COMPREHENSIVE ENERGY AUDIT REPORT

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

R K Potteries

Junction Road, Khurja

14-04-2015

Submitted to

BUREAU OF ENERGY EFFICIENCY

4th Floor, Sewa Bhawan, R K Puram, Sector-I, New Delhi -110066

Submitted by

DEVELOPMENT ENVIRONERGY SERVICES LTD

819, Antriksh Bhawan, 22 Kasturba Gandhi Marg, New Delhi -110001

Tel.: +91 11 4079 1100 Fax : +91 11 4079 1101; www.deslenergy.com

DISCLAIMER

ACKNOWLEDGEMENT

DESL places on record its sincere thanks to Global Environment Facility (GEF), United Nations Industrial Development Organization (UNIDO) and Bureau of Energy Efficiency (BEE) for vesting confidence in DESL to carry out the assignment “Conducting energy audit and dissemination programs in MSME clusters” under their national project *“promoting energy efficiency and renewable energy in selected MSME clusters in India”.*

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. Shalabh Singhania, Managing Director, for showing keen interest in the energy audit and also thankful to the progressive management of M/SR K Potteries 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.

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DESL Team

DESL Team

Project Head	**Mr. R. Rajmohan** Chief Executive Officer
Team leader and co-coordinator	**Mr. Suparno R Majumdar** Consultant
Team member(s)	**Mr. Mithlesh Priya** Analyst
	Mr. Prabhat Sharma Project Analyst
	Mr. Oisik Mishra Project Associate
	Mr. Vishnu P Project Associate

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ABBREVIATIONS

Abbreviations	Expansions
APFC	Automatic Power Factor Correction
BEE	Bureau of Energy Efficiency
CEA	Comprehensive Energy Audit
DESL	Development Environergy Services Limited
DG	Diesel Generator
EE	Energy Efficiency
EPIA	Energy Performance Improvement Action
GEF	Global Environment Facility
HSD	High Speed Diesel
HVAC	Heating Ventilation and Air Conditioning
KPMA	Khurja Pottery Manufacturers Association
LED	Light Emitting Diode
LT	Low Tension
MD	Maximum Demand
MSME	Micro, Small and Medium Enterprises
MT	Metric Tons
MTOE	Million Tons of Oil Equivalent
PF	Power Factor
PNG	Piped Natural Gas
PVVNL	Paschimanchal Vidyut Vitran Nigam Limited
R & C	Radiation & Convection
RE	Renewable Energy
SEC	Specific Energy Consumption
SEGR	Specific Energy Generation Ratio
SLD	Single Line Diagram
SME	Small and Medium Enterprises
UNIDO	United Nations Industrial Development Organization
VFD	Variable Frequency Drives

EXECUTIVE SUMMARY

Bureau of Energy Efficiency (BEE) in association with the United Nations Industrial Development Organization (UNIDO) and Global Environment Facility (GEF) is implementing a project titled "Promoting energy efficiency and renewable energy technology in selected MSME clusters in India". The objective of the project is to provide impetus to energy efficiency initiatives in the small and medium enterprises (SMEs) sector in India.

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

The project awarded to DESL consists of four major tasks:

1) Conducting pre-activity cluster-level workshops
2) Conducting comprehensive energy audit (CEA) at 6 units selected by the cluster association – Khurja Pottery Manufacturers Association (KPMA)
3) Submission of reports – comprehensive energy audit, cluster level best operating practices for 5 major energy consuming equipments / processes, list of common regularly monitorable parameters for measurement of major energy consuming parameters, list of energy audit equipments
4) Conducting three cluster level post audit training workshops

Brief Introduction of the Unit

Table 1: Details of Unit

Name of the Unit	M/s R K Potteries
Constitution	Private Limited
MSME Classification	Small
No. of years in operation	22 (Since 1993)
Address: Registered Office:	Junction road, Khurja – 203131
Administrative Office	Junction road, Khurja – 203131
Factory :	Junction road, Khurja – 203131
Industry-sector	Ceramics
Products Manufactured	Kitchen wares
Name(s) of the Promoters / Directors	Mr. Shalabh Singhania

Comprehensive Energy Audit

The study was conducted in 3 stages:

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

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

The production process of the unit

The main process equipment in the unit includes the following:

- The main energy consuming equipment is kiln in which the fuel used is diesel blend The temperature maintained in kiln is approximately 1120 – 1150℃ (in firing zone).
- There are other equipments, viz. ball mills, filter presses, pug mills, jigger jollies which also contribute to the production process and consume electrical energy.
- The raw material used is a mixture of clay, feldspar and quartz which is mixed along with water to form a slurry. The water and air are removed from this slurry in various process machines and the material is given required shape 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 kiln include proper insulation to reduce radiation and convection heat loss from surface, excess air control and replacement of kiln car material. VFD application is recommended in the pug mill to control its speed. It is also proposed to implement energy efficient fans for cooling and drying of moulds and energy efficient LED lights in place of conventional tube lights. Other EE measures proposed were power factor improvement, reduction in frequency of power generated by DG sets and installing energy monitoring system. The details of energy improvement actions are given in Table – 2.

