COMPREHENSIVE ENERGY AUDIT REPORT

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

Hindustan Chemicals

Industrial Area, G.T Road, Khurja

06-05-2015

Submitted to

ENERGY IS LIFE
BEE
CONSERVE IT

BUREAU OF ENERGY EFFICIENCY

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Submitted by

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As a part of this assignment, work in Khurja ceramic cluster was awarded to DESL and DESL is grateful to GEF-UNIDO-BEE PMU for their full-fledged coordination and support throughout the study.

The study team is indebted to Mr. Vipul Gupta, owner of the unit for showing keen interest in the energy audit and also thankful to the progressive management of M/s Hindustan Chemicals for their wholehearted support and cooperation for the preparation of comprehensive energy audit report without which the study would not have steered to its successful completion. Special thanks to other members of the unit for their diligent involvement and cooperation.

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

Last but not the least, the interaction and deliberation with Mr. Tariq Anwar, President, Khurja Pottery Manufacturers 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 Environmental 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
RbO	Rubber Oil
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 Environmental Facility (GEF) is implementing a project titled "Promoting energy efficiency and renewable energy technology in selected MSME clusters in India". The objective of the project is to provide impetus to energy efficiency initiatives in the small and medium enterprises (SMEs) sector in India.

As part of this project DESL has been engaged to implement the project in the MSME ceramic cluster in Khurja, Uttar Pradesh. The ceramic cluster in Khurja consists of three distinct types of units – pottery works, insulator works and crockery works. The production process of all the three types of units are almost similar in nature and the main difference is in the amount of ceramic material ratios being mixed in ball mills and the firing time required in kilns for the 3 different products. The main fuels used in the MSME ceramic units of Khurja are electricity, diesel blend and PNG.

The project 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 and 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 Hindustan Chemicals
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	Porcelain Insulators
Name(s) of the Promoters / Directors	Mr. Vipul Gupta

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 and assessment of scope, measurability and formulation of audit plan and obtaining required information

- **Stage 2:** Detailed energy audit data collection & field measurement for performance evaluation of equipment/ system performance 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 main energy consuming equipment is kiln in which the fuel used is diesel blend. The temperature maintained in the kiln is approximately 1220℃- 1230 ℃ (in firing zone).
- There are other equipments viz. ball mills, filter presses, pug mills, jigger jollies which also contribute to the production process and consume electrical energy.
- The raw material used is a mixture of clay, feldspar and quartz which is mixed along with water to form slurry. Water and air are removed from this slurry in various process machines and the material is given required shape using dies, and then fired in the kiln for hardening. Later, the material is cooled and packed for dispatch.

Identified Energy Performance Improvement Actions (EPIA)

The comprehensive energy audit covered all equipments which were operational during the field study. The main energy consuming equipment in the unit is kiln which consumes more than 94% 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 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 molds and energy efficient LED lights in place of conventional tube lights. 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					Estimated investment	Simple payback period	Annual emission reductions
		HSD-2	Electricit y	HSD	Others	Monetary savings			
		Liter/y	kWh/y	Liter/y	Rs/y	Rs. lakh/y	Rs. lakh	y	tCO2/y
1	Skin loss reduction from the kiln	13276.3				5.3	0.36	0.1	32.4
2	Excess control using PID and installation of separate blower for cooling and combustion air supply	26569.4	-12506			9.4	14.00	1.5	53.8
3	Replacement of kiln car	30900.5				12.4	11.00	0.9	75.5
4	VFD installation on PUG mill		4297			0.4	0.60	1.5	3.8
5	Speed optimization and EE drive system installation on ball mill-1 (300 kg)		33237			3.1	1.50	0.5	29.6
6	Installation of LED fixture instead of T12 tube light system		1836			0.2	0.11	0.7	1.6
7	Installation of LED lighting instead of 23 watt CFL		1404			0.13	0.18	1.4	1.2
8	Installation of energy efficient fan instead of conventional fan		3780			0.4	0.60	1.7	3.4
9	Energy monitoring system	4665.8	6800	324.0		1.2	1.20	1.0	18.3
10	Replacing present burner with energy efficient burner	15657.3				6.3	2.91	0.5	38.2
	Total	91069.3	38847.8	324.0	0.0	38.8	32.5	0.8	257.8

The projects proposed may result in energy savings of approximately 16.74% and cost savings of Rs. 38.8 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 Environmental 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 SMEs;
- Scaling up of the project to the national level;
- Strengthening policy, institutional and decision making frameworks.

1.2 Scope of work of Comprehensive Energy Audit

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

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, 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 (with or without investment) 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 1.7 Years).
- Classify parameters related to EE enhancements such as estimated quantum of energy savings, investment required, timeframe 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 for coverage of the audit.

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

1.3.2 General methodology

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

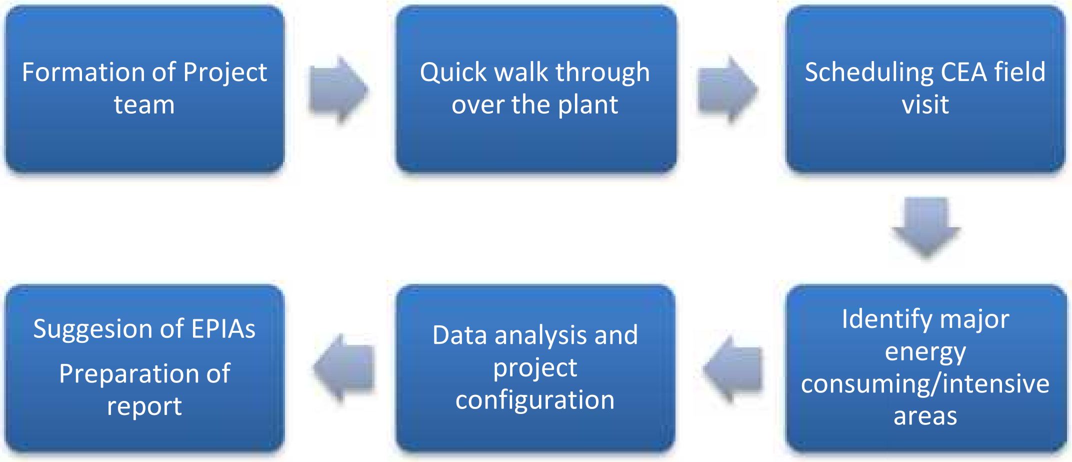


Figure 1: General methodology

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 and assessment of scope, measurability and formulation of audit plan and obtaining required information
- **Stage 2:** Detailed energy audit-testing & measurement for identification of saving potential, technology assessment and understanding of project constraints
- **Stage 3**: Data analysis, initial configuration of projects, savings quantification, vendor consultation, interaction with the unit and freezing of projects for implementation and preparation of energy audit report

1.3.3 Comprehensive energy audit – field assessment

A 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 financial performance of the unit.
- Assess the energy conservation potential at macro level
- Finalize the schedule of equipments and systems for testing and measurement

The audit identified the following potential areas of study:

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

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

- Preparation of the process & energy flow diagrams

- Study of the system & associated equipments
- Conducting field testing & measurement
- Data analysis for preliminary estimation of savings potential at site
- Presentation to 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 finding solutions to minimize the same. This entailed data collection, measurements/ testing of the system using calibrated, portable instruments analyzing the data/ test results and identifying the approach to improve efficiency. The following instruments were used during the energy audit.

Table 4: Energy audit instruments

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

12	High touch probe Temperature Meter	CIG		Temperature upto 1300℃
13	Lux Meter	Kusum Meco (KM-LUX-99) and Mastech		Lumens
14	Manometer	Comark	C 9553	Differential air pressure in duct
15	Pressure Gauge	Wika		Water pressure 0 to 40 kg

1.3.4 Comprehensive energy audit – desk work

Post audit off-site work carried out included:

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

2 ABOUT THE MSME UNIT

2.1 Particulars of the unit

Table 5: General particulars of the unit

Sl. No.	Particulars	Details
1	Name of the unit	M/s Hindustan Chemicals
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. R. Roy Director +91 9690011866 chemhind@gmail.com
5	Address of the unit	G.T Road, Khurja – 203131
6	Industry / sector	Ceramic
7	Products manufactured	Porcelain insulators
8	No. of operational hours	24
9	No. of shifts / day	3
10	No. of days of operation / year	300
11	Whether the unit is exporting its products (yes / no)	No
12	No. of employees	40

3 DETAILED TECHNICAL FEASIBILITY ASSESSMENT OF THE UNIT

3.1 Description of manufacturing process

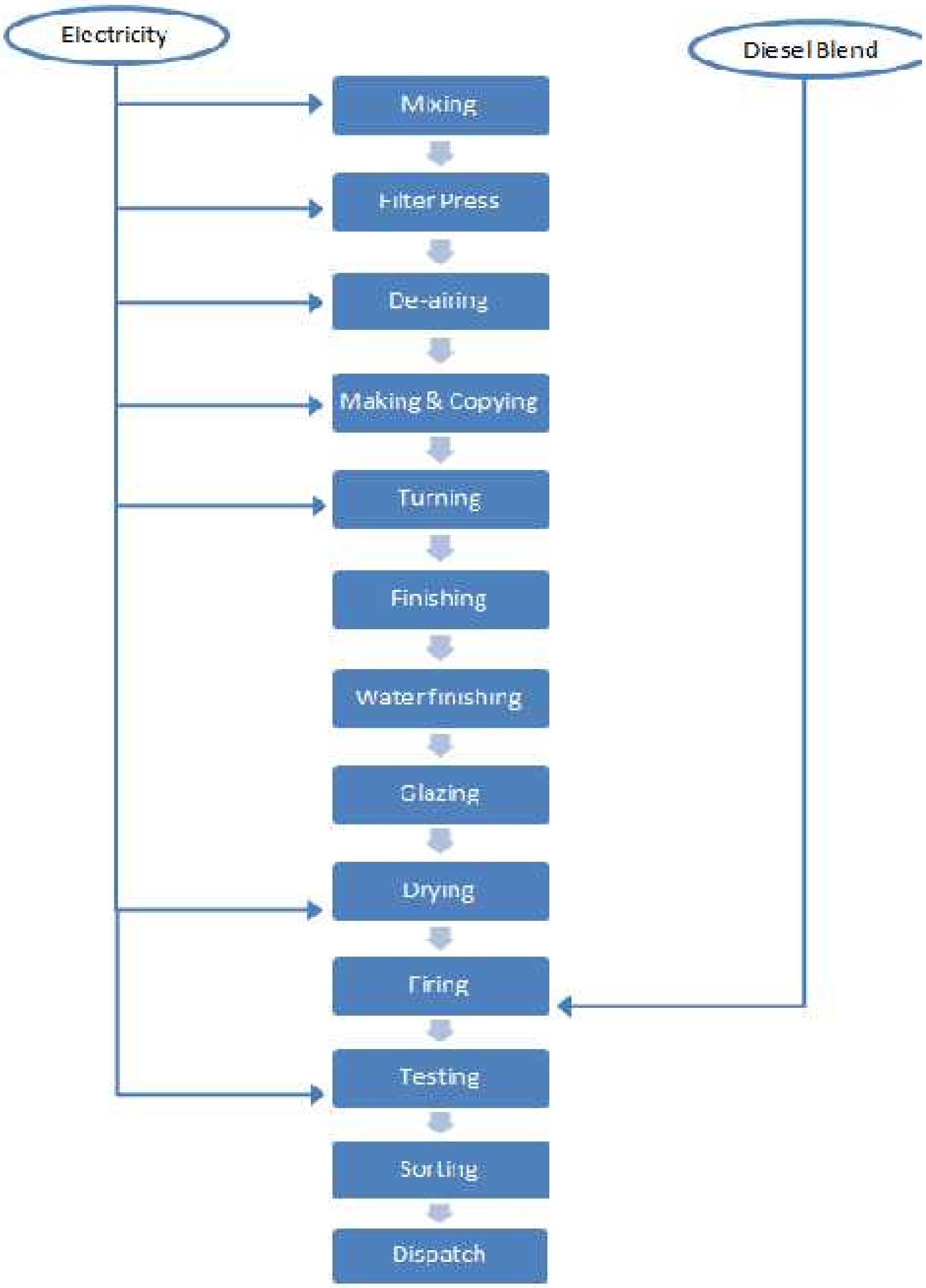


Figure 2: Process flow diagram

3.1.1 Process description

M/s Hindustan Chemicals is a manufacturer of porcelain insulators.

