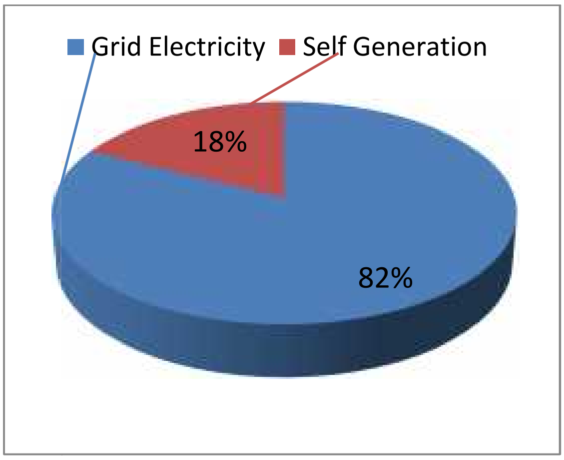


Figure 8: Share of electricity by cost

The requirement of power supply from DG set is about 12% of the total power which is not very high, but it accounts for about 18% in term of cost of total power used. This indicates the high cost of power from DG set due to rise in the price of diesel. 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 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.	:	12342208
b)	Power Supply	:	11 kV line
c)	Contract Demand	:	130 kVA
d)	Sanctioned Load	:	NA
e)	Nature of Industry	:	HT – G

The tariff structure is as follows:

Table 10: Tariff structure

Particulars	Tariff structure	
Energy Charges	6.26	Rs./kVAh
Regulatory	0.35	Rs./kVA
Fuel Surcharge	0.00	Rs./kVAh
Electricity duty	0.00	Rs./kVAh
Municipality tax	0.00	Rs./kVAh

(As per bill for February – 15)

Table 11: Electriciy bill analysis

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	Charge due to old meter	Electricity Duty Charge@7.5% of (Demand +Energy	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.
14-Apr	130	120	84	0.89	23435	9578	14025	5848	29451	184449	29959	0	10359	0	16080	0	244278
14-May	130	120	84	0.89	23435	9578	14025	5848	29451	184449	29959	0	10359	0	16080	0	244278
14-Jun	130	120	84	0.89	23435	9578	14025	5848	29451	184449	29959	0	10359	0	16080	0	244278
14-Jul	130	120	84	0.89	23435	9578	14025	5848	29451	184449	29959	0	10359	0	16080	0	244278
14-Aug	130	120	84	0.89	23435	9578	14025	5848	29451	184449	29959	0	10359	0	16080	0	244278
14-Sep	130	98	60	0.89	1828	6096	10488	3868	20452	121393	24375	0	4140	894	10933	0	161734
14-Oct	130	98	70	0.84	30546	12232	17156	7078	36466	226291	24375	0	11556	0	18800	0	281023
14-Nov	130	123	123	0.76	31940	13684	19638	8788	42110	267132	30753	0	15550	0	22341	706	336482
14-Dec	130	123	58	0.97	22870	7616	10966	4924	23506	149142	30753	0	9391	0	13492	2	202780
15-Jan	130	168	82	0.95	23324	7744	11022	4558	23324	147589	41993	18986	9896	0	14219	0	232683
15-Feb	130	110	110	0.98	30106	10096	14884	5872	30852	195146	27504	0	11622	0	16699	0	250971
15-Mar	130	120	84	0.89	23435	9578	14025	5848	29451	184449	29959	0	10359	0	16080	0	244278
Max	130	168	123	0.98	31940	13684	19638	8788	42110	267132	41993	18986	15550	894	22341	706	336482
Min	130	98	58	0.76	1828	6096	10488	3868	20452	121393	24375	0	4140	0	10933	0	161734
Avg	130	120	84	0.89	23435	9578	14025	5848	29451	184449	29959	1582	10359	74.5	16080	59	244279
Total					281224	114936	168304	70176	353416	2213388	359508	18986	124309	894	192964	707	2931342

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

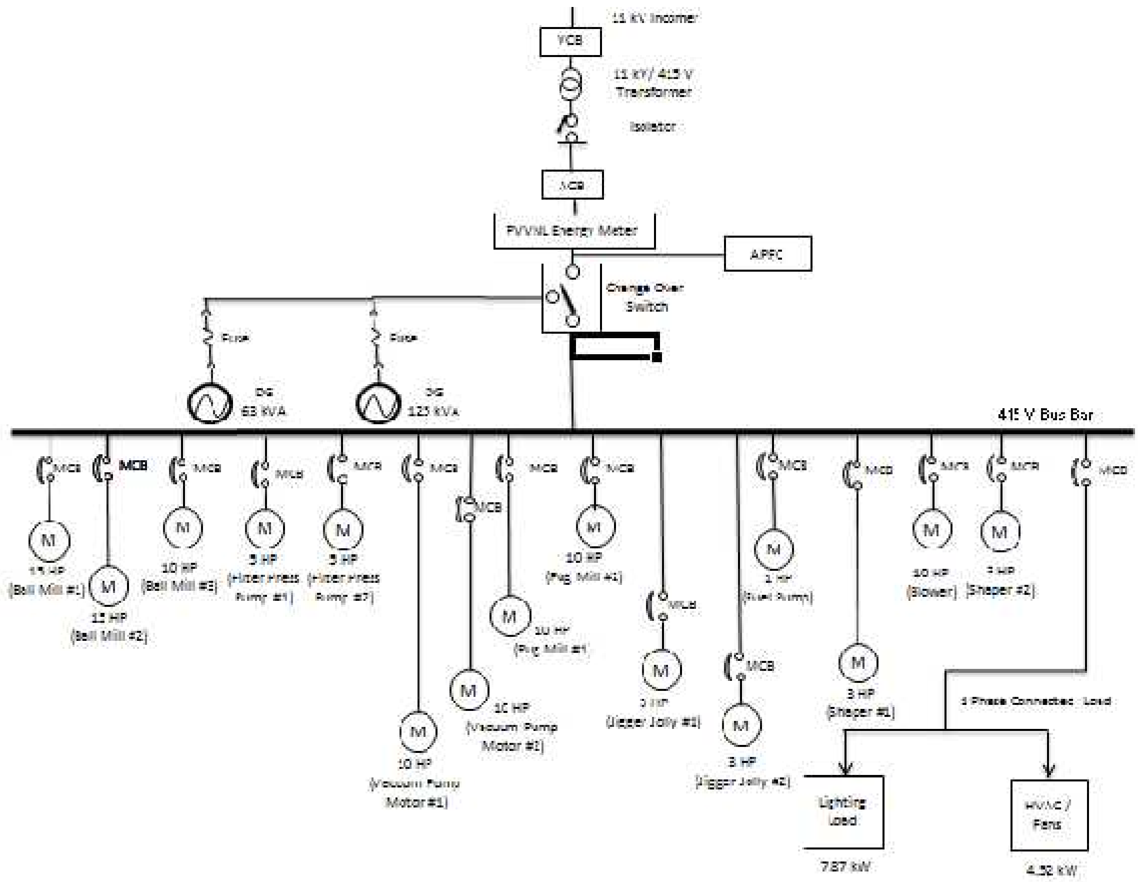


Figure 9 SLD of electrical load

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 using a power analyzer. The average power factor was found to be 0.98 with the minimum being 0.78 and the maximum being 1.