Table 2 Summary of EPIA

Sl. No.	Name of the project	Estimated energy saving						
		Diesel Blend[1]	Electricity	HSD	Material savings	Monetary savings	Estimated investment	Simple payback period
		Liter/y	kWh/y	Liter/y	Rs/y	Rs. lakh/y	Rs. lakh	y
1	Heat loss reduction due to Radiation & Convection from the kiln body (surface)	3121.5				1.2	0.42	0.3
2	Excess-Air control in the kiln	20400	1817.1			8.2	7.00	0.9
3	Installation of energy efficient fan instead of conventional fan		11340.0			1.0	1.80	1.9
4	Installation of LED fixture instead of T12 tube light system		15177.6			1.3	0.47	0.4
5	VFD installation on PUG mill		1520.9			0.1	0.30	2.3
6	DG frequency optimization			134.4		0.1	0.05	0.7
7	Energy monitoring system	5400.0	7503.1	225.4		2.9	0.60	0.2
8	Power factor improvement		0		0.95	0.9	0.50	0.5
9	Increasing Contract demand				0.54	0.54	0.00	0.0
10	Replacement of present kiln car with energy efficient kiln car (lighter in weight and better material; lower heat absorption)	19890.5				7.8	4.80	0.6
11	Speed optimization and EE drive system installation on Ball mill-1(11.2 kW)		5359			0.5	0.70	1.5
12	Replacement of present burner with energy efficient burner	9000.0				3.5	0.73	0.2
	Total	**57812.0**	**42717.3**	**359.9**	**1.5**	**28.0**	**17.4**	**0.6**

The implementation of above suggested projects in the unit may result in energy savings of up to 29.58 % and energy cost savings of Rs. 28.0 Lakh/y.

[1] Blend of diesel and Rubber Oil (RbO)

1 INTRODUCTION

1.1 Background and Project objective

Bureau of Energy Efficiency (BEE) in association with the United Nations Industrial Development Organization (UNIDO) and Global Environment Facility (GEF) is implementing a project titled "Promoting energy efficiency and renewable energy technology in selected MSME clusters in India". The objective of the project is to provide impetus to energy efficiency initiatives in the small and medium enterprises (SMEs) sector in India.

The targeted 12 MSME clusters under the project and the indicative information are given below:

Table 3: List of 12 targeted MSME clusters covered under the project

Sl. No.	Sub – sector	Cluster
1	Brass	Jagadhri, Jamnagar
2	Ceramic	Khurja, Morbi, Thangarh
3	Dairy	Gujarat, Madhya Pradesh
4	Foundry	Belgaum, Coimbatore, Indore
5	Hand tools	Jalandhar, Nagaur

The objectives of this project are as under:

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

1.2 Scope of work for Comprehensive Energy Audit

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

- Data Collection
    - Current energy usage (month wise) for all forms of energy for the last 12-24 months (quantity and cost)
    - Data on production for corresponding period (quantity and cost).
    - Data on production cost and sales for the corresponding period (cost)
    - Mapping of process
    - Company profile including name of company, constitution, promoters, years in operation and products manufactured, turnover and net profit during each of the preceding three years
    - Existing manpower and levels of expertise
    - List of major equipments and specifications

    - Data required for preliminary environmental and social screening
- Analysis :
    - Energy cost and trend analysis
    - Energy quantities and trend analysis
    - Specific consumption and trend analysis
    - Scope and potential for improvement in energy efficiency
- Detailed process mapping to identify major areas of energy use.
- To identify all areas for energy saving in the following areas:
    - Electrical: Power factor 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.
    - Water usage and pumping efficiencies (including water receipt, storage, distribution, utilization, etc.), pump specifications, break-down maintenance.
- Evaluate the energy consumption vis-à-vis the production levels and to identify the potential for energy savings/energy optimization (both short term requiring minor investments with attractive payback, and mid to long terms system improvement areas needing moderate investments and with payback of 2.3 years).
- Classify parameters related to EE Enhancements such as estimated quantum of energy savings, investment required, time frame for implementation, payback period, re-skilling of existing man power, etc. and to classify the same in order of priority.
- Identify obvious and essential environmental and social improvement enhancement measures as part of overall implementation of EE Measures and integrate as part of investment proposals.
- Design and "energy monitoring system" for effective monitoring and analysis of energy consumption, energy efficiency.

1.3 Methodology

1.3.1 Boundary parameters

Following boundary parameters were set on coverage of the audit:

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

1.3.2 General methodology

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

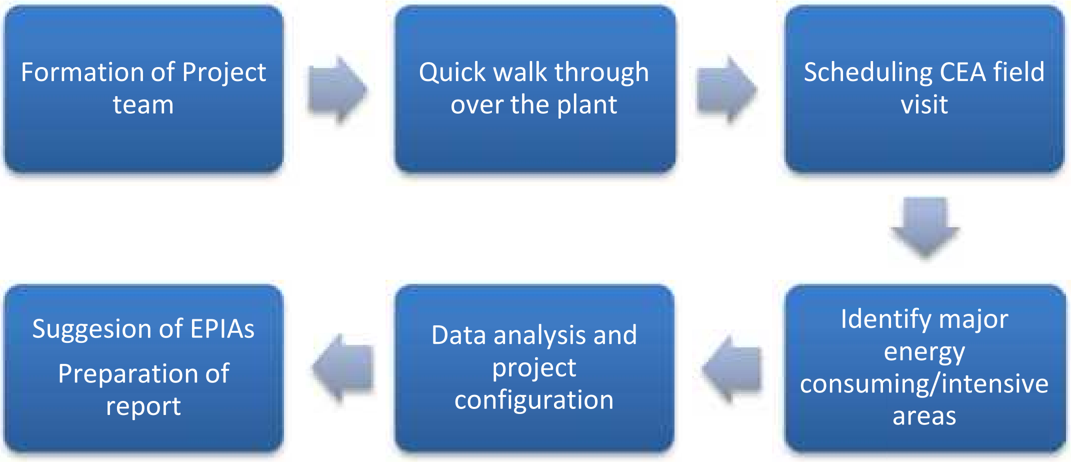


Figure 1: General methodology

The study was conducted in 3 stages:

- **Stage 1:** Walk through energy audit of the plant to understand the process, energy drivers, assessment of the measurement system, assessment of scope, measurability, formulation of audit plan and obtaining required information
- **Stage 2:** Detailed energy audit-testing & measurement for identification of saving potential, technology assessment and understanding of project constraints
- **Stage 3**: Data analysis, initial configuration of projects, savings quantification, vendor consultation, interaction with the unit and freezing of projects for implementation and preparation of energy audit report

1.3.3 Comprehensive energy audit – field assessment

A quick walk through was carried out on 14th April, 2015 before the start of audit with a view to:

- Understand the manufacturing process and collect historical energy consumption data
- Obtaining cost and other operational data with a view to understand the impact of energy cost on the units financial performance
- Assess the energy conservation potential at a macro level
- Finalize the schedule of equipment's and systems for testing and measurement

The audit identified the following potential areas of study:

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

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

- Preparation of the process & energy flow diagrams

- Study of the system & associated equipments
- Conducting field testing & measurement
- Data analysis for preliminary estimation of savings potential at site
- Discussion with the unit on the summary of findings and energy efficiency measures identified

Audit methodology involved system study to identify the energy losses (thermal/ electrical) and then finding solutions to minimize the same. This entailed data collection, measurements/ testing of the system using calibrated, portable instruments analyzing the data/ test results and identifying the approach to improve 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	Raytek	Minitemp	Distant Surface Temperature

Sl. No.	Instruments	Make	Model	Parameters Measured
	Temperature Gun			
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 R K Potteries
2	Constitution	Private
3	Date of incorporation / commencement of business	1993
4	Name of the contact person Designation Mobile/Phone No. E-mail ID	Mr. Shalabh Singhania Managing Director +91 9897178122 singhania_shalabh@yahoo.co.in
5	Address of the unit	Near Shivam technical campus, Junction road, Khurja – 203131
6	Industry / sector	Ceramic
7	Products manufactured	Crockery
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)	Yes
12	No. of employees	25

3 DETAILED TECHNICAL FEASIBILITY ASSESSMENT OF THE UNIT

3.1 Description of manufacturing process

3.1.1 Process & Energy flow diagram

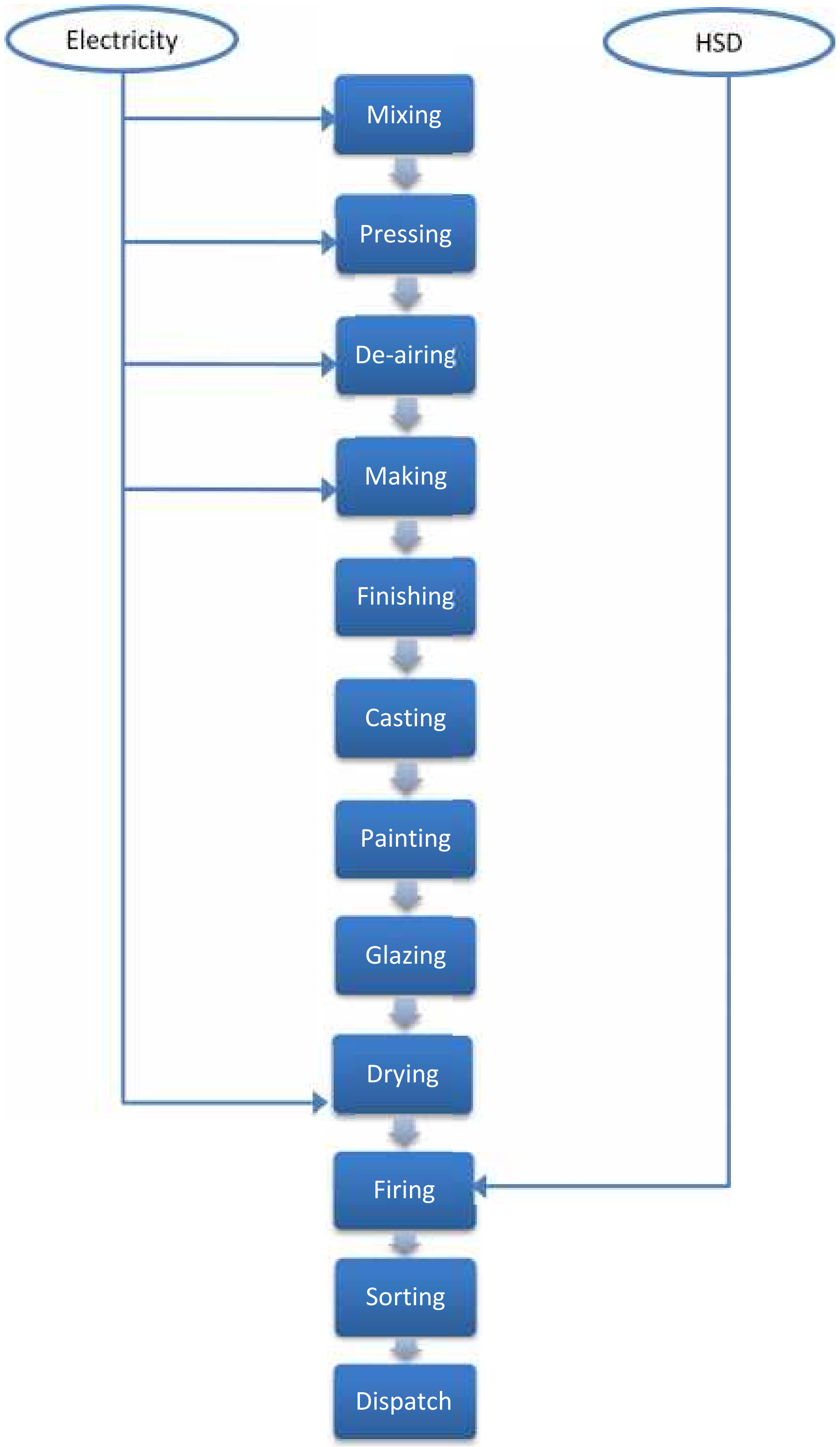


Figure 2: Process flow diagram

3.1.2 Process description

M/s R K Potteries is a manufacturer of ceramic kitchenwares like cup and saucer, milk mugs, etc. The process description is as follows:

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

3.2 Description of manufacturing process

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

3.3 Types of energy used and description of usage pattern

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

- Electricity is being sought from two different sources:
  - From the Utility, PVVNL (Paschimanchal Vidyut Vitran Nigam Limited)
  - Captive backup diesel generator (DG) 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

Particular	Energy cost distribution		Energy use distribution	
	Rs. In Lakhs	% of total	MTOE	% of total
Grid – Electricity	19.11	20	21.5	10.85
HSD– DG	4.06	4	7.4	3.71
Thermal – Diesel Blend	70.74	76	177.6	86.02
Total	**93.91**	**100**	**206.5**	**100**

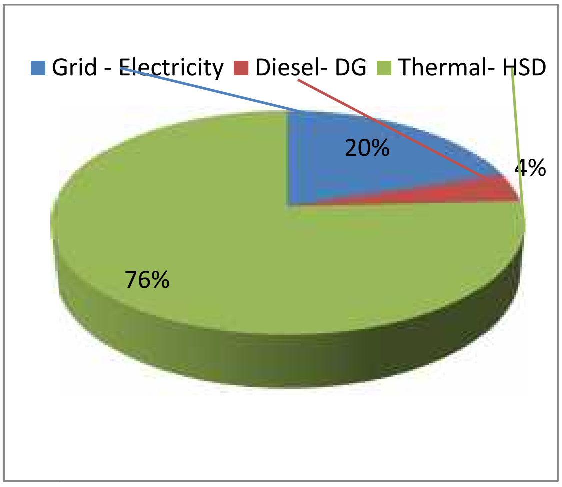


Figure 3: Energy cost share (Rs. Lakh)

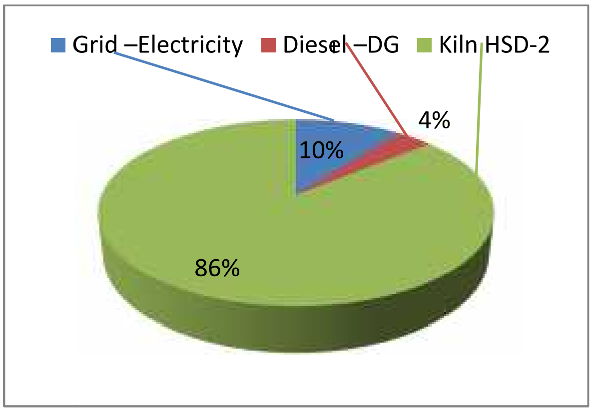


Figure 4: Energy use share (MTOE)

Major observations are as under:

- The unit uses both thermal and electrical energy for manufacturing operations. Electricity is sourced from the grid and self generated by a DG set when power from grid is not available. Thermal energy consumption is in the form of HSD, which is used for firing in the kiln.
- Diesel blend used in kilns account for 76% of the total energy cost. HSD used in DG sets account for 4% of total energy cost and electricity used in plant process account for 20% of total energy cost.
- Diesel blend used in kilns account for 86% of overall energy consumption. HSD used in DG sets account for 4% of overall energy consumption and electricity used in plant account for10% 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 after implementation of the projects. The rates shown are the landed rates.

Table 7: Baseline parameters

Electricity Rate (Excluding Rs./kVA)	7.24	Rs./ KVAH inclusive of taxes
Weighted Average Electricity Cost	8.47	Rs./ kWh for 2014-15
Percentage of total DG based Generation	9%	
Average Cost of Diesel blend	39.30	Rs./litre
Annual Operating Days per year	300	Days/yr
Annual Operating Hours per day	24	Hr/day
Production	1224	MT
GCV of Diesel blend	10661	kCal/ litre
Density of Diesel Blend	0.88	kg/litre

3.4.2 Electricity load profile

Following observation has been made from the utility inventory:

- The plant and machinery load is 84.7 kW
- The utility load (fans & lighting) is about 6 kW including the single phase load
- The plant total connected load is 90.625 kW