The process description is as follows:

- The raw materials clay, feldspar and quartz are mixed and ground 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 transferred to the filter press to remove water content from it.
- The filtered cakes formed are then placed in a pug mill for de-airing bubbles by a vacuum pump connected to it.
- Output from pug mill is cut down into smaller sizes and given required shapes using jigger jollies after which they are simply dried for a few days under fans.
- 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 1,220 – 1,230°C.
- After firing, the products are quality checked, packed and dispatched.

3.2 Inventory of process machines/equipments and utilities

Major energy consuming equipments in the plant are:

- **Ball mill:** Here the raw materials like clay, feldspar and quartz are mixed in the ratio of 2:1:1 respectively along with water to form slurry.
- **Agitator:** The slurry after getting mixed in the ball mill is poured into a sump where an agitator is fitted for thorough mixing of materials and for preventing it 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 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 pores and crack formation during firing. The output from the pug mill is cut into small pieces and transferred to the shaping section. The moisture content is reduced by 20% in this process.
- **Jigger jollies:** The final products are given required shape by the jigger jollies along with molds, and then dried. .
- **Tunnel Kiln:** The shaped materials are glazed, painted and then stacked on the kiln car, which are then sent for firing in the tunnel kiln with the help of pusher motor kept at a specified rpm. The tunnel is about 16 feet long and the temperature gradually increases up to the firing zone and then decreases (in the cooling zone) with the highest temperature being 1,230°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 blend generator sets for the whole plant
- Thermal energy is used for following applications :
  - Diesel blend 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. In Lakhs	% of total	MTOE	% of total
Grid – Electricity	20.18	8	21.3	3.78
HSD– DG	5.83	2	10.6	1.88
Thermal – diesel blend	214.29	89	530.6	94.34
Total	240.31	100	562.4	100

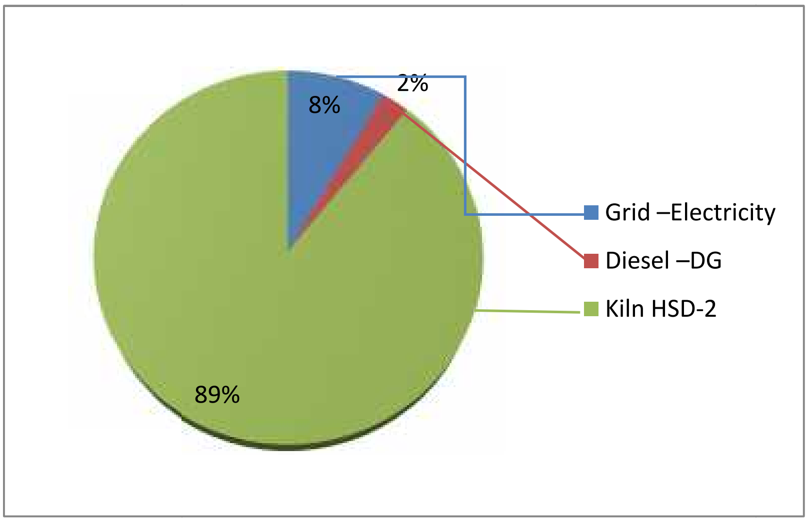


Figure 3: Energy cost share (Rs. Lakh)

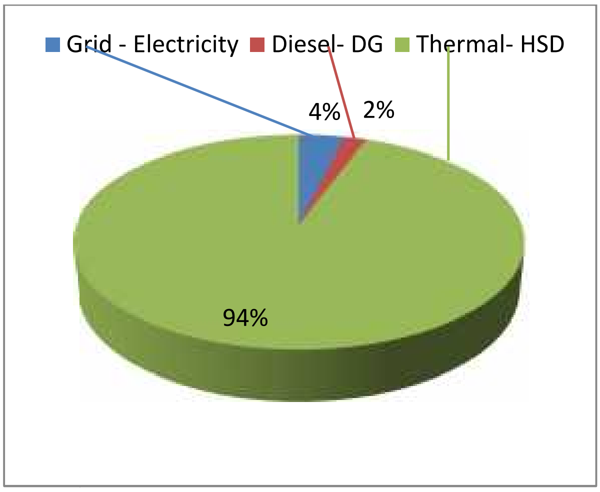


Figure 4: Energy use share (MTOE)

Major observations are as under:

- The unit uses both thermal and electrical energy for carrying out manufacturing operations. Electricity is supplied by the grid and also 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 89% of the total energy cost. HSD used in DG sets account for 2% of total energy cost and electricity used in plant process account for 8% of total energy cost.
- Diesel blend used in kilns account for 94% of overall energy consumption. HSD used in DG sets account for 2% of overall energy consumption and electricity used in plant account for 4% of overall energy consumption.

3.4 Analysis of electricity consumption by the unit

3.4.1 Baseline parameters

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

Table 7: Baseline parameters

Electricity Rate (Excluding Rs/kVA)	6.09	Rs./ KVAH inclusive of taxes
Weighted Average Electricity Cost	9.42	Rs./ kWh for 2013-14
Percentage of total DG based Generation	12%	
Average Cost of diesel blend	40.00	Rs./liter
Average cost of HSD	54.00	Rs./liter
Annual Operating Days per year	300	Day/yr
Annual Operating Hours per day	24	Hr/day
Production	1,819	MT

GCV of diesel blend	9,904	kCal/ litre
Density of diesel blend	0.91	kg/litre

3.4.2 Electricity load profile

Following observation have been made from the utility inventory:

- Plant and machinery load is 128.3 kW
- The utility load is about 8.5 kW including the single phase load
- The total connected plant load is 136.8 kW

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

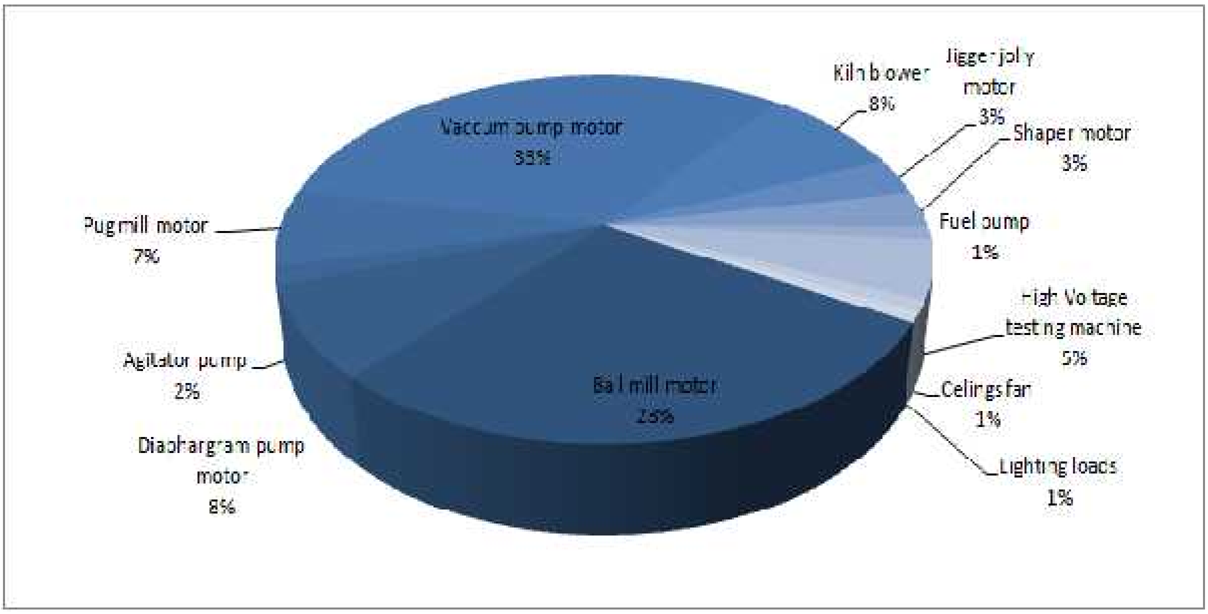


Figure 5: Details of connected load

As shown in the pie chart of connected load, the maximum share of connected load is for the ball mill – 28%, diaphragm pump – 8%, pug mill – 7%, vacuum pump – 33% and kiln blower - 8%. Other loads are for jigger jolly motor and shaper motor – 3% each, fuel pump – 1%, fans – 1% and lighting loads account for 1% of the connected load.