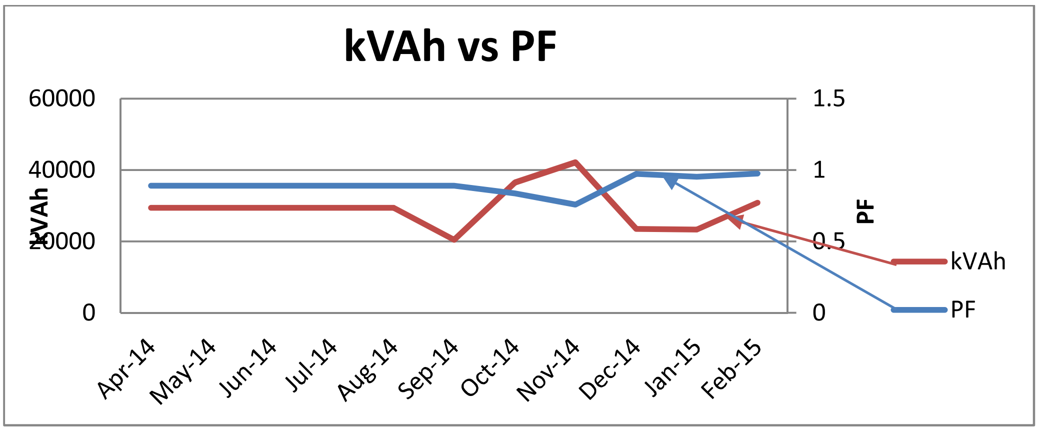


Figure 10: Monthly trend of PF

Maximum demand

Maximum demand as reflected in the utility bill is 123 kVA from the bill analysis.

3.4.5 Self-generation

The unit has one DG set of 125 kVA. The unit does not have a system for monitoring the energy generation and fuel usage in DG. Diesel purchase records are, however, maintained by the unit. In order to evaluate the month wise energy contribution by DG, the results of performance testing of the DG set, carried out during the detailed energy audit was used.

Performance testing was conducted for the 125 kVA DG set and the specific energy generation ratio (SEGR) was calculated as 3.11 kWh/litre. Diesel consumption by the DG set is 12,144 liters annually costing Rs. 6.56 lakh with a power generation 37,824 kWh.

Note: Since only monthly consumption was given by operating person verbally, hence the average value of HSD consumption in DG set 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[1]	Total	Grid	DG	Total
	kWh	kWh	kWh	Rs	Rs.	Rs.
Apr-14	23,435	3,152	26,587	244,278	54,648	298,926
May-14	23,435	3,152	26,587	244,278	54,648	298,926
Jun-14	23,435	3,152	26,587	244,278	54,648	298,926
Jul-14	23,435	3,152	26,587	244,278	54,648	298,926
Aug-14	23,435	3,152	26,587	244,278	54,648	298,926
Sep-14	1,828	3,152	4,980	161,734	54,648	216,382
Oct-14	30,546	3,152	33,698	281,023	54,648	335,671
Nov-14	31,940	3,152	35,092	336,482	54,648	391,130
Dec-14	22,870	3,152	26,022	202,780	54,648	257,428
Jan-15	23,324	3,152	26,476	232,683	54,648	287,331
Feb-15	30,106	3,152	33,258	250,971	54,648	305,619
Mar-15	23,435	3,152	26,587	244,278	54,648	298,926
Total	**281,224**	**37,824**	**319,048**	**2,931,342**	**655,776**	**3,587,118**

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

[1] Since only monthly consumption was given by the operating person verbally, hence the average value of HSD consumption in DG set is taken for the evaluation

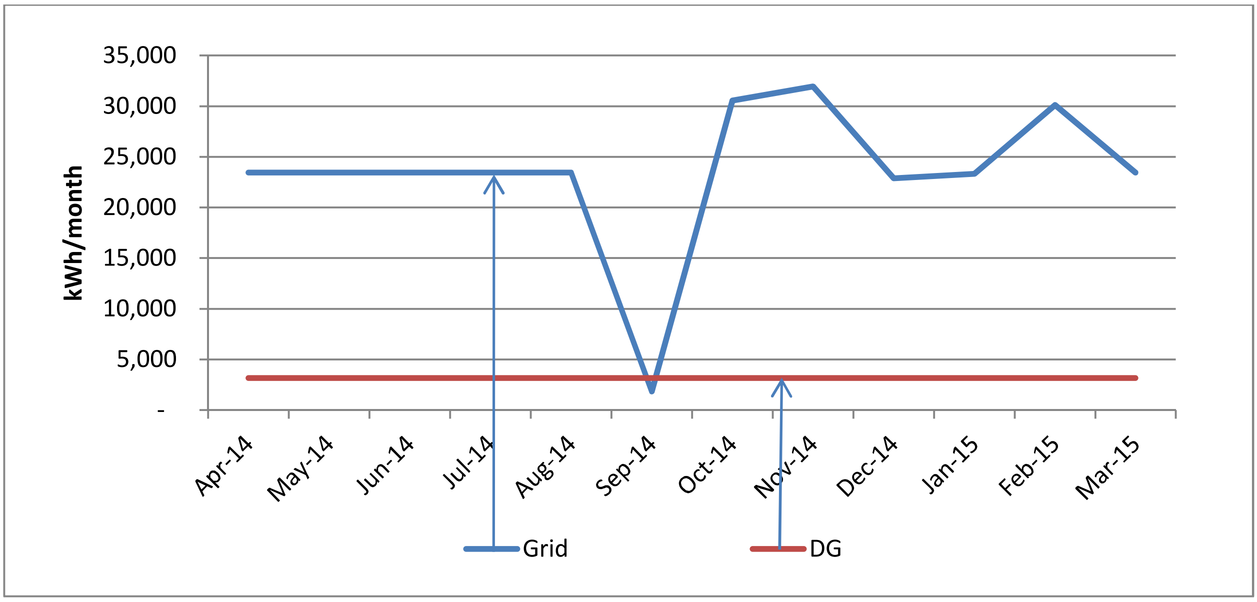


Figure 11: Month wise variation in electricity consumption from different sources

As shown in figure above, the consumption of electrical energy was on higher side during the months of October, November 2014 and February 2015 and it fluctuated during the remaining months. However, it was noticed that electricity consumption during September 2014 was low, 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.

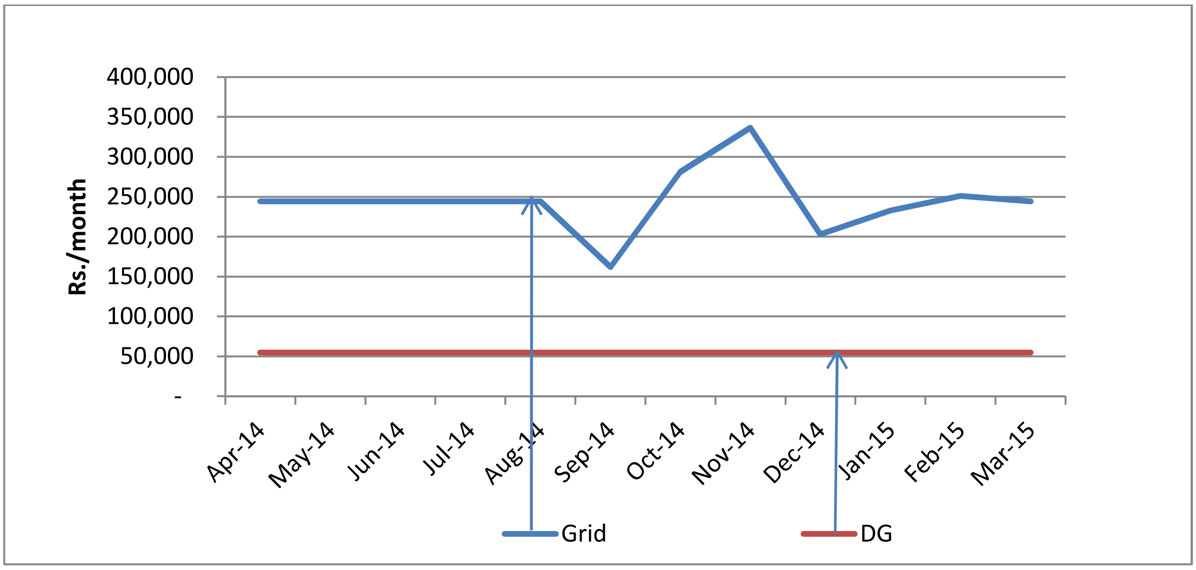


Figure 12: Month wise variation in electricity cost from different sources

From the analysis of utility bills, the cost per unit of kWh consumption decreases with the rise in consumption. As the consumption increases, the share of fixed charge decreases and vice versa. The annual variation of cost of energy from utility as well as DG set is shown in the figure below:

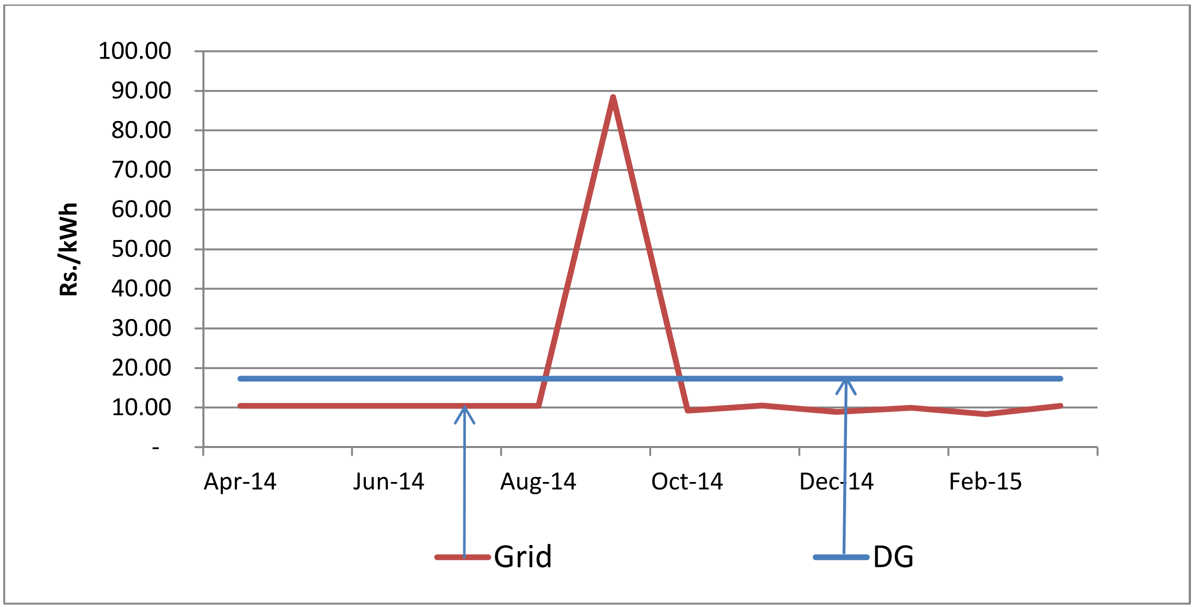


Figure 13: Average cost of power (Rs./kWh) from different sources

The above graph, it clearly indicates that the cost of electrical energy from DG set is very high, which is nearly 1.5 times the cost of utility power.

3.5 Analysis of thermal consumption by the unit

Diesel blend is used as the fuel for firing in the kiln. Diesel blend is procured from local suppliers and the average landed rate is Rs. 47.07/litre. There was no meter installed for measuring the fuel consumption in kiln. Diesel blend consumption by kiln is 20.089 liters monthly costing Rs. 9.45 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	281,224	kWh
Annual DG Generation Unit	37,824	kWh
Annual Total Electricity Consumption	319,048	kWh
Diesel Consumption for Electricity Generation	12144	Litres
Annual Fuel Consumption in kiln (Diesel blend)	241,071	Liter
Annual Energy Consumption	273	MTOE
Annual Energy Cost	149.34	Lakh Rs.

Annual Production	2,376	MT
SEC; Electricity from Grid	134	kWh/MT
SEC; Thermal	101	Liter/MT
SEC; Overall	0.115	MTOE/MT
SEC; Cost Based	6,286	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 : 11,840 kCal/ kg
- Density of diesel blend : 0.8263 kg/litre
- CO_2 Conversion factor
  - Grid : 0.89 kg/kWh
  - Diesel : 3.07 tons/ ton

3.7 Identified energy conservation measures in the plant

Diagnostic Study

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

3.7.1 Electricity Supply from Grid

Electrical parameters at the main incomer from PVVNL were recorded for 8 hours using a portable power analyzer. Following observations were made:

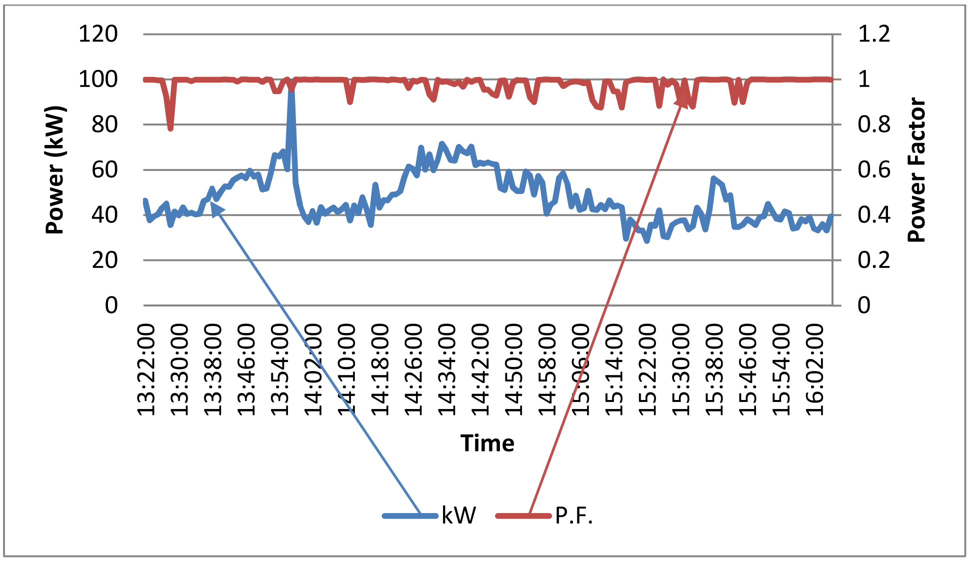


Figure 14: Load profile and power factor

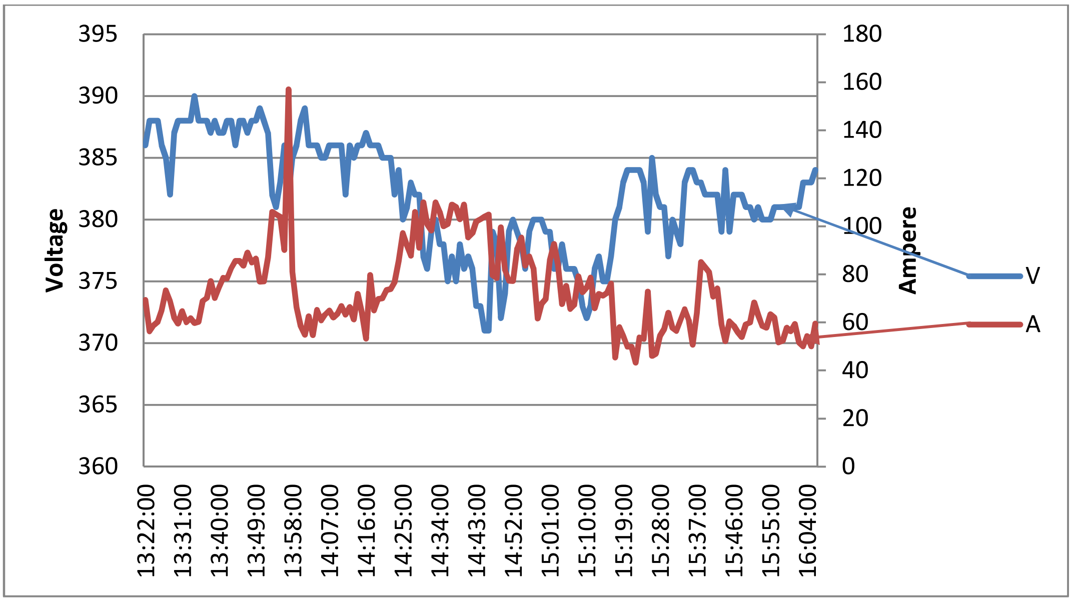


Figure 15: Voltage and current profile

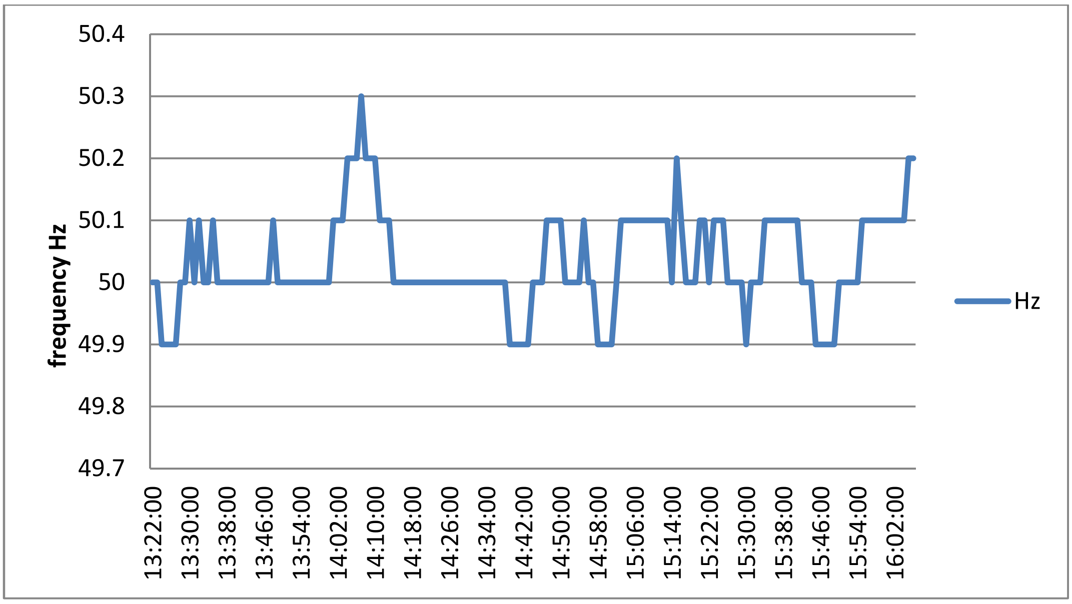


Figure 16: Harmonic profile

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	The maximum kVA recorded during study period was 104 kVA. As per utility bill; the MD	No EPIAs were suggested.

	has a HT connection. The contract demand of the unit is 130 kVA.	was 123 KVA which is less than the contract demand.	
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 0.98. It varied between 0.78 and 1.00 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 381.9 V. Maximum voltage was 390 V and minimum was 371 V.	No EPIA's were 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 125 kVA. Performance testing was conducted for 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 diesel 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 sets are evaluated as follows:

Table 15: Analysis of DG set

Particulars	DG
Rated KVA	125
Specific Energy Generation Ratio (kWh/Liter)	3.11

The observations made are as under.

- The SEGR of DG set was 3.11 kWh/litre
- The power factor was 0.84.
- The present average frequency of the DG set is 50.1 Hz