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

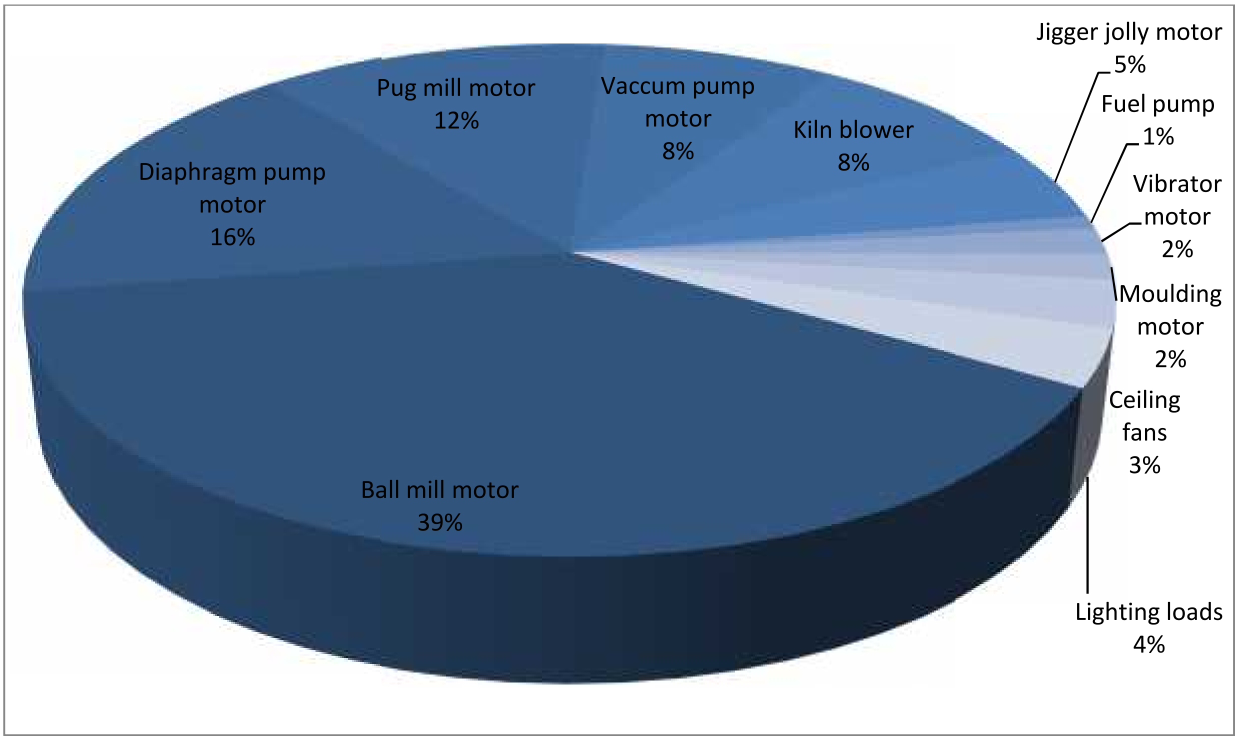


Figure 5: Details of connected load

As shown in the pie chart of connected load, the maximum share of connected load is for the ball mill – 39%, diaphragm pump – 16%, pug mill – 12%, vacuum pump and kiln blower of 8% each. Other plant and machinery including jigger jolly motor – 5%, vibrator motor and moulding motor – 2% each, fuel pump – 1%, fans – 3% and lighting and HVAC loads accounts for 4% of the connected load.

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

Table 8: Area wise electricity consumption (estimated)

Consumption	kW	kWh/y	% of Total
Ball mill motor	28.3	102052.8	37.5%
Diaphragm pump motor	11.9	28646.4	10.5%
Pug mill motor	9.0	32227.2	11.8%
Vacuum pump motor	7.5	26856	9.9%
Kiln blower	7.5	32227.2	11.8%
Jigger jolly motor	4.5	10742.4	3.9%
Fuel pump	0.7	2148.48	0.8%
Vibrator motor	1.5	3580.8	1.3%
Molding motor	1.5	1342.8	0.5%
Ceiling fans	2.7	14742	5.4%
Lighting loads	3.2	17409.6	6.4%
Total	**78.3**	**271975.7**	**100**

This is represented graphically in the figure below:

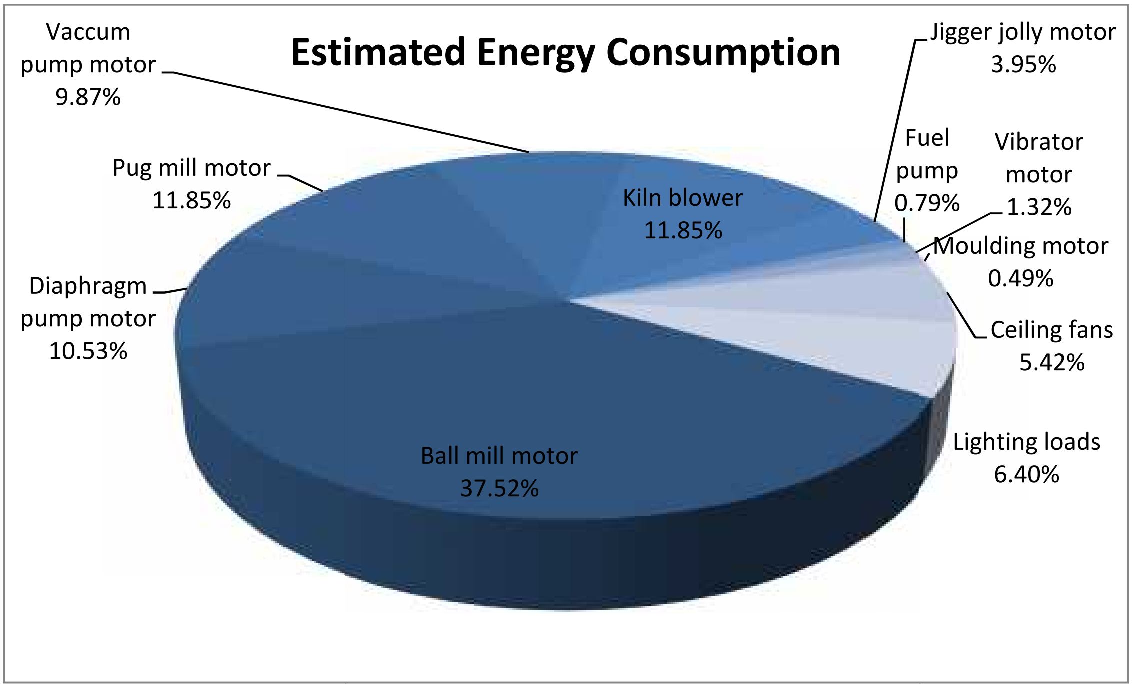


Figure 6: Area wise electricity consumption

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 (Paschimanchal Vidhut Vitran Nigam Limited) through regulated tariff
- Captive DG set which is used as a backup source and supplies electrical power in case of grid power failure