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

Table 8: Area wise electricity consumption (estimated)

Consumption	kW	kWh/year	% of Total
Ball mill motor	27.4	74021.9	26.5%
Diaphragm pump motor	7.8	21149.1	7.6%
Agitator pump	2.2	7251.1	2.6%
Pug mill motor	2.1	3845.7	1.4%

Vacuum pump motor	20.1	54383.4	19.5%
Kiln blower	11.2	48340.8	17.3%
Jigger jolly motor	4.5	9668.2	3.5%
Shaper machine	4.5	14502.2	5.2%
Fuel pump	1.5	6445.4	2.3%
High voltage testing machine	7.1	25656.6	9.2%
Ceiling Fan	1.4	7560.0	2.7%
Lighting load	1.2	6696.0	2.4%
Total	**91.2**	**279520.4**	**100%**

This is represented graphically in the figure below:

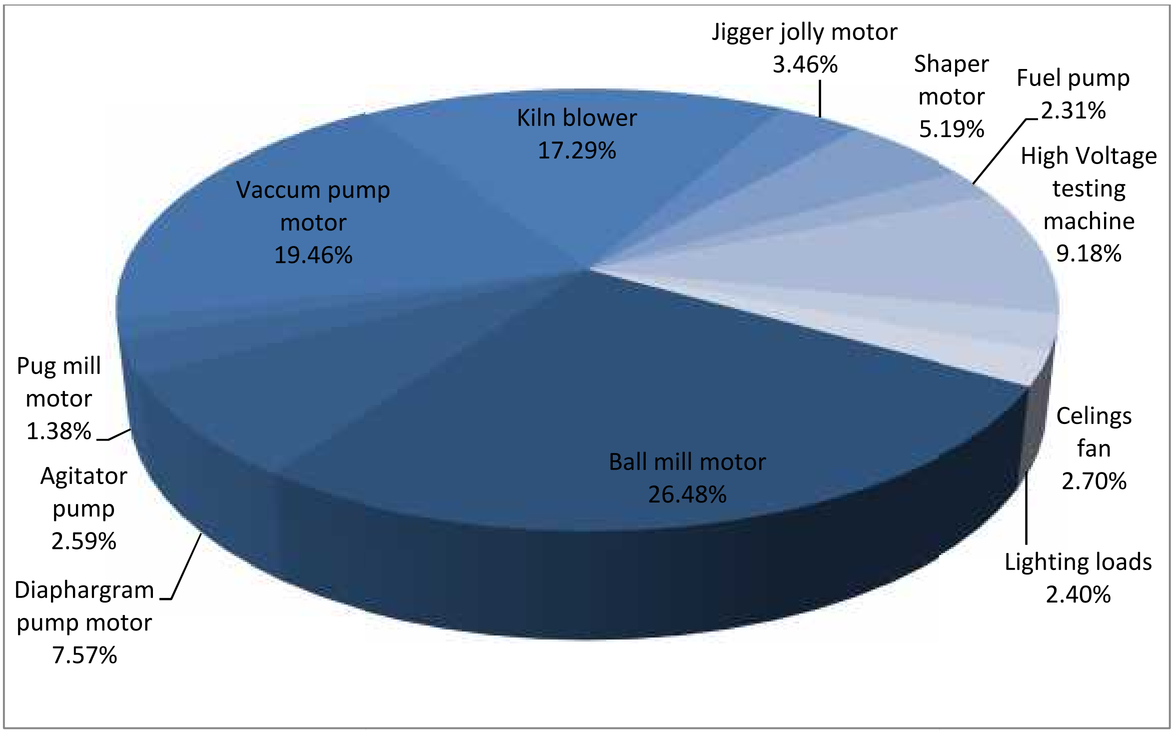


Figure 6: Area wise electricity consumption

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

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	247,255	88	20.2	78
Self Generation	32,400	12	5.8	22
Total	279,655	100	26.0	100

This is graphically depicted as follows:

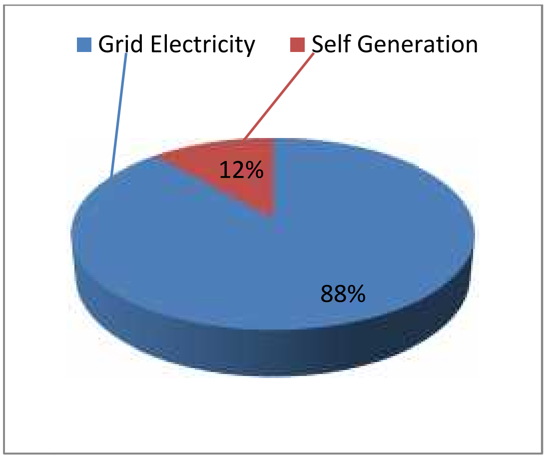


Figure 7: Share of electricity by source

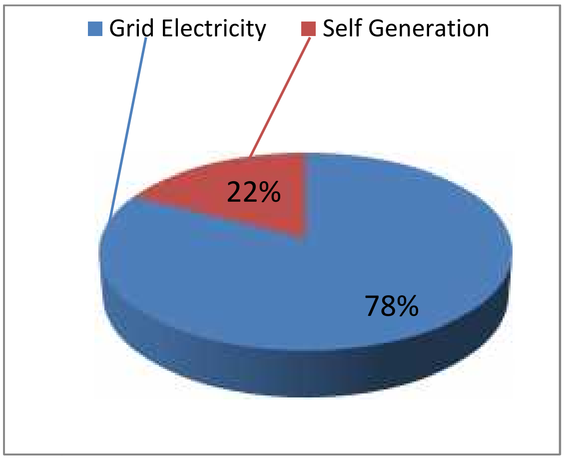


Figure 8: Share of electricity by cost

The requirement of power supply from DG sets is about 12% of the total power which is not very high, but it accounts for about 22% of total cost of power. This indicates the high cost of DG power due to rise in the price of HSD. For economical operations, utilization of DG sets needs to be minimized, however, it depends upon the supply condition of the grid as well as the 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. : 11267655
b) Power Supply : 11 kV line
c) Contract Demand : 150 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	6.06	Rs./kVAh
Regulatory	0.23	Rs./kVA
Fuel Surcharge	0.00	Rs./kVAh
Electricity duty	0.54	Rs./kVAh
Municipality tax	0.00	Rs./kVAh

(As per bill for March – 15)

Table 11: Electricity bill analysis

Electricity Bill Analysis															
Month	Contract Demand	Bill Demand	Recorded Maximum Demand	PF	Electricity Consumption					Energy - TOD Charges	Demand Charge	Regulatory charges @ 2.84% Energy	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.
Apr-14	150	112.5	6.42	0.98	17,418	5,406	9,174	3,246	17,826	105,656	28,125	0	10,033	-24.0	143,791
May-14	150	112.5	65.93	0.98	15,615	5,133	8,466	2,370	15,969	94,043	28,125	0	9,162	-12.0	131,318
Jun-14	150	112.5	74.81	0.97	19,566	5,823	10,521	3,759	20,103	119,357	28,125	2,492	11,061	162.0	161,198
Jul-14	150	112.5	52.94	0.98	24,651	7,014	13,275	4,800	25,089	149,169	28,125	5,035	13,297	0.0	195,626
Aug-14	150	112.5	93.10	0.98	19,647	5,061	10,671	4,221	19,953	119,218	28,125	4,184	11,050	0.0	162,579
Sep-14	150	93.1	89.51	0.98	18,060	5,064	9,723	3,552	18,339	109,102	23,275	3,759	9,928	0.0	146,066
Oct-14	95	77.5	77.46	0.98	25,446	7,794	14,103	4,059	25,956	159,873	19,364	7,560	13,442	0.0	200,241
Nov-14	95	77.5	53.055	0.98	17,634	5,199	9,489	3,342	18,030	114,290	19,364	6,976	10,024	0.0	150,655
Dec-14	95	71.3	70.01	0.98	28,113	9,135	14,670	4,905	28,710	181,191	17,812	10,388	14,925	0.0	224,317
Jan-15	95	73.3	73.33	0.98	19,419	6,681	10,218	3,015	19,914	125,150	18,333	7,489	10,761	0.0	161,734
Feb-15	95	71.3	70.02	0.98	21,081	6,960	11,280	3,255	21,495	135,205	17,812	7,987	11,476	0.0	172,482
Mar-15	125	93.3	66.05	0.98	20,604	6,297	11,053	3,684	21,034	128,387	23,326	5,079	11,378	11.45	168,182
Max	150	112.5	93.10	0.98	28,113	9,135	14,670	4,905	28,710	181,191	28,125	10,388	14,925	162.0	224,317
Min	95	71.3	6.40	0.97	15,615	5,061	8,466	2,370	15,969	94,043	17,812	0	9,162	-24.0	131,318
Avg	125	93.3	66.10	0.98	20,604	6,297	11,053	3,684	21,034	128,387	23,326	5,079	11,378	11.5	168,183
Total					226,650	69,270	121,590	40,524	231,384	1,412,261	256,587	55,874	125,163	126.0	1,850,012

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

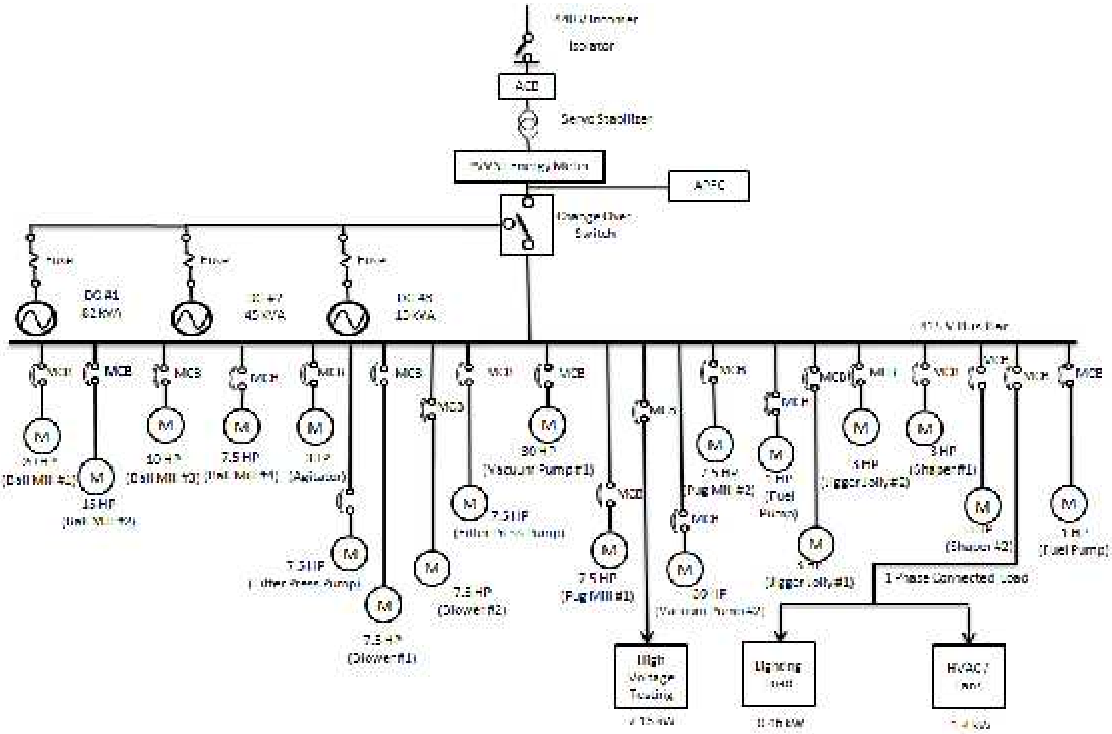


Figure 9: SLD of electrical load

Power factor

The utility bills of the unit reflect the power factor. A study was conducted by logging electrical parameters of the main incomer. The average power factor was found to be 0.979 with the minimum being 0.973 and the maximum being 0.984.