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

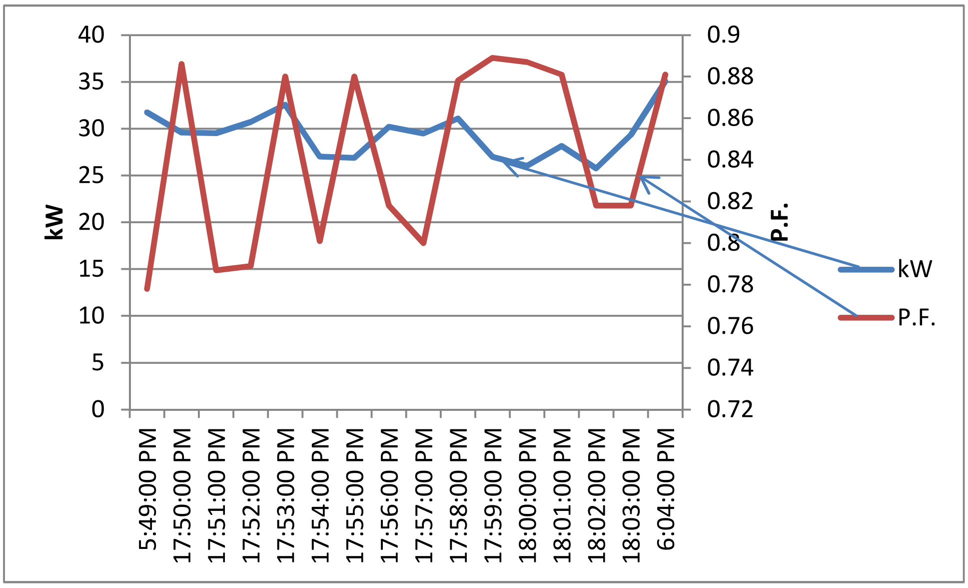


Figure 17: Load and power factor profile of DG set

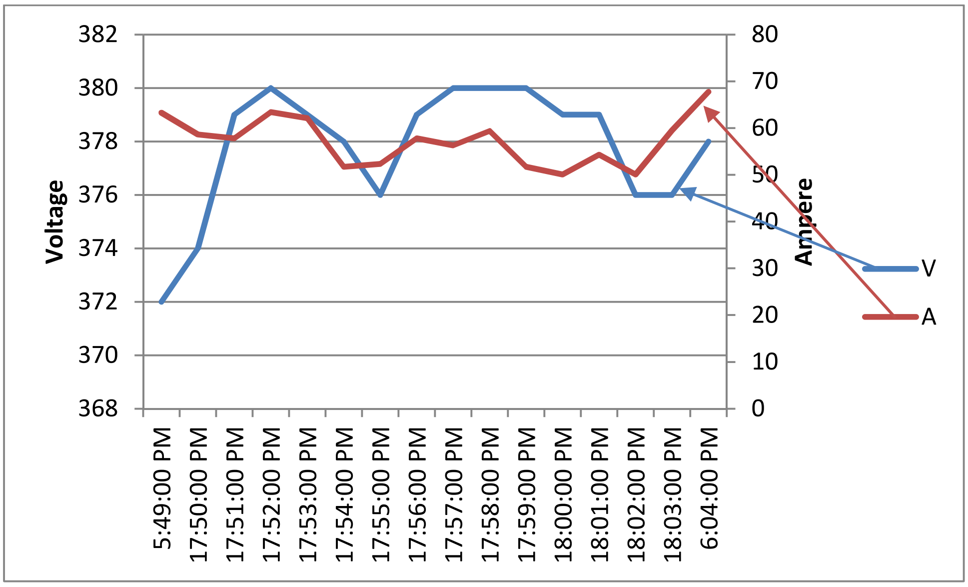


Figure 18: Voltage and current profile of DG set

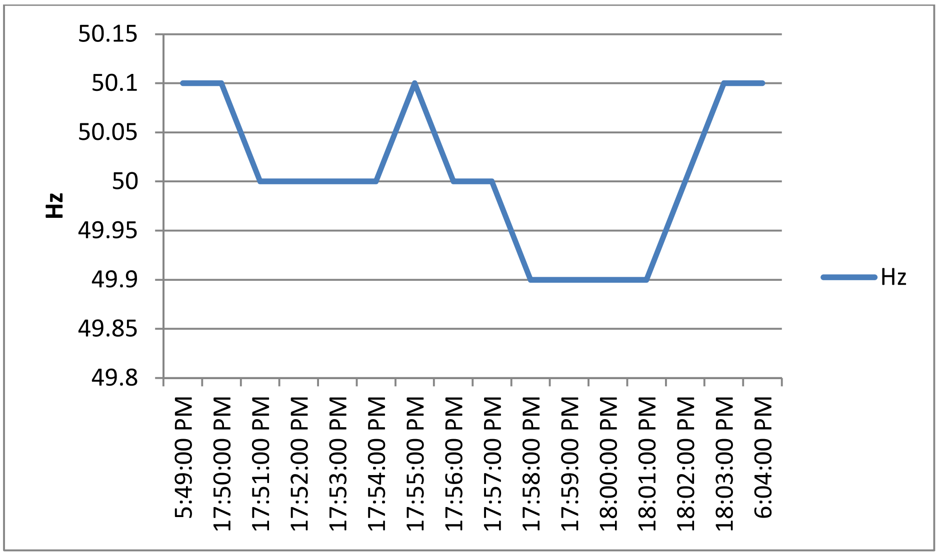


Figure 19: Harmonics profile of DG set

3.7.3 Electrical consumption areas

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

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

<table>
<tr><th>Name of Area</th><th>Present Set-up</th><th>Observations during field Study & measurements</th><th>Proposed Energy performance improvement actions</th></tr>
<tr><td>Ball mill</td><td>There are 3 ball mills in the unit out of which 2 are connected with 15 HP motors and 1 with a 10 HP motor respectively. Ball mills account for 28% of overall energy consumption.</td><td>Out of the 3 ball mills 1 of 3.5 T was in operation during CEA and its characteristics were studied.

The results of the study areas below:<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Ball Mill</td><td>9.44</td><td>0.98</td></tr></table></td><td>No EPIAs were suggested for the ball mill.</td></tr>
<tr><td>Diaphragm pump</td><td>There are 2 diaphragm pumps in the unit out of which only 1 was studied during the CEA. The rated motor power of this pump was 5 HP. The diaphragm</td><td>1 diaphragm pump was studied during the CEA.

The results of the study are as below:<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr></table></td><td>No EPIA is suggested.</td></tr>
</table>

<table>
<tr>
<td></td>
<td>pumps account for an estimated 7% of overall electrical energy.</td>
<td><table><tr><td>Diaphragm pump</td><td>2.36</td><td>0.82</td></tr></table></td>
<td></td>
</tr>
<tr>
<td>Pug mill</td>
<td>There are 2 pug mills installed in the unit. They account for about 21% of total energy consumption.</td>
<td>Two pug mills were operating during the CEA. Data logging was done out on them 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 1</td><td>3.57</td><td>0.77</td></tr><tr><td>Pug mill 2</td><td>5.72</td><td>0.55</td></tr></table></td>
<td>Application of VFD has been suggested on the pug mills based on the loading and unloading profile of power consumption observed.</td>
</tr>
<tr>
<td>Vacuum pump</td>
<td>The unit has two vacuum pumps attached to each of the pug mills to remove entrapped air from the material during its operation. It accounts for about 14% of the total electrical energy consumption.</td>
<td>One vacuum pump was studied during the CEA.

The results of the study are asbelow:
<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Vacuum pump</td><td>6.82</td><td>0.92</td></tr></table></td>
<td>No EPIAs were suggested.</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 blowers account for 10% 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>8.59</td><td>0.99</td></tr></table></td>
<td>Excess air control by PID controller was suggested as an EPIA.</td>
</tr>
</table>

3.7.4 Thermal consumption areas

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

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 SCK Insulators 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 1220°C to 1230°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.

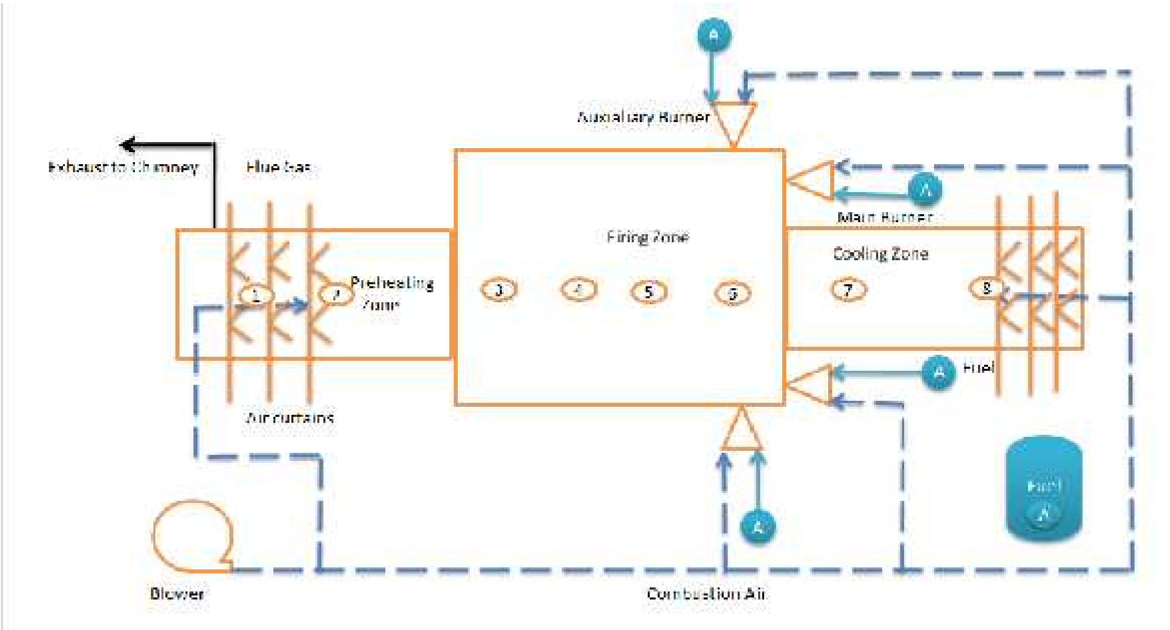


Figure 20: Tunnel kiln

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

Table 16: Temperature at various sections of tunnel kiln

Section of kiln	Temperature
1	240 °C
2	730 °C
3	1181 °C
4	1200 °C
5	1209 °C
6	1210 °C
7	725 °C
8	260 °C

Table 17: Dimensions of kiln

Zone	Length	Width	Height
Pre-heating	1750 cm	150 cm	180 cm
Firing	739 cm	290 cm	180 cm
Cooling	2467 cm	150 cm	180 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 Temperature</th><th>Exhaust Temperature of Flue Gas</th></tr>
<tr><td>Tunnel kiln</td><td>12%</td><td>35.2°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.
The inlet temperature of raw material in kiln was in the range of 35 – 42 deg C.
The exhaust temperature of flue gas in the chimney after the effect of air curtains was in the range of 198 - 205 deg C whereas at the exit of firing zone it was found to be 860 – 926 deg C during.
</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 kiln is recommended.
It is recommended to change the kiln car material with other materials of lower Cp values that absorbs lesser heat.
</td></tr>
</table>

The kiln car was made up of fire clay bricks, pillars and tiles to stack the materials. All these materials have different specific heat (Cp) values. It is to be noted that the kiln car takes away lot of useful heat.	