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

Table 9 Electricity share from grid and DG

	Consumption (kWh)	%	Cost (Lakh Rs.)	%
Grid Electricity	250,101.82	91%	19.1	82%
Self Generation	25,058	9%	4.1	18%
Total	275,159.51	100%	23.2	100%

This is graphically depicted as follows:

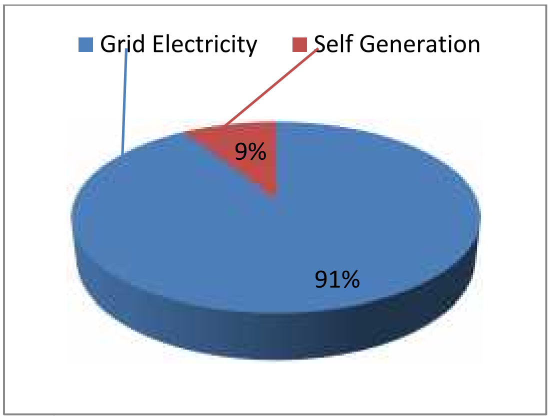


Figure 7: Share of electricity by source

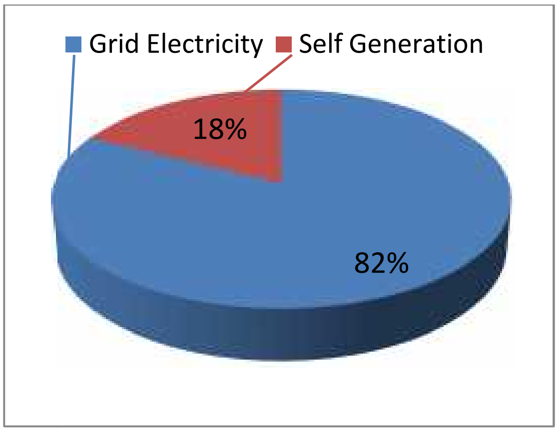


Figure 8: Share of electricity by cost

The share of electrical power as shown in the above chart indicates the condition of power supply from the utility. The requirement of power supply from backup source, i.e. DG set is about 9% of the total power which is not very high. Although the share of DG power in term of kWh is just 9% of the total electrical power, but it accounts for about 18% in term of total cost of electrical power. It indicates the high cost of DG power due to rise in the price of HSD. For economical operation, the utilization of DG set needs to be minimized, but it will depend upon the supply condition of the grid as well as job requirement of the plant.

3.4.4 Supply from utility

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

a)	Meter K No.	:	UMV69210
b)	Power Supply	:	0.42 kV line
c)	Contract Demand	:	48 kVA
d)	Sanctioned Load	:	NA
e)	Nature of Industry	:	LT – G

The tariff structure is as follows:

Table 10: Tariff structure

Particulars	Tariff structure	
Energy Charges	5.73	Rs./kVAh
Regulatory	3.82	Rs./kVA
Fuel Surcharge	0.00	Rs./kVAh
Electricity duty	2.10	Rs./kVAh
Municipality tax	0.00	Rs./kVAh

(As per bill for February – 15)

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	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.
14-Apr	48	65	54	0.90	17536	6686	9148	3682	19516	105661	13203	6966	0	8915	2802	137547
14-May	48	54	60	0.88	11744	4288	5590	2314	12192	65975	10854	2268	0	5762	8	84866
14-Jun	48	60	70	0.97	18836	6882	8652	3318	18852	101701	12110	4779	1981	8536	0	129106
14-Jul	48	70	116	0.94	26944	9864	13176	5516	28556	154675	14135	8829	4794	12661	107	195201
14-Aug	48	71	71	0.95	25016	8928	12348	5060	26336	142697	14337	9234	4460	11778	45609	228114
14-Sep	48	71	76	0.96	17188	6400	7848	3728	17976	97498	14337	9234	3176	8388	167	132800
14-Oct	48	76	78	0.93	20952	7300	11392	3808	22500	130571	15471	11502	6162	10953	-99509	75149
14-Nov	48	78	73	0.93	20824	7480	10116	4784	22380	136079	15795	12150	7928	11391	0	183343
14-Dec	48	73	72	0.95	32168	11360	15240	7160	33760	207366	14742	10044	11594	16658	0	260404
15-Jan	48	72	74	0.97	16216	5632	7760	3336	16728	102250	14661	9882	6103	8768	0	141664
15-Feb	48	74	74	0.97	21836	7904	9852	4816	22572	138330	15066	10692	8007	11505	0	183600
15-Mar	48	69	74	0.94	20842	7520	10102	4320	21943	125709	14065	8689	4928	10483	-4620	159254
Max	48	78	116	1.00	32168	11360	15240	7160	33760	207366	15795	12150	11594	16658	45609	260404
Min	48	54	54	0.90	11744	4288	5590	2314	12192	65975	10854	2268	0	5762	-99509	75149
Avg	48	70	74	0.90	20842	7520	10102	4320	21943	125709	14065	8689	4928	10483	-4620	159254
Total					250102	90244	121224	51842	263311	1508513	168775	104269	59132	125797	-55436	1911049