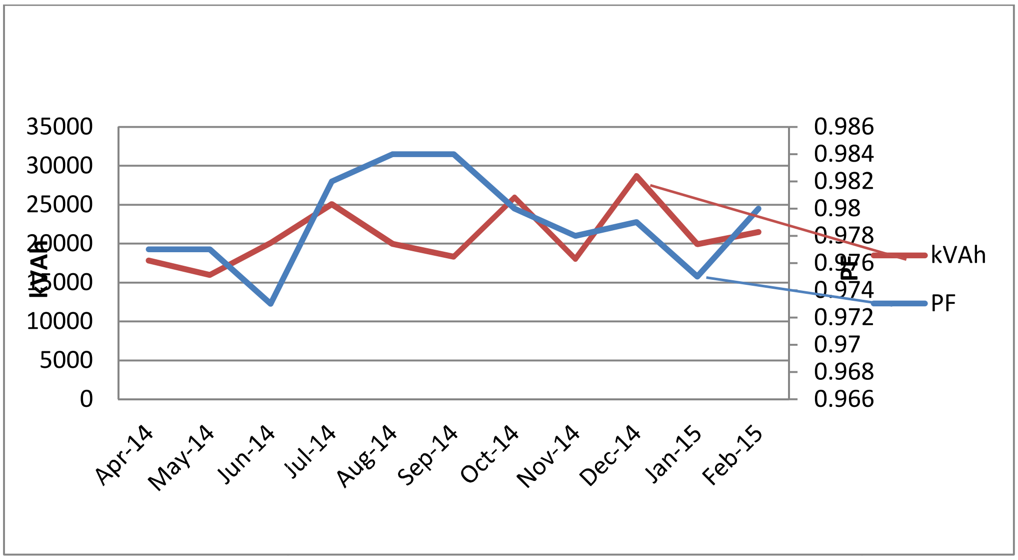


Figure 10: Monthly trend of PF

Maximum demand

The maximum demand as reflected in the utility bill was 93.1 from the bill analysis.

3.4.5 Self-generation

The unit has three DG sets of 82 kVA, 45 kVA and 15 kVA ratings each. The unit does not have a system for monitoring the energy generation and fuel usage by the DG. HSD purchase records are, however, maintained by the unit. In order to find the month wise energy contribution by the DG sets, the results of performance testing of the DG sets, carried out during the detailed energy audit was used.

Performance testing was conducted for the82 kVA DG set and the specific energy generation ratio (SEGR) was calculated as 3 kWh/litre. HSD consumption by DG sets is 10,800 liters annually costing Rs. 5.83 lakh with a power generation of 32,400 kWh.

Note: 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 which is correspondingly computed annually too.

3.4.6 Month wise electricity consumption

Month wise total electrical energy consumption from different sources 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	17,418	2,700	20,118	143,791	48,600	192,391
May-14	15,615	2,700	18,315	131,319	48,600	179,919
Jun-14	19,566	2,700	22,266	161,198	48,600	209,798
Jul-14	24,651	2,700	27,351	195,627	48,600	244,227
Aug-14	19,647	2,700	22,347	162,579	48,600	211,179
Sep-14	18,060	2,700	20,760	146,066	48,600	194,666
Oct-14	25,446	2,700	28,146	200,242	48,600	248,842
Nov-14	17,634	2,700	20,334	150,656	48,600	199,256
Dec-14	28,113	2,700	30,813	224,318	48,600	272,918
Jan-15	19,419	2,700	22,119	161,735	48,600	210,335
Feb-15	21,081	2,700	23,781	172,482	48,600	221,082
Mar-15	20,605	2,700	23,305	168,183	48,600	216,783
Total	**247,255**	**32,400**	**279,655**	**2,018,196**	**583,200**	**2,601,396**

[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

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

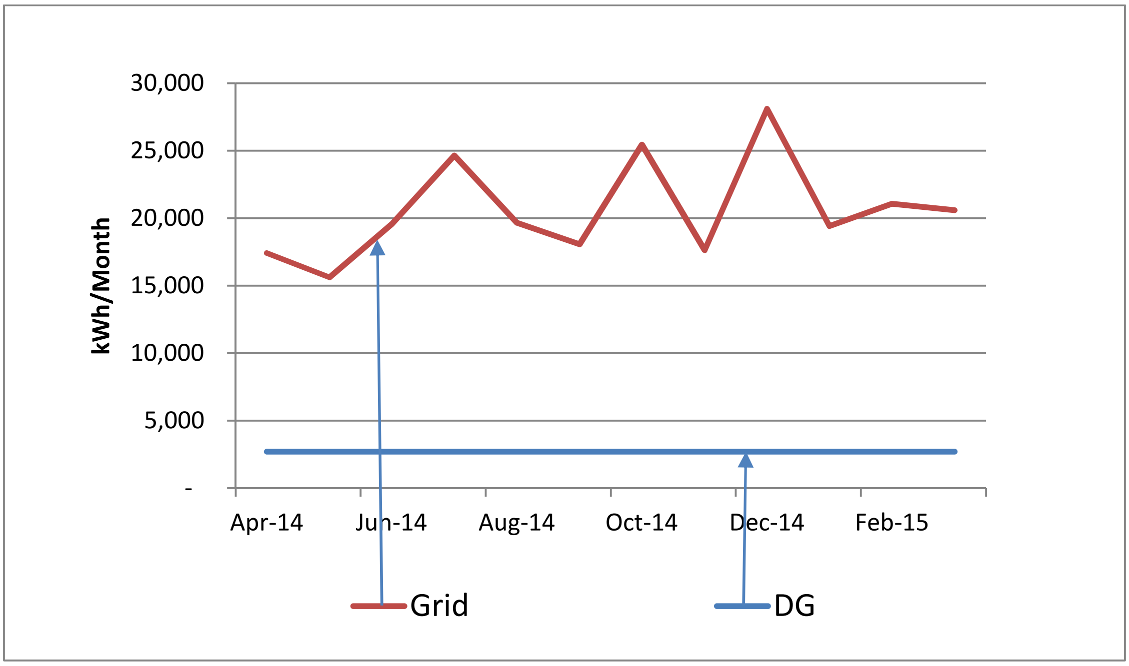


Figure 11: Month wise variation in electricity consumption from different sources

As seen from the figure above, consumption of electrical energy is on higher side during the months of July 2014, October 2014 and December 2014, and was fluctuating during the remaining months. However, it is noticed that electricity consumption during May 2014 was low because the plant was shut down at that time for maintenance purpose. The corresponding month wise variation in electricity cost is shown graphically in the figure below:

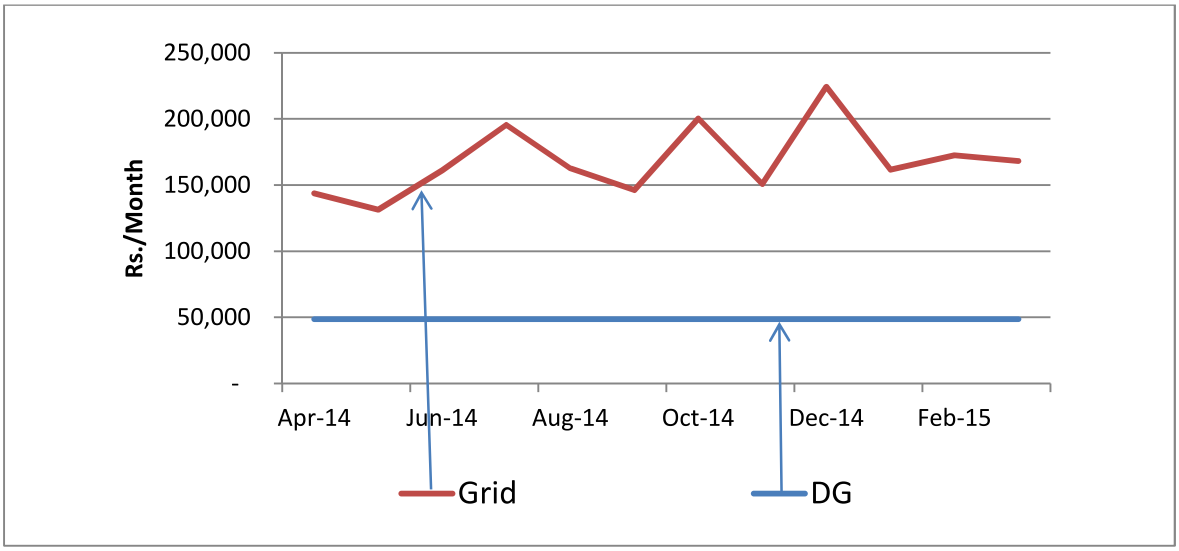


Figure 12: Month wise variation in electricity cost from different sources

From the utility bill analysis, it is seen that the cost (Rs.) per unit of kWh consumption decreases with the rise in consumption. As consumption increases, the share of fixed charge decreases and vice versa. The annual variation of cost of energy from utility as well as DG sets is shown in the figure below:

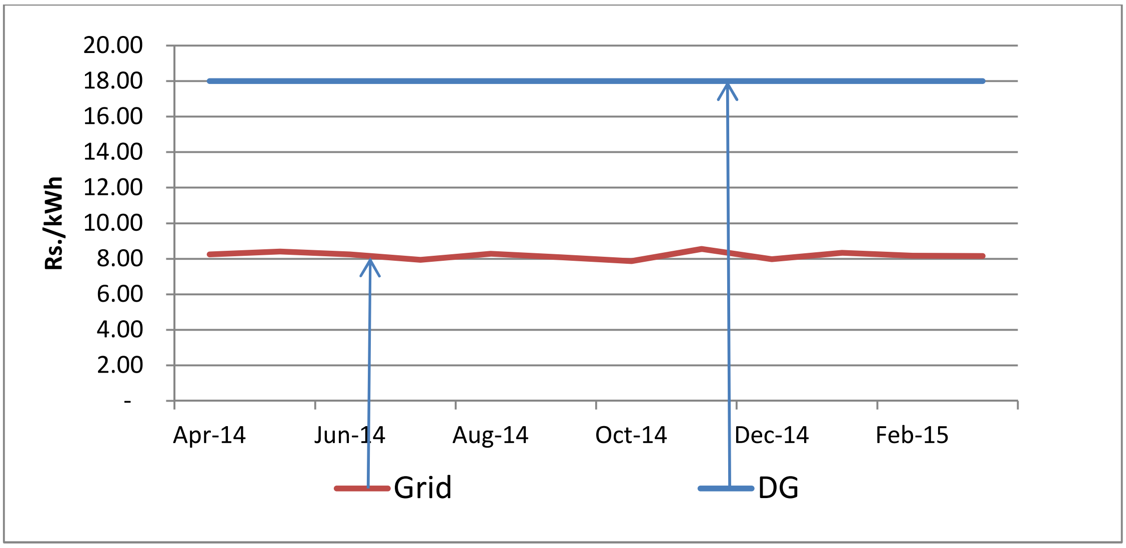


Figure 13: Average cost of power (Rs./kWh) from different sources

The above graph clearly indicates that the cost of electrical energy from DG sets 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 in the kiln for firing ceramic materials. Diesel blend is procured from local suppliers and the average landed rate is Rs. 40/ liter. There was no meter installed for measurement of fuel consumption in the kiln. Diesel blend consumption by kilns is 44,644 liters monthly costing Rs. 17.85 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 13: Overall specific energy consumption

Parameters	Value	UoM
Annual Grid Electricity Consumption	247,255	kWh
Annual DG Generation Unit	32,400	kWh
Annual Total Electricity Consumption	279,655	kWh
Diesel consumption for Electricity Generation	10,800	Litres

Annual Fuel Consumption in Kiln (diesel blend)	535,728	Litre
Annual Energy Consumption; MTOE	562.44	MTOE
Annual Energy Cost	240.31	Lakh Rs
Annual Production	1,819	MT
SEC; Electricity from Grid + DG	154	kWh/MT
SEC; Thermal	294	Liter/MT
SEC; Overall	0.309	MTOE/MT
SEC; Cost Based	13,208	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 : 10,000 kCal
- GCV of Diesel blend : 11,840 kCal/ kg
- Density of DIESEL BLEND : 0.8263 kg/liter
- CO_2 Conversion factor
  - Grid : 0.89 kg/kWh
  - Diesel blend : 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 a 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 feeder from PVVNL supply were recorded for 8 hours using a portable power analyzer. Summary of key observations is as below.