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: Reduction in radiation and convection losses from surface of kiln

Technology description

A significant portion of the losses in a kiln occurs as radiation and convection loss from the kiln walls and roof. These losses are substantially higher on areas of openings or in case of infiltration of cold air. Ideally, optimum amount of refractory and insulation should be provided on the kiln walls and roof to maintain the skin temperature of the furnace at around 45-50°C to avoid heat loss due to radiation and convection. Refractories are heat-resistant materials that constitute the linings for high-temperature tunnel kilns. In addition to being resistant to thermal stress and other physical phenomena induced by heat, refractories must also withstand physical wear and corrosion by chemical agents.

Thermal insulations are used for reduction in heat transfer (the transfer of thermal energy between objects of differing temperatures) between objects in thermal contact or in range of radiative influence.

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

Study and investigation

There are three different zones in the kiln, i.e. pre- heating, firing and cooling zones. The surface temperatures of all the three zones were measured. The average surface temperature of the kiln body in the firing zone must be in the range of 45-50°C, however, it was measured to be 103.94°C. Hence, the kiln surface has to be properly insulated to keep the surface temperature within the specified range.

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

Recommended action

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

Table 19: R & C losses

Total radiation and convection heat loss per hour	Units	Value
Pre-Heating Zone	kCal / hr	4,127
Firing Zone	kCal / hr	13,963
Cooling Zone	kCal / hr	16,748
Total R&C loss	kCal / hr	34,838

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	103.94
Recommended skin temperature of Firing Zone	deg. C	50.00
Present heat loss due to Radiation & Convection from Firing zone walls	kCal / hr	13,963
Recommended heat loss due to Radiation & Convection from Firingzone	W / m2	88.80
	kCal / m2	76.37
	kCal / hr	6,782
Total reduction in heat loss due to Radiation & convection by limiting skin temperature at Firing zone	kCal / hr	28,056
Calorific value of Fuel	kCal / kg	11,517
Equivalent savings in Fuel	kg / hr	2.44
Plant running time	days / year	300
	hrs / day	24
Annual savings in Fuel	litre/y	21,226
Cost of fuel	Rs. / litre	47
Annual Monitory savings	Rs. / Year	999,124
	Rs. Lakhs / Year	9.99
Estimated investment	Rs. Lakhs	0.32

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 process requires certain amount of excess air in addition to the theoretical air supplied. Excess air supplied needs to be maintained at optimum levels, as too much excess air results in excessive heat loss through the flue gases. Similarly, too little excess air results in incomplete combustion of fuel and formation of black coloured smoke in flue gases.

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

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 the air from one common FD fan was not a good practice.

Recommended action

Two separate blowers have been recommended for supplying combustion air and cooling air. It is proposed to install control system to regulate the supply of excess air for proper combustion. As a thumb rule, reduction in every 10% of excess air will save 1% in specific fuel consumption. The cost benefit analysis of the energy conservation measure is given below:

Table 21: Cost benefit analysis (EPIA 2)

Parameters	UOM	Present	Proposed
Oxygen level in flue gas	%	12.00	3.00
Excess air percentage in combustion air supplied	%	133.33	16.67
Dry flue gas loss	%	10.74	
Saving in fuel	Every 10% reduction in excess air leads to savings in specific fuel consumption by 1%		
Specific fuel consumption	Liter/t	101.46	89.62

Saving in specific fuel consumption	Liter/h		3.91
Savings in fuel cost	Rs. Lakh/y		13.24
Installed capacity of blower	kW	11.19	9.336
Operating hours	hrs/y	7,200	7,200
Electrical energy consumed	kWh/y	61813.	53712
Savings in electrical energy	kWh/y		8101
Cost of increased electrical energy	Rs. Lakh/y	5.16	4.48
Savings in terms of energy cost	Rs. Lakh/Y		13.91
Estimated investment	Rs. lakh		7.00
Simple payback	y		0.50

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

Technology description

Replacing old ceiling fans of conventional types installed in various sections of the plant with energy efficient fans will reduce the power consumption by approximately 50%. The energy efficient fans have a noiseless operation and it is controlled by electronic drives which on speed reduction will automatically sense the rpm and reduce the power consumption. Since a large number of ceiling fans is used in the ceramic units for drying purposes, replacing present conventional ceiling fans with energy efficient fans will help in energy conservation.

Study and investigation

The unit is having 56 conventional ceiling fans which are very old and can be replaced with EE fans.

Recommended action

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

Table 22: Cost benefit analysis (EPIA 3)

Data & Assumptions	UOM	Present	Proposed
Number of Ceiling fans in the plant	Nos	56	56
Running hours per day (avg.) - for fans	hrs / day	24	24
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	8.34	8.34
Fan unit price	Rs./piece	1,500	3,000

Electricity consumption:			
Electricity demand	kW	3.92	1.96
Power consumption by fans in a year	kWh/y	28,224	14,112
Savings in terms of power consumption	kWh/y		14,112
Savings in terms of cost	Rs. Lakh/y		1.18
Estimated investment	Rs. Lakh/y		1.68
Pay back period	y		1.43

4.4 EPIA 4: Replacing present conventional lighting system with Energy efficient LEDs

Technology description

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

Study and investigation

The unit is having 138 T12 tube light and 7 incandescent lamps (GLS bulbs).

Recommended action

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

Table 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	300	300
Energy Used per year/fixture	kWh/y	42,530	12,528
Electricity tariff	Rs./kWh	8.34	8.34
No. of Fixtures – T12	Unit	138	138
No. of fixtures – incandescent lamps	Unit	7	7
Operating cost per year	Rs. Lakh/Year	4	1.05

Saving in terms of electrical energy	kWh/Year	30,002
Savings in terms of cost	Rs. Lakh/Year	2.50
Investment per fixture of LED	Rs. Lakh	0.0125
Investment of project	Rs. Lakh	1.8125
Payback period	Years	0.72

4.5 EPIA 5: Installation of 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 drawn by a motor with respect to its load condition. 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. The installation of a VFD will help in regulating the speed of the pug mill 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.

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 parameter, for e.g. weight of raw material introduced in to the pug mill for de-airing. 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	14.92	14.92
Estimated energy saving by installing VFD on (Pug-Mill motor)	%		20.0
Average power consumption	kW	6.8	5
No of operating hrs per day	Hrs	20	20
Operating Days per Year	Days	300	300
Average electricity consumption per year	kWh	40,935	32,748
Annual electricity saving	kWh/y		8187
Average electricity tariff	Rs/kWh	8.34	8.34
Annual saving in terms of cost	Lakhs Rs.		0.68
Estimated investment	Lakh Rs		0.7
Simple Payback	Y		1.0

4.6 EPIA 6: Change in operating frequency of DG sets

Technology description

Reducing frequency of electricity generation from a DG set will help in reduction of its speed. This will in turn reduce the speed of all centrifugal loads connected with the DG power and result in power savings in the plant. The product of the resulting power savings and present specific fuel consumption by the DG set will be the net estimated fuel savings due to reduction in operating frequency of the DG set.