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

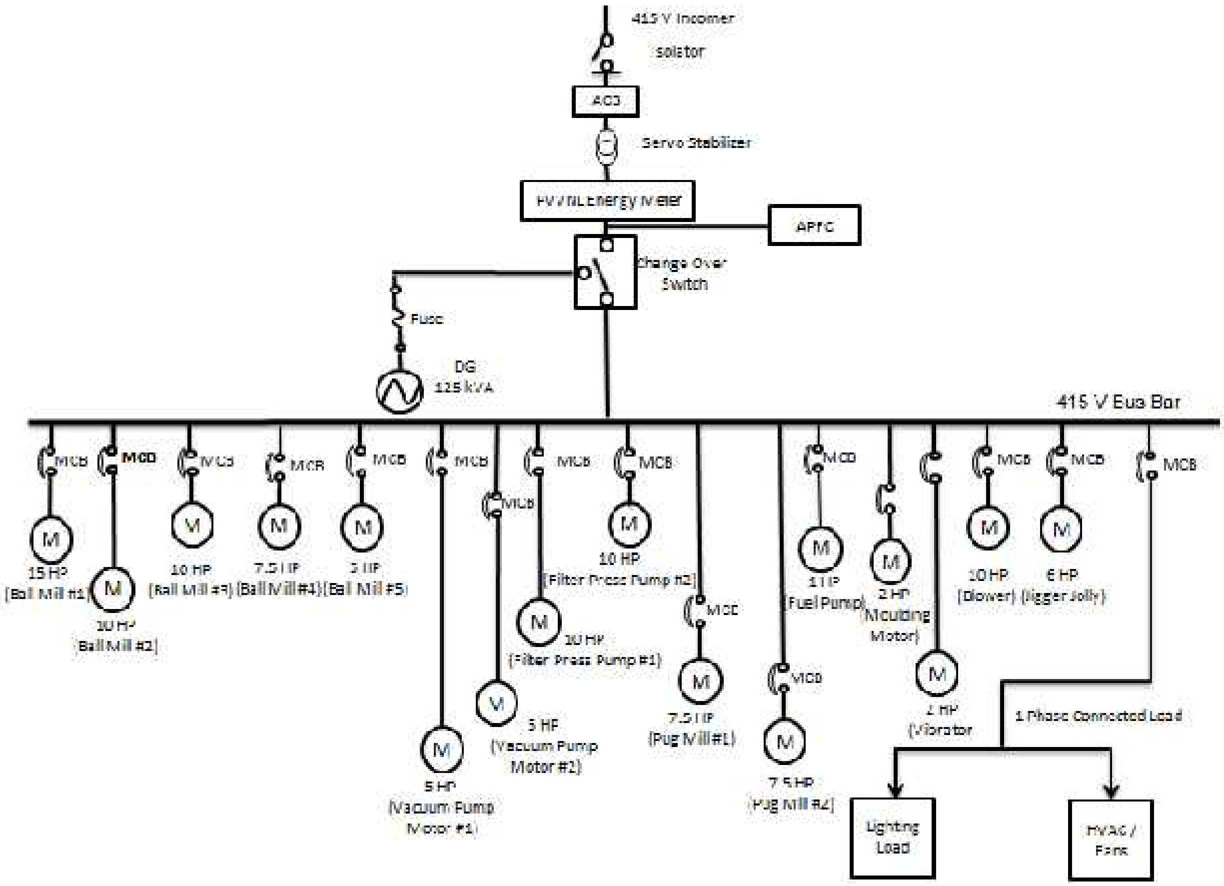


Figure 9: SLD of electrical load

Power factor

The utility bills of the unit reflect the power factor, however, the study was done by logging of the main incomer. The power factor was found to be 0.90.

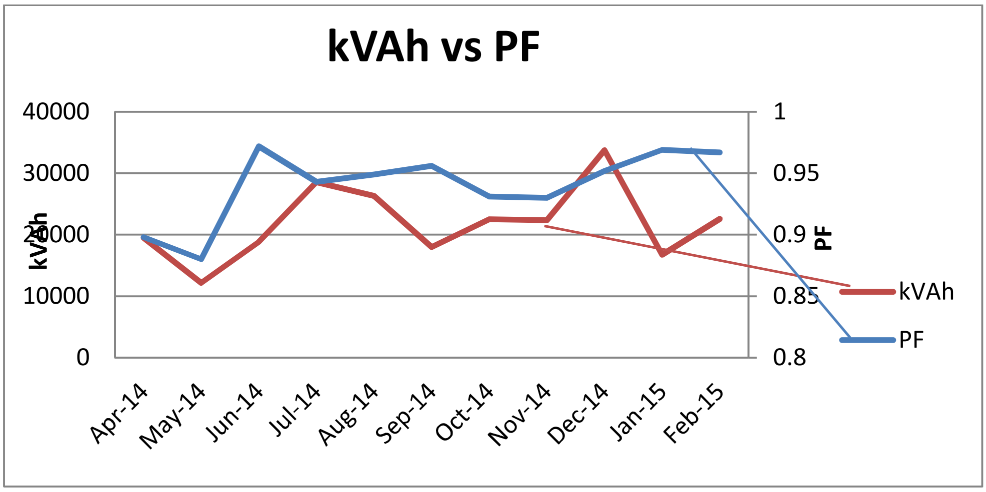


Figure 10: Monthly trend of PF

Maximum demand

Maximum demand as reflected in the utility bill is 74.3 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 consumption and fuel usage in DG. HSD purchase records are, however, maintained by the unit. IN order to find the month wise energy contribution by the DG set, the results of performance testing of the DG set, carried out during the detailed energy audit was used.

Performance testing was done of the 125 kVA DG set and the specific energy generation ratio (SEGR) was calculated as 3 kWh/litre. HSD consumption by DG set is 14,400 litres annually costing Rs. 4.06 lakh with a power generation of 25,058 kWh.