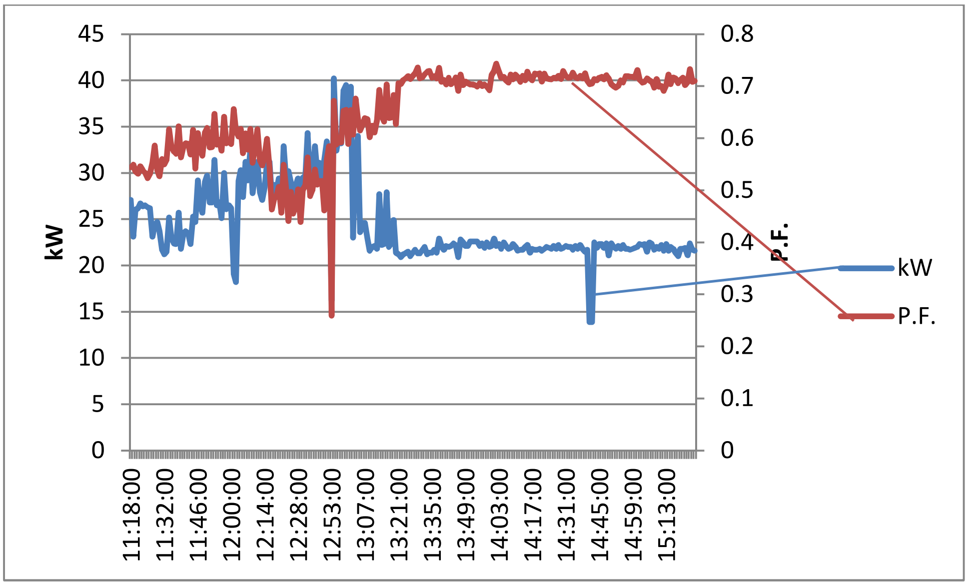


Figure 14: Load profile and power factor

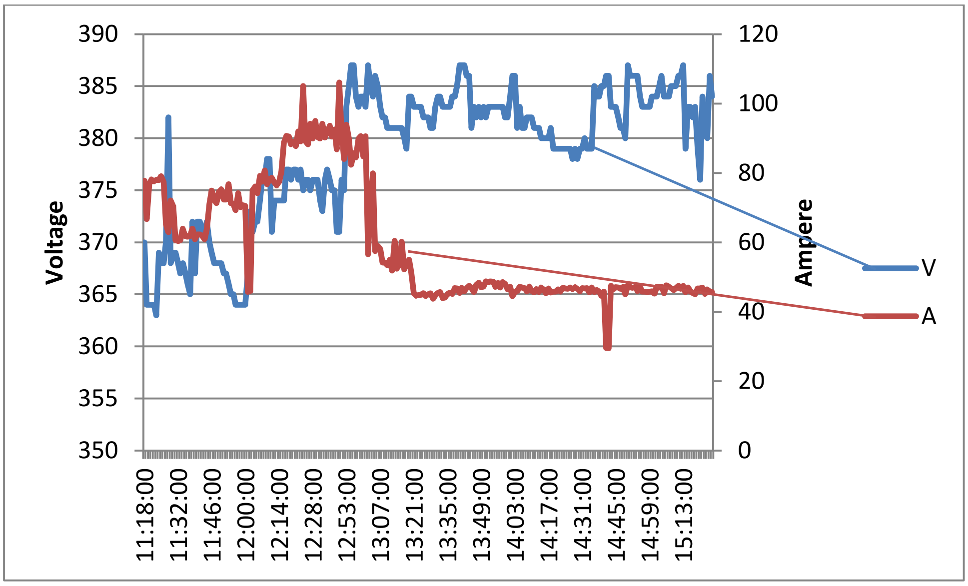


Figure 15: Voltage and current profile

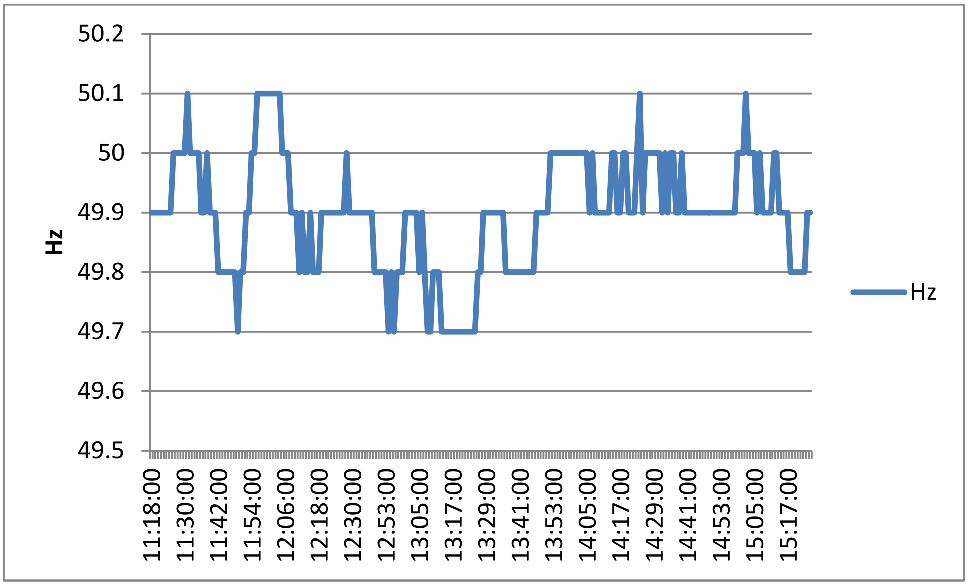


Figure 16: Harmonics profile

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 by PVVNL through a separate transformer. The unit has a HT connection and its contract demand was150 kVA.	The maximum kVA recorded during study period was 68.50 kVA. As per utility bill, the MD was 93.1 KVA which is less than the contract demand.	No EPIAs were suggested.
Power Factor	Unit has an HT connection and billing is in kVAh. The utility bills reflect the PF of the unit. The unit has an APFC panel installed to control the power factor.	The average PF found during the measurement was 0.979 and it varied between 0.973 and 0.984.	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 378.61 V. Maximum voltage was 387 V and minimum was 363 V.	No EPIAs were recommended.

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

3.7.2 Electrical consumption areas

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

The details of the measurements conducted, observations recorded 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 4ball mills in the unit which are connected with 7.5 HP, 10 HP, 15 HP and 20 HP motors. Ball mills account for an estimated 27.7% of overall energy consumption.</td><td>Out of the 4ball mills, one mill of 2.5 T was in operation during CEA and its characteristics were studied.

The results of the study are as below:<table><tr><td>Machine</td><td>Avg. kW</td><td>Avg. PF</td></tr><tr><td>Ball Mill</td><td>6.27</td><td>0.44</td></tr></table></td><td>No EPIAs were suggested for ball mill.</td></tr>
<tr><td>Kiln blower</td><td>The unit has one blower for each of the kilns, which is used for supplying both the combustion air and cooling air in the kilns. The blowers account for 7.9% of the total electricity consumption.</td><td>Data logging was carried out in blower of kiln-1 to establish its power profile.

The results of the study on blower for kiln 1 is as below:<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Blower</td><td>3.29</td><td>0.99</td></tr></table></td><td>Excess air control by PID controller was suggested as an EPIA.</td></tr>
</table>

3.7.3 Thermal consumption areas

As discussed in the earlier section, about 92 % of energy cost and 94% of energy consumption was 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. The kiln installed in Hindustan Chemicals was diesel blend fired. 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 pre-heating 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.

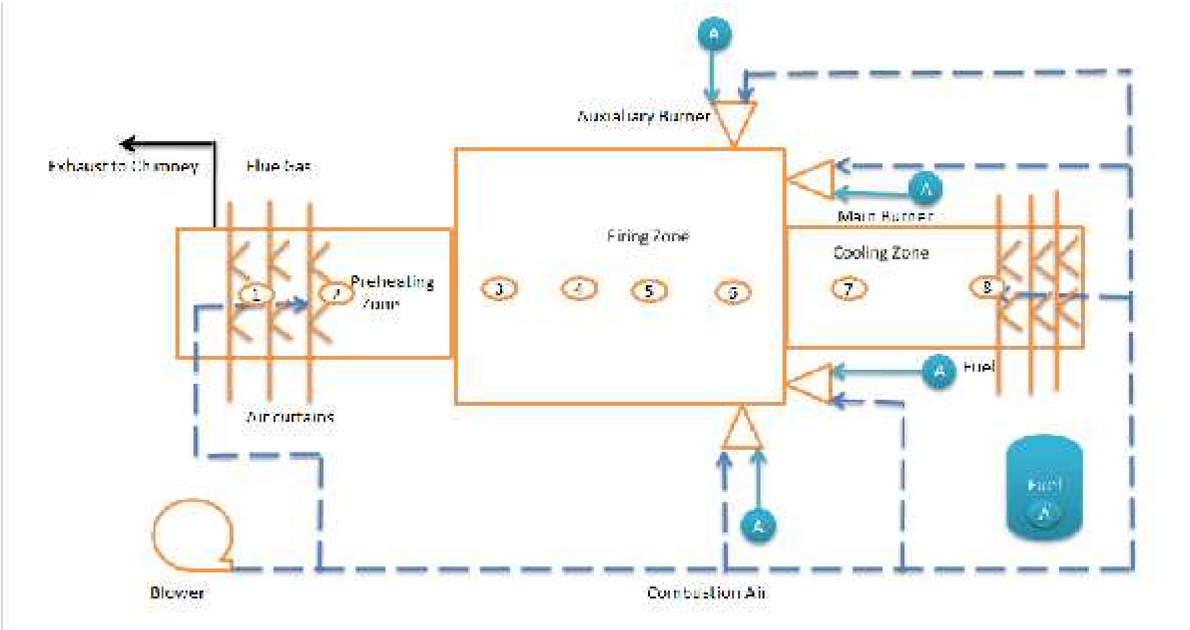


Figure 17: Tunnel Kiln

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

Table 15: Temperatures at various sections of tunnel kiln-1

Section of kiln	Temperature
1	260°C
2	780°C
3	1200°C
4	1214°C

5	1220°C
6	1190°C
7	780°C
8	265°C

Table 16: Dimensions of kiln-1

Zone	Length	Width	Height
Pre-heating	1080 cm	135 cm	128 cm
Firing	496 cm	285 cm	147 cm
Cooling	2040 cm	135 cm	128 cm

Table 17: Temperatures at various sections of tunnel kiln-2

Section of kiln	Temperature
1	242°C
2	793°C
3	1190°C
4	1218°C
5	1224°C
6	1180°C
7	765°C
8	270°C

Table 18: Dimension of kiln-2

Zone	Length	Width	Height
Pre-heating	1120 cm	138 cm	155 cm
Firing	628	138 cm	169 cm
Cooling	1196 cm	138 cm	155 cm

Table 19: Observation during field study and suggested EPIA

Observations during field Study & measurements	Proposed Energy performance improvement actions
The fuel consumption of kiln was measured using dip stick method as no metering was available. Machine | Oxygen Level | Ambient Air Temp | Exhaust Temperatur	No recommendations have been suggested as the exit flue gas temperature is low and cannot be used for waste heat recovery. Reducing the skin losses by improving insulation is recommended in firing zone of the kiln.

	measured in Flue Gas		e of Flue Gas
Tunnel kiln	11%	40.2°C	248°C

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

The inlet temperature of raw materials in both the kilns was in the range of 35 – 42°C .