Study and investigation

The DG present in the unit delivers power with the frequency of 50.1 Hz and diesel consumption is found to be higher than the desired amount.

Recommended action

The frequency setting for power generated by DG sets could be changed and reduced from present levels to 49.5 Hz. This will result in decreased power demand by the plant when operating on DG power leading to fuel savings of 0.1 litre per hour. The cost benefit analysis for this project is given below:

Table 25: Cost benefit analysis (EPIA 6)

Parameters	Unit	Present	Proposed
Present average frequency of the DG Sets	Hz	50.10	49.5
Average load on DG	kW	29	29.4
Specific Fuel Consumption	Litre/kWh	0.32	0.32
Centrifugal Load	%	80%	80%
Possible power savings	kW	-	0.7
Possible savings	Litres/h	-	0.2
Operation hours per day	h/day	2	2.0
DG operating hours	h/y	600	600
Annual Diesel savings	Litres/y	-	136.1
Diesel Cost	Rs./Litre	54.00	54.0
Annual Monetary savings	Lakh Rs/y	-	0.07
Investment	Rs. Lakh	-	0.05
Payback Period	y	-	0.7

4.6 EPIA 7: Installation of energy monitoring system

Technology description

Installation of energy monitoring system will help the unit to better 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 increased consumption can be diagnosed and proper remedial actions can be taken.

Study and investigation

It was observed during the audit that, there was no online data measurement system present in the plant for monitoring various electrical energy data on main in-comer and other MCC panels in the plant. It was also noticed that there was no fuel monitoring system installed in the DG sets and in kilns like online flow-meters.

Recommended action

It is recommended to install online electrical energy monitoring systems (smart energy meters) on the main incomer and on the various electricity distribution panels. It is also recommended to install online flow-meters on the individual DG sets and kilns to measure the oil flow. This measure will help in reduction in energy consumption by 3% approx. from its present levels. The cost benefit analysis for this project is given below:

Table 26: Cost benefit analysis (EPIA 7)

Parameters	Unit	As Is	To Be
Energy monitoring saving	%		3.00
Energy consumption of major machines per year	kWh/Yr	281,224	272,787
Annual electricity saving per year	kWh/Yr		8,437
W. Average Electricity Tariff	Rs./kWh		8.34
Annual monetary savings	lakh Rs./yr		0.70
Estimate of Investment	Lakh Rs.		0.35
Simple Payback	Months		5.97
Current diesel blend consumption	Litre/y	241,071	233,840
Annual fuel saving per year	Litre/y		7,232
Unit Cost of diesel blend	Rs./Litre		47.07
Annual monetary savings	lakh Rs./year		3.40
Estimate of Investment	Lakh Rs.		0.20
Simple Payback	y		0.06

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 leads 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 0.98 due to unhealthy condition of few capacitors. It is recommended to replace the de-rated capacitors. The average power factor maintained in the unit was found to be 0.89 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	0.76
Present Maximum PF	Cos ø	0.98
Present Average PF	Cos ø	0.89
Minimum Load	kW	28.6
Maximum Load	kW	99.0
Average Load	kW	47.5
Target Average Power Factor		0.99
Capacitor Bank Capacity at Average Load and Average PF	kVAR	15.9
Capacitor Bank Capacity at Maximum Load and Average PF	kVAR	33.2
Capacitor Bank Capacity at Maximum Load and Minimum PF	kVAR	63.3
Capacitor Bank Capacity at Minimum Load and Minimum PF	kVAR	18.3
Required capacitor bank for PF at Unity	kVAR	63
APFC Panel (Rating) for maintaining optimum PF	kVAR	63

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	0.76	0.99
Maximum PF	Cos ø	0.98	0.99
Average PF	Cos ø	0.89	0.99
Maximum Load	kW	99	99.00
Average Load	kW	47.5	47.52
Capacitor Bank	kVAR	70.0	133.3

Annual Grid Electricity Consumption	kVAh/y	353416.0	319056.1
	kWh/y	315865.6	315865.6
Annual Grid Electricity Savings	kVAh/y	-	34359.89
Electricity Tariff	Rs./kVAh	8.3	8.3
Annual Monetary Saving	Lakh Rs./y	-	2.87
Investment	Lakh Rs.	-	0.50
Payback Period	Months	-	0.17

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 increases the dead weight of the car. The present kiln car also carries away much of the useful heat supplied to the kilns thus reducing its efficiency. A new material called ultralite[2] can be used in the kiln car construction thereby replacing the present material, which will help in reducing its dead weight. This will also help in reduction in losses due to useful heat carried away by the kiln car as this material has lower specific heat.

Study and investigation

Presently, kiln car used is made up of HFK bricks, quadrite tiles and pillars and these materials contribute to a dead weight (of kiln car) of 586 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 kiln cars to travel along the kiln. So, in order to reduce this necessary wastage, it is recommended to select kiln car material that shall absorb as minimum heat as possible, so that most of the heat supplied is gained by the ceramic material. This will also help in reduced fuel consumption in the kiln.

Recommended action

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

Table 29: Cost benefit analysis (EPIA 10)

Parameters	UoM	Present	Proposed

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

Present Production of kiln	tph	0.33	0.33
Weight of existing kiln car	kg	586	410
Total number of kiln car s inside kiln	Nos.	24	24
Initial temperature of kiln car	deg c	35.2	35.2
Final temperature of kiln car	deg c	1,145	1,145
Estimated percentage saving by replacing present kiln car with new EE kiln car	%		30
Heat carried away by the kiln material	kcal/h	121,986	85,390
Reduction in the heat carried by the new EE kiln car	kcal/h		36,596
Operating hours of kiln	h	7,200	7,200
Savings in terms of fuel consumption	Litre/y		22,878
Savings in terms of cost	Rs. lakh/y		10.8
Estimated investment of kiln car material	Rs. lakh/y		4.80
Payback period	y		0.4

4.10 EPIA 10: 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

Sl. No.	Replacing persent burners with energy efficient burners		Kiln	
	Parameters	**Unit**	**As Is**	**To Be**
1	Production rate of the kiln	kg/hr	330	330
2	Total number of main burner	Nos.	2.0	2.0
3	Total number of auxilary burner	Nos.	6.0	6
4	Total numbers of energy efficient burner required	Nos.	8.0	8.0
5	Estimated saving by energy effcient burner	%		5.0
6	Current fuel firing in kiln	kg/hr	29	27

7	Savings in fuel per hours	kg/hr		1.43
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		10281
10	Unit cost of fuel	Rs./kg		55.19
11	Cost savings per year	Lakh Rs./yr		5.67
12	Estimated investment for all burners	Lakh Rs.		1.9
13	Payback period	Yr		0.3

5 ANNEXURE

Participation of the unit in this project

UPTT No. KJ-0063509 dt. 30.11.06
C S T No. KJ-5040443 dt. 06.12.06
TIN No. 09767701081 dt. 30.11.06

SCK INSULATORS

AN ISO 9001 : 2008 CERTIFIED COMPANY
Mfrs. of H. T. & L. T. Porcelain Insulators
Industrial Area, Opp. CGCRI, G. T. Road, KHURJA 203131 (U. P.)