The exhaust temperature of flue gas from the chimney after the effect of air curtains is in the range of 198 - 250°C, whereas near the firing zone it was found to be 860 – 926°C.

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 a lot of useful heat.

Reducing opening losses in the kiln is recommended.

It is recommended to change the kiln car material with other materials of lower Cp values that absorb lesser heat.

4 EE TECHNOLOGY OPTIONS AND TECHNO – ECONOMIC FEASIBILTY

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

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

4.1 EPIA 1: Reduction in radiation and convection losses from surface of kiln

Technology description

A significant portion of the losses in a kiln occurs as radiation and convection loss from the kiln walls and the roof. These losses are substantially higher in areas of openings or in case of infiltration of cold air. Ideally, optimum amount of refractory and insulation should be provided on the kiln walls and the roof to maintain the skin temperature of the furnace at around 45-50°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 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 to avoid 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 each of the three zones were measured. The average surface temperature of 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.

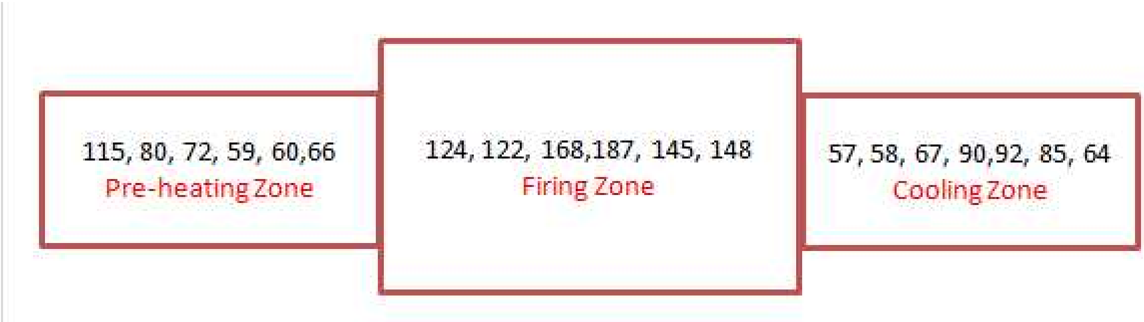


Figure 18: Measured skin temperatures of kiln 1 (deg C)

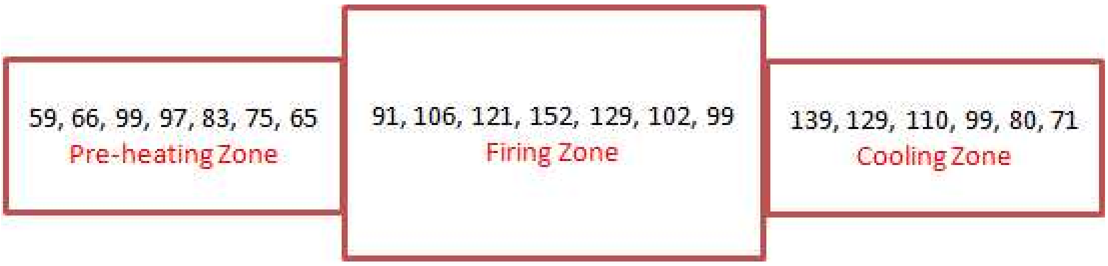


Figure 19: Measured skin temperature of kiln 2 (deg C)

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 due to radiation and convection in each zone (for kiln-1 and kiln-2) is given in the table below.

Table 20: R & C losses (for kiln – 1)

Total radiation and convection heat loss per hour	Units	Value
Pre-Heating Zone	kCal / hr	5,467
Firing Zone	kCal / hr	8,595
Cooling Zone	kCal / hr	11,123
Total R&C loss	kCal / hr	25,184

Table 21: R & C losses (for kiln – 2)

Total radiation and convection heat loss per hour	Units	Value
Pre-Heating Zone	kCal / hr	7,852
Firing Zone	kCal / hr	11,303
Cooling Zone	kCal / hr	20,912
Total R&C loss	kCal / hr	40,067

The cost benefit analysis of the energy conservation measure (for kiln – 1) is given below:

Table 22: Cost benefit analysis (EPIA 1)

Parameters	UoM	Value
Present average skin temperature of Firing zone	deg. C	115.39
Recommended skin temperature of Firing Zone	deg. C	50.00
Present heat loss due to Radiation & Convection from Heating zone walls	kCal / hr	8,595
Recommended heat loss due to Radiation & Convection from Firing zone	W / m2	53.09
	kCal / m2	45.66
	kCal / hr	666
Total reduction in heat loss due to Radiation & convection by limiting skin temperature at firing zone	kCal / hr	7,929
Calorific value of Fuel	kCal / kg	10,920
Equivalent savings in Fuel	kg / hr	0.73
Plant running time	days / year	300
	hrs / day	24
Annual savings in Fuel	kg/y	5,228
Cost of fuel	Rs / litre	40
avings	Rs. Lakhs / Year	2.31
Estimated investment	Rs. Lakhs	0.18

The cost benefit analysis of the energy conservation measure (for kiln – 2) is given below:

Table 23: Cost benefit analysis (EPIA 1)

Parameters	UoM	Value
Present average skin temperature of firing zone	deg. C	109.61
Recommended skin temperature of firing Zone	deg. C	50.00
Present heat loss due to Radiation & Convection from Heating zone walls	kCal / hr	11,303
Recommended heat loss due to Radiation & Convection from firing zone	W / m2	53.09
	kCal / m2	45.66
	kCal / hr	969
Total reduction in heat loss due to Radiation & convection by limiting skin temperature at firing zone	kCal / hr	10,334
Calorific value of fuel	kCal / kg	10,920

Equivalent savings in fuel	kg / hr	0.95
Plant running time	days / year	300
	hrs / day	24
Annual savings in fuel	kg/y	6,814
Cost of fuel	Rs / litre	40
Annual monetary savings	Rs. Lakhs / Year	3.00
Estimated investment	Rs. Lakhs	0.18

4.2 EPIA 2: Excess air control

Technology description

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

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

A PID controller, if installed, can 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) will 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:

The cost benefit analysis of the energy conservation measure (for kiln – 1) is given below:

Table 24: Cost benefit analysis (EPIA 2)

Parameters	UOM	Present	Proposed
Oxygen level in flue gas	%	10.90	3.00
Excess air percentage in combustion air supplied	%	107.92	16.67
Dry flue gas loss	%	12.95	
Savings in fuel	Every 10% reduction in excess air leads to savings in specific fuel consumption by 1%		
Specific fuel consumption	kg/t	193.19	175.56
Saving in specific fuel consumption	kg/h		1.62
Savings in fuel cost	Rs. Lakh/y		11,675
Installed capacity of blower	kW		5.15
Operating hours	hrs/y	5.60	7.83
Electrical energy consumed	kWh/y	3.30	6.27
Savings in electrical energy	kWh/y	7200.00	7200.00
Cost of increased electrical energy	Rs. Lakh/y	23744.46	45118.08
Savings in terms of energy cost	Rs. Lakh/Y		-21374
Estimated investment	Rs. lakh	2.24	4.25
Simple payback	y		3.14

The cost benefit analysis of the energy conservation measure (for kiln – 2) is given below:

Table 25: Cost benefit analysis (EPIA 2)

Parameters	UOM	Present	Proposed
Oxygen level in flue gas	%	10.30	3.00
Excess air percentage in combustion air supplied	%	96.26	16.67
Dry flue gas loss	%	17.69	
Saving in fuel	Every 10% reduction in excess air leads to savings in specific fuel consumption by 1%		
Specific fuel consumption	kg/t	134.89	124.16
Savings in specific fuel consumption	kg/h		1.73
Savings in fuel cost	Rs. Lakh/y		12,423
Installed capacity of blower	kW		5.48
Operating hours	hrs/y	5.60	7.83
Electrical energy consumed	kWh/y	3.32	6.27

Savings in electrical energy	kWh/y	7200.00	7200.00
Cost of increased electrical energy	Rs. Lakh/y	23907.47	45118.08
Savings in terms of energy cost	Rs. Lakh/Y		-21211
Estimated investment	Rs. lakh	2.25	4.25
Simple payback	y		3.48

4.3 EPIA 3: Replacement of Kiln car material

Technology description

The existing kiln car consists of refractory bricks and tiles which are very heavy and hence increase the dead weight of the car. The present kiln car also carries away much of the useful heat supplied to the kilns, thus reducing its efficiency. A new material called ultralite[2] can be used in the kiln car construction, 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, the kiln car used in the unit is made up of HFK bricks, quadrite tiles and pillars. These materials contribute to a dead weight (of kiln car) of 400 - 530 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 firing zone to cooling zone. The kiln car also gains useful heat that is supplied by fuel to heat the ceramic materials and they carry the same with them out of the kiln. The heat gained by kiln car is wastage of useful heat supplied, as the heat is being supplied to heat the ceramic material and not the kiln car. However, this wastage is inevitable, as the materials have to be placed on the kiln cars to travel along the kiln. So, in order to reduce this wastage, it is recommended to select kiln car material that absorbs as minimum heat as possible, so that most of the heat supplied is gained by the ceramic material. This will also help in reducing fuel consumption in the kiln.

Recommended action

It is recommended to replace the present kiln car material with “ultralite” material with a little modification in the arrangement of refractories. This will help reduce its dead weight besides reducing the heat gained by it, and also help in reduction in fuel consumption in the kiln considerably. The cost benefit analysis for the EPIA is given in the table below:

The cost benefit analysis for the EPIA (kiln – 1) is given in the table:

[2] Kiln car material by Inter-kiln Industries, Ahmedabad, Gujarat.

Table 26: Cost benefit analysis (EPIA 3)

Parameters	UoM	Present	Proposed
Present Production from kiln	tph	0.09	0.09
Weight of existing kiln car	kg	506	330
Total number of kiln cars inside kiln	Nos.	27	27
Initial temperature of kiln car	Deg c	40.2	40.2
Final temperature of kiln car	Deg c	1,098	1,098
Estimated percentage savings by replacing present kiln car with new EE kiln car	%		30
Heat carried away by the kiln material	kcal/h	71,402	49,982
Reduction in heat carried by the new EE kiln car	kcal/h		21,421
Operating hours of kiln	h	7,200	7,200
Savings in terms of fuel consumption	Litre/y		14,124
Savings in terms of cost	Rs. lakh/y		6.2
Estimated investment of kiln car material	Rs. lakh/y		5.40
Payback period	y		0.9

The cost benefit analysis for the EPIA (kiln – 2) is given in the table:

Table 27: Cost benefit analysis (EPIA 3)

Parameters	UoM	Present	Proposed
Present Production of kiln	tph	0.16	0.16
Weight of existing kiln car	kg	472	330
Total number of kiln cars inside kiln	Nos.	28	28
Initial temperature of kiln car	Deg c	40.2	40.2
Final temperature of kiln car	Deg c	1,168	1,168
Estimated percentage savings by replacing present kiln car with new EE kiln car	%		
Heat carried away by the kiln material	kcal/h	70,289	49,202
Reduction in the heat carried by the new EE kiln car	kcal/h		21,087
Operating hours of kiln	h	7,200	7,200
Savings in terms of fuel consumption	kg/y		13,903
Savings in terms of cost	Rs. lakh/y		6.1
Estimated investment of kiln car material	Rs. lakh/y		5.60
Payback period	y		0.9

4.3 EPIA 4: 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. Installation of a VFD will help in regulating 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 period.

Recommended action

It is recommended to install VFD with the pug mill motor. This will ensure that the machine draws minimal current during unloading by sensing the required parameter, for e.g. weight of raw material introduced into the pug mill for de-airing. The cost benefit analysis of the energy conservation measure is given below:

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

Table 28: Cost benefit analysis (EPIA 4)

Parameters	Unit	Present	Proposed
Installed capacity of motor	kW	6	6
Estimated energy savings by installing VFD on (Pug-Mill motor)	%		20.0
Average power consumption	kW	4.5	4
No of operating hours per day	Hrs	16	16
Operating Days per Year	Days	300	300
Average electricity consumption per year	kWh	21,485	17,188
Annual electricity savings	kWh/y		4,297
Average electricity tariff	Rs/kWh	9.42	9.42
Annual monetary savings	Lakhs Rs.		0.40
Estimated investment	Lakh Rs		0.6
Simple Payback	Y		1.5

4.4 EPIA 5: Speed optimization by installation of VFD on ball mill – 1

Technology description

All rotary machineries have a critical speed beyond which the rotation stops. Normally, 70% of the critical speed is the nominal operating speed in which thorough mixing and crushing takes place in a ball mill. If the rotating speed is above or below the nominal operating speed, a variable frequency drive can be installed to regulate the speed of rotation, thereby reducing electricity consumption.

Study and investigation

It has been observed during the CEA that the speed of rotation of ball mill-1 was higher than the normal operating speed.

Recommended action

It is recommended to install a VFD to control the speed of the ball mill and to reduce its electricity consumption.

Table 29: Cost benefit analysis (EPIA 5)

Parameters	Unit	Present	Proposed
Ball mill diameter	m	3	3
Ball mill critical speed	rpm		24
Ball mill speed	rpm	22	17
Installed capacity of motor	kW	14.92	14.92
Average power consumption	kW	10.4	5
No of operating hours per day	Hrs	20	20
Operating Days per Year	Days	300	300
Average electricity consumption per year	kWh	62664	29427
Annual electricity savings	kWh/y		33237
Average electricity tariff	Rs./kWh	9.42	9.42
Annual savings in terms of cost	Lakhs Rs.		3.13
Estimated investment	Lakh Rs.		1.5
Simple Payback	Y		0.5

4.5 EPIA 6: Replacing present conventional T-12 with Energy efficient LEDs

Technology description

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

Study and investigation

The unit is having 15 T-12 tube lights.

Recommended action

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

Table 30: Cost benefit analysis (EPIA 6)

Parameters	UoM	Present	Proposed
Fixture		T-12	18 Watt LED tube light
Power consumed by T12	W	40	18
Power consumed by Ballast	W	12	0
Total power consumption (by T12)	W	52	18
Operating Hours/day	Hr	12	12
Annual days of operation	Day	300	300
Energy Used per year/fixture	kWh/y	187	65
Energy Rate	Rs./kWh	9.42	9.42
No. of Fixture	Unit	15	15
Power consumption per year	kWh/Year	2808	972
Operating cost per year	Rs. Lakh/Year	0.26	0.09
Savings in terms of electrical energy	kWh/Year		1836
Savings in terms of cost	Rs. Lakh/Year		0.17
Investment per fixture of LED	Rs. Lakh		0.0075
Investment of project	Rs. Lakh		1.11
Payback period	Years		0.65

4.6 EPIA 7: Replacing 23 watt CFL lamps with LEDs

Technology description

Replacing conventional lights like CFLs 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 20 CFL lights.

Recommended action

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

Table 31: Cost benefit analysis (EPIA 7)

Parameters	UoM	Present	Proposed
Fixture		23 Watt CFL	10 Watt LED tubelight
Power consumed by CFL	W	23	10
Total power consumption	kW	0.46	0.20
Operating Hours/day	Hr	18	18

Annual days of operation	Day	300	300
Energy Used per year/fixture	kWh/y	2484	1080
Energy Rate	Rs./kWh	9.42	9.42
No. of Fixture	Unit	20	20
Operating cost per year	Rs. Lakh/Year	0.23	0.10
Saving in terms of electrical energy	kWh/Year		1404
Savings in terms of cost	Rs. Lakh/Year		0.13
Investment per fixture of LED	Rs. Lakh		0.01
Investment of project	Rs. Lakh		1.18
Payback period	Years		1.36

4.7 EPIA 8: 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 are controlled by electronic drives which on speed reduction automatically sense the rpm and reduce the power consumption. Since a large number of ceiling fans are used in the ceramic units for drying purposes, replacing present conventional ceiling fans with EE fans will help in energy conservation.

Study and investigation

The unit is having about 20 conventional ceiling fans which are very old and can be replaced with EE fans.

Recommended action

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

Table 32: Cost benefit analysis (EPIA 8

Data & Assumptions	UOM	Present	Proposed
Number of ceiling fans in the plant	Nos	20	20
Running hours per day (avgerage) - 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	9.42	9.42
Fan unit price	Rs./piece	1500	3000
Electricity consumption:			
Electricity demand	kW	1.40	0.70
Power consumption by fans in a year	kWh/y	7560	3780

Savings in terms of power consumption	kWh/y	3780
Savings in terms of cost	Rs. Lakh/y	0.36
Estimated investment	Rs. Lakh/y	0.60
Payback period	y	1.68

4.8 EPIA 9: Installation of energy monitoring system

Technology description

Installation of energy monitoring systems will help the unit to better monitor the energy consumed by various machines. From this, the benchmark energy consumption with respect to production of the machines can be set. If an increase in energy consumption is noticed for any machine, then the reasons for the increased consumption can be diagnosed and proper remedial actions can be taken.

Study and investigation

It was observed during the audit that there was no online data measurement system present in the plant for monitoring various electrical energy data on main incomer and other MCC panels. 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 various electricity distribution panels. It is also recommended to install online flow-meters on individual DG sets and kilns to measure the oil flow. This measure will help in reducing energy consumption by approximately 3% from its present levels. The cost benefit analysis for this project is given below:

Table 33: Cost benefit analysis (EPIA 9)

Parameters	Unit	As Is	To Be
Energy monitoring saving	%		3.00
Energy consumption of major machines per year	kWh/Yr	2,26,650	2,19,851
Annual electricity savings per year	kWh/Yr		68008,437
W. Average Electricity Tariff	Rs./kWh		9.42
Annual monetary savings	lakh Rs./yr		0.64
Estimate of Investment	Lakh Rs.		0.35
Simple Payback	Months		6.6
Current diesel blend consumption	kg/y	1,27,943	1,24,105
Annual fuel saving per year	kg/y		3,838
Unit Cost of diesel blend fuel	Rs./kg		44.10
Annual monetary savings	Lakh Rs. /		1.69

	year	
Estimate of Investment	Lakh Rs.	0.40
Simple Payback	y	0.

4.9 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 34 Cost benefit analysis

Sl. No.	Replacing present burners with energy efficient burners		Kiln-1		Kiln-2	
	Parameters	**Unit**	**As Is**	**To Be**	**As Is**	**To Be**
1	Production rate of the kiln	kg/hr	92	92	161	161
2	Total number of main burner	Nos.	2.0	2.0	2.0	2.0
3	Total number of auxilary burner	Nos.	4.0	4	4.0	4
4	Total numbers of energy efficient burner required	Nos.	6.0	6.0	6.0	6.0
5	Estimated saving by energy effcient burner	%		5.0		5.0
6	Current fuel firing in kiln	kg/hr	18	17	22	21
7	Savings in fuel per hours	kg/hr		0.89		1.08
7	Number of operating days	days	300	300	300	300
8	Number of operating hours per day	hrs	24	24	24	24
9	Total savings per year into fuel firing	kg/yr		6397		7804
10	Unit cost of fuel	Rs./kg		44.10		44.10
11	Cost savings per year	Lakh Rs./yr		2.82		3.44
12	Estimated investment for all burners	Lakh Rs.		1.5		1.5
13	Payback period	Yr		0.5		0.4

5 ANNEXURE

Participation of the unit in this project

HINDUSTAN CHEMICALS

(AN ISO 9001 : 2000 CERTIFIED FIRM)

POWER GUARANTEED

Factory: NH 91 G.T. Road KHURJA-U.P. 203131 INDIA

Ph. +91-5738-232262, Fax +91-5738-231202

E-mail : chemhind@gmail.com

Dated : 6th April 2015

To
The President
MSME, ceramic cluster
Khurja
Uttar Pradesh

(Sub.: Participation in BEE-UNIDO energy efficiency project in Khurja Ceramic 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 successfuly conduct the comprehensive energy audit at our unit which shall result in identification of energy saving options for our unit

Thanks and Regards

For Hindustan Chemicals

For HINDUSTAN CHEMICALS

6/4/15

(Authorised Signatory)

Authorised Signatory/Proprietor

Kiln efficiency calculations

Input parameters

Parameters	Value		UoM
	Kiln – 1	**Kiln – 2**	
Tunnel Kiln Operating temperature (Firing Zone)	1220	1220	Deg C
Final temperature of material (at outlet of Firing zone)		1000	Deg C
Initial temperature of kiln car	40.2	40.2	Deg C
Avg. fuel Consumption	17.77	21.7	Kg/hr
Flue Gas Details			
Flue gas temp. after APH (in chimney; No APH installed)	248	268	deg C
Preheated air temp./Ambient (it is ambient temperature)	40.2	40.2	deg C
O2 in flue gas	10.9	10.3	%
CO2 in flue gas	10.9	10.3	%
CO in flue gas	91	23	ppm
Atmospheric Air			
Ambient Temp.	40.2	40.2	Deg C
Relative Humidity	45	47	%
Humidity in ambient air	0.03	0.03	kg/kg dry air
Fuel Analysis			
C	77.00	77.00	%
H	12.00	12.00	%
N	0.00	0.00	%
O	11.00	11.00	%
S	0.01	0.01	%
Moisture	0.00	0.00	%
Ash	0.00	0.00	%
Weighted Average GCV of Fuel-mix	10920	10920	kcal/kg
Ash Analysis			
Unburnt in bottom ash	0.00	0.00	%
Unburnt in fly ash	0.00	0.00	%
GCV of bottom ash	0	0	kCal/kg
GCV of fly ash	0	0	kCal/kg
Material and flue gas data			
Weight of Kiln car material (Dead weight of kiln car)	314	289	Kg/Hr
Weight of ceramic material green body) being fired in Kiln	92	161	Kg/Hr
Weight of Stock	92	161	kg/hr
Specific heat of clay material	0.22	0.22	Kcal/kg DegC