SCK INSULATORS

Date 06/04/2015

Date:

To,
The President
MSME Ceramic Cluster
Khurja
Uttar Pradesh

(Sub: Participation in BEE – GEF – UNIDO project on EE & RE in Khurja 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 manufacturing unit where BEE-UNIDO team can undertake comprehensive energy audit. We shall provide all necessary cooperation 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,

Yours faithfully,

Name & signature of unit head

Tele Fax : 91-5738-244071 ✦ Mobile : +91-9258066206 ✦ E-mail : sck.krj@gmail.com

Kiln efficiency calculations

Input parameters

Parameters	Value	UoM
Tunnel Kiln Operating temperature (Firing Zone)	1145	*Deg C*
Final temperature of material (at outlet of Firing zone)	1000	*Deg C*
Initial temperature of kiln car	35.2	*Deg C*
Average fuel Consumption	28.6	*Kg/hr*
Flue Gas Details		
Flue gas temp. after APH (in chimney; No APH installed)	197	*deg C*
Preheated air temp./Ambient (it is ambient temperature)	35.2	*deg C*
O2 in flue gas	12	*%*
CO2 in flue gas	8.9	*%*
CO in flue gas	34	*ppm*
Atmospheric Air		
Ambient Temp.	35.2	*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		
Un-burnt in bottom ash	*0.00*	%
Un-burnt 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)	586	*Kg/Hr*
Weight of ceramic material (Raw material) being fired in Kiln	330	*Kg/Hr*
Weight of Stock	330	*kg/hr*
Specific heat of clay material	0.20	*Kcal/kgdegC*
Specific heat of kiln car material	0.19	*Kcal/kgdegC*
Avg. specific heat of fuel	0.417	*Kcal/kgdegC*

fuel temp[3]	35.2	*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	4127	*kcal/hr*
Radiation and Convection from firing zone surface	13963	*kcal/hr*
Radiation and Convection from Cooling zone surface	16748	*kcal/hr*
Heat loss from all zones	34838	*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	335	*deg K*

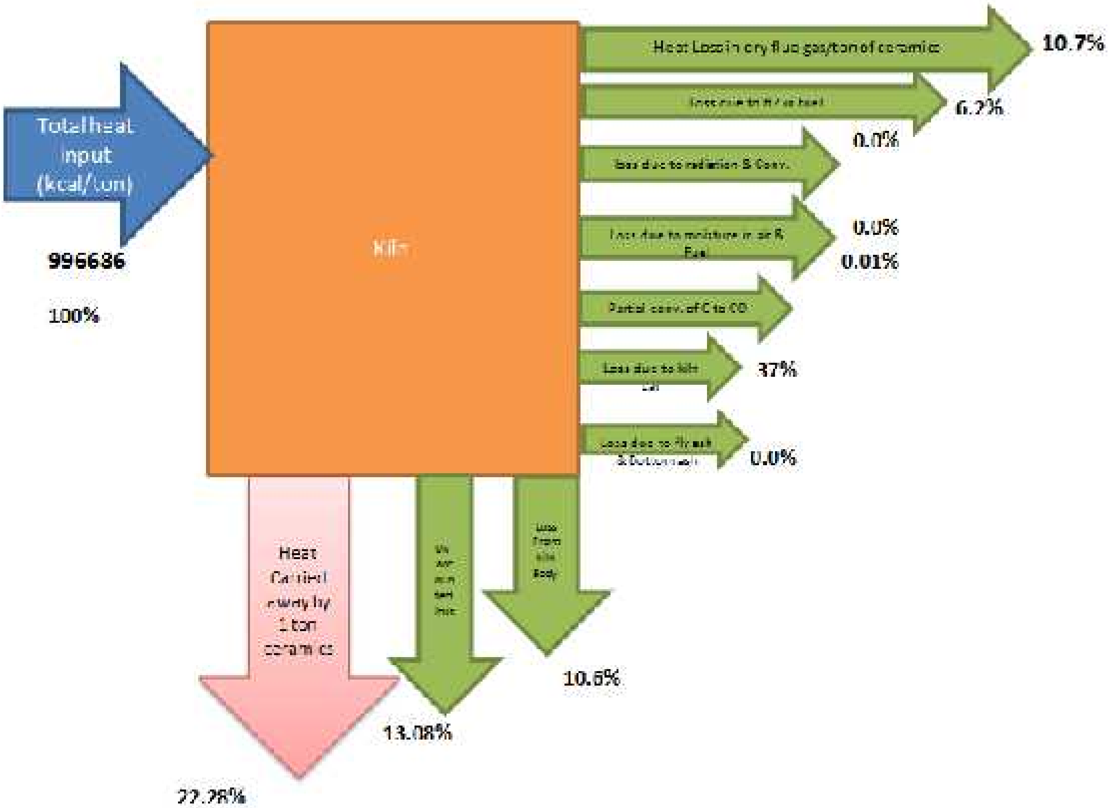
Efficiency calculations

Calculations	Values	UoM
Theoretical Air Required	12.63	*kg/kg of fuel*
Excess Air supplied	133.33	*%*
Actual Mass of Supplied Air	29.47	*kg/kg of fuel*
Mass of dry flue gas	29.39	*kg/kg of fuel*
Amount of Wet flue gas	30.47	*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	29.39	*kg/kg of fuel*
Specific Fuel consumption	86.54	*kg of fuel/ton of ceramic material*
Heat Input Calculation		
Total heat input	996,686	*Kcal/ton of ceramic material*
Heat Output Calculation		
Heat carried away by 1 ton of ceramics (useful heat)	222,035	*Kcal/ton of ceramic material*
Heat loss in dry flue gas per ton of ceramics	106,995	*Kcal/ton of ceramic material*
Loss due to H2 in fuel	61,387	*Kcal/ton of ceramic material*

[3] 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 moisture in combustion air	64	*Kcal/ton of ceramic material*
Loss due to partial conversion of C to CO	144	*Kcal/ton of ceramic material*
Loss due to convection and radiation (openings in kiln - inlet & outlet of kiln car)	456	*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	105,571	*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	369,655	*Kcal/ton of ceramic material*
Unaccounted heat losses	130,380	*Kcal/ton of ceramic material*
Heat loss from Kiln body and ceilings		
Total heat loss from kiln	105,571	*Kcal/tons*
Kiln Efficiency	**22.28**	*%*

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@philli ps.com, sandeep.raina@philli ps.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.Rah ul Khare), (9899660832)Mr.Atul Baluja, Garving Gaur(9717100273),9 810461907(Kapil)	kushagra.kishore@ba jajelectricals.com, kushagrakishore@gm ail.com; sanjay.adlakha@bajaj electricals.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),9582 252422(Mr.Rajesh),7 838299559(Mr.Vikra m-sales),(PrIthvi power-technical)-9818899637,981002 8865(Mr.Ajit),851099 9637(Mr.Avinash	Email: bhallar@lntebg.com, vikram.garg@lntebg.com, prithvipowers@yahoo.co m, rajesh.bhalla@lntebg.com ,ajeet.singh@lntebg.com

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

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 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 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
	Krishna	ESTERN CHAWLA	Mob:	krishnaautomationsyste

2	Automation System Contact Person: Vikram Singh Bhati	COLONY, NEAR KAUSHIK VATIKA, GURGAON CANAL BALLBGARH FARIDABAD 121004	9015877030, 9582325232	ms@gmail.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

EPIA 9: Replacement of kiln car material

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,	T: 022-25917880/82/83 M: 9967515330	thermprocess@yahoo.com sanjay@thermprocess.co

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
		Minerva Estate, Opp Asha Nagar, P.K.Cross Road, Mulund (W) Mumbai-400080		m