Specific heat of kiln car material	0.21	0.22	Kcal/kg DegC
Average specific heat of fuel	0.417	0.417	Kcal/kg DegC
Fuel temperature[3]	40.2	40.2	Deg C
Specific heat of flue gas	0.26	0.26	Kcal/kg DegC
Specific heat of superheated vapour	0.45	0.45	*Kcal/kg DegC*
Heat loss from surfaces of various zone			
Radiation and Convection from preheating zone surface	5467	7852	*kcal/hr*
Radiation and Convection from firing zone surface	8595	11303	*kcal/hr*
Radiation and Convection from cooling zone surface	11123	20912	*kcal/hr*
Heat loss from all zones	25184	40067	*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	1	*Hr*
Area of opening in m2	1	1	*m2*
Coefficient based on profile of kiln opening	0.7	0.7	
Max operating temp. of kiln	343	338	*Deg K*

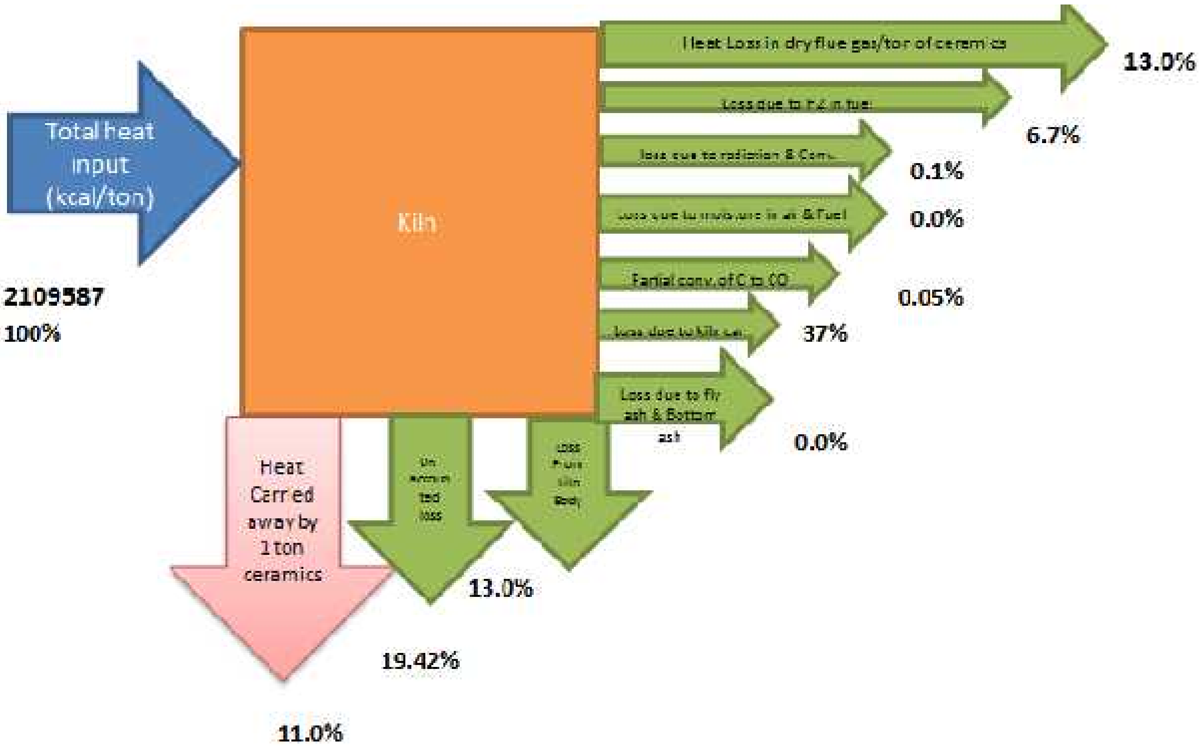
Efficiency calculations

Calculations	Values		UoM
	Kiln - 1	**Kiln - 2**	
Theoretical Air Required	12.63	12.63	*kg/kg of fuel*
Excess Air supplied	107.92	96.26	*%*
Actual Mass of Supplied Air	26.26	24.79	*kg/kg of fuel*
Mass of dry flue gas	26.18	24.71	*kg/kg of fuel*
Amount of Wet flue gas	27.26	25.79	*Kg of flue gas/kg of fuel*
Amount of water vapour in flue gas	1.08	1.08	*Kg of H2O/kg of fuel*
Amount of dry flue gas	26.18	24.71	*kg/kg of fuel*
Specific Fuel consumption	193.19	134.89	*kg of fuel/ton of ceramic material*
Heat Input Calculation			
Total heat input	2109587	1473035	*Kcal/ton of ceramic material*
Heat Output Calculation			
Heat carried away by 1 ton of ceramics (useful heat)	232716	248116	*Kcal/ton of ceramic material*

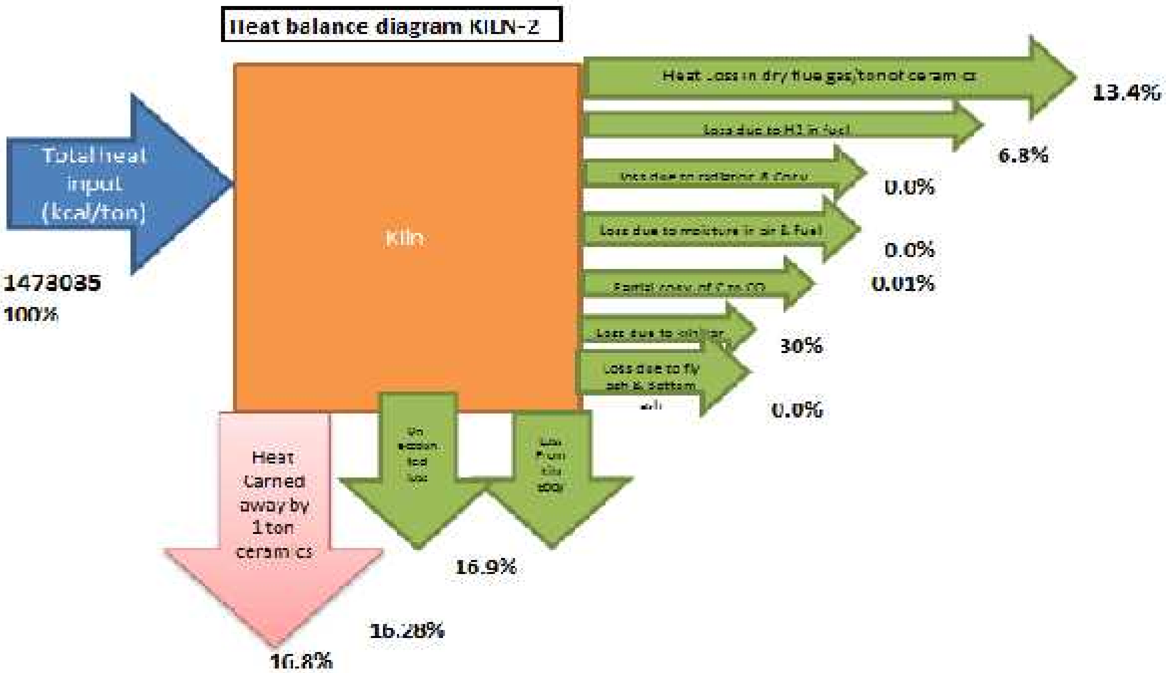
[3] [3] Pre-heating zone is already a waste heat recovery system. 3 nos. of air curtains are present in pre-heating zone which supplies ambient air to prevent thermal shock to ceramic material while it to travel through the pre-heating zone to firing zone. Due to effect of these air curtains which supplies 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 % while at the exit of firing zone it was 12.8 %, 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.

Heat loss in dry flue gas per ton of ceramics	273255	197401	*Kcal/ton of ceramic material*
Loss due to H2 in fuel	141356	100014	*Kcal/ton of ceramic material*
Loss due to moisture in combustion air	74	76	*Kcal/ton of ceramic material*
Loss due to partial conversion of C to CO	980	169	*Kcal/ton of ceramic material*
Loss due to convection and radiation (openings in kiln - inlet & outlet of kiln car)	1,567	729	*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	273793	249324	*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	776252	437382	*Kcal/ton of ceramic material*
Unaccounted heat losses	409594	239823	*Kcal/ton of ceramic material*
Heat loss from Kiln body and ceilings			
Total heat loss from kiln	273793	249324	*Kcal/tons*
Furnace Efficiency	**11.0**	**16.8**	*%*

Sankey diagram kiln-1



Sankey diagram kiln-2



6 LIST OF VENDORS

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

S.No	Name of Company	Address	Phone No.	E-mail
1	Morgan Advanced Materials - Thermal Ceramics	P.O. Box 1570, Dare House Complex, Old No. 234, New No. 2, NSC Bose Rd, Chennai - 600001, INDIA	T 91 44 2530 6888 F 91 44 2534 5985 M 919840334836	munuswamy.kadhirvelu@morganplc.com mmtcl.india@morganplc.com ramaswamy.pondian@morganplc.com
2	M/s LLOYD Insulations (India) Limited,	2,Kalka ji Industrial Area, New Delhi-110019	Phone: +91-11-30882874 / 75 Fax: +91-11-44-30882894 /95 Mr. Rajneesh Phone : 0161-2819388 Mobile : 9417004025	Email: kk.mitra@lloydinsulation.com

EPIA 2: Excess Air Control

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
Automation				
1	Delta Energy Nature Contact Person Gurinder Jeet Singh, Director	F-187, Indl. Area, Phase-VIII-Bm Mohali-160059	Tel.: 0172-4004213/ 3097657/ 2268197 Mobile: 9316523651 9814014144	dengjss@yahoo.com den8353@yahoo.com

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
			9316523651	
2	International Automation Inc Contact Person Sanjeev Sharma)	# 1698, First Floor, Canara Bank Building, Near Cheema Chowk, Link Road, Ludhiana	Office: +91-161-4624392, Mobile: +91-9815600392	Email: interautoinc@yahoo.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 & 5: VFD on pug mill motor

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

Sl. No	Name of Company	Address	Phone No.	E-mail
			power-technical)-9818899637,9810028865(Mr.Ajit),8510999637(Mr.Avinash Vigh)	m, rajesh.bhalla@lntebg.com ,ajeet.singh@lntebg.com

EPIA 6 & 7: LED & Energy efficient light

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Syska LED Contact Person: Mr. Charan Singh	Shree Sant Kripa Appliances Pvt. Ltd. Dhole Patil Road, Pune	+91 8909758586 +91 20 40131000	info@sskgroup.in
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@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.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 9: 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 10: Energy Efficient Burner

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