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

3.4.6 Month wise electricity consumption

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

Table 11: Electricity consumption & cost

Months	Electricity Used (kWh)			Electricity Cost, Rs.		
	Grid	DG	Total	Grid	DG	Total
	kWh	kWh	kWh	Rs	Rs.	Rs.
Apr-14	17,536	2,088	19,624	137,547	33,813	171,360
May-14	11,744	2,088	13,832	84,866	33,813	118,679
Jun-14	18,836	2,088	20,924	129,106	33,813	162,919
Jul-14	26,944	2,088	29,032	195,201	33,813	229,013
Aug-14	25,016	2,088	27,104	228,114	33,813	261,927
Sep-14	17,188	2,088	19,276	132,800	33,813	166,613
Oct-14	20,952	2,088	23,040	75,149	33,813	108,962
Nov-14	20,824	2,088	22,912	183,343	33,813	217,155
Dec-14	32,168	2,088	34,256	260,404	33,813	294,217
Jan-15	16,216	2,088	18,304	141,664	33,813	175,477
Feb-15	21,836	2,088	23,924	183,600	33,813	217,413
Mar-15	20,842	2,088	22,930	159,254	33,813	193,067
Total	**250,102**	**25,058**	**275,160**	**1,911,049**	**405,753**	**2,316,802**

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

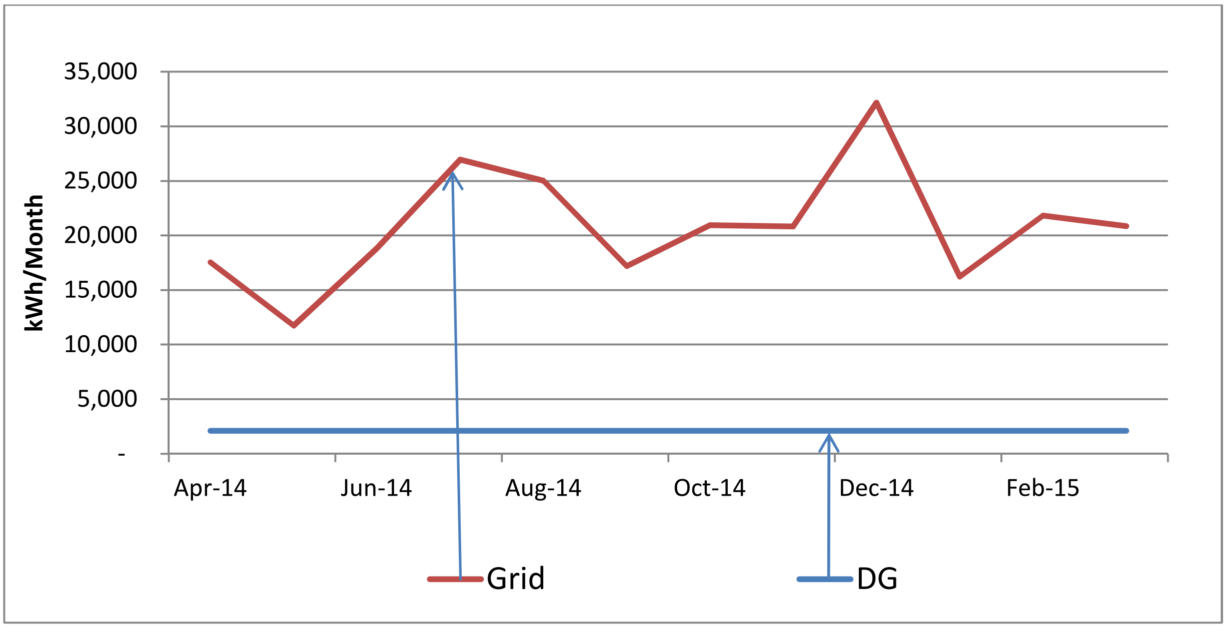


Figure 11: Month wise variation in electricity consumption from different sources

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

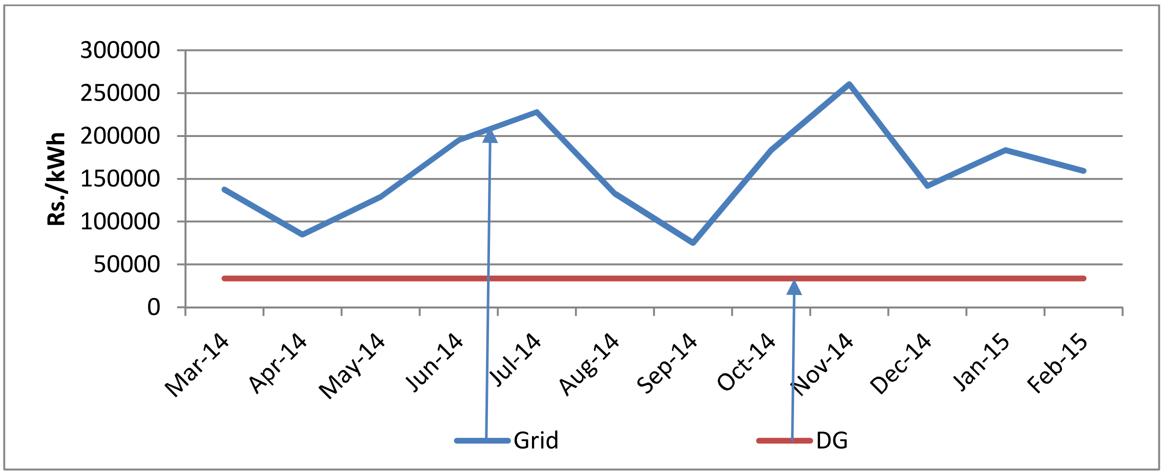


Figure 12: Month wise variation in electricity cost from different sources

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

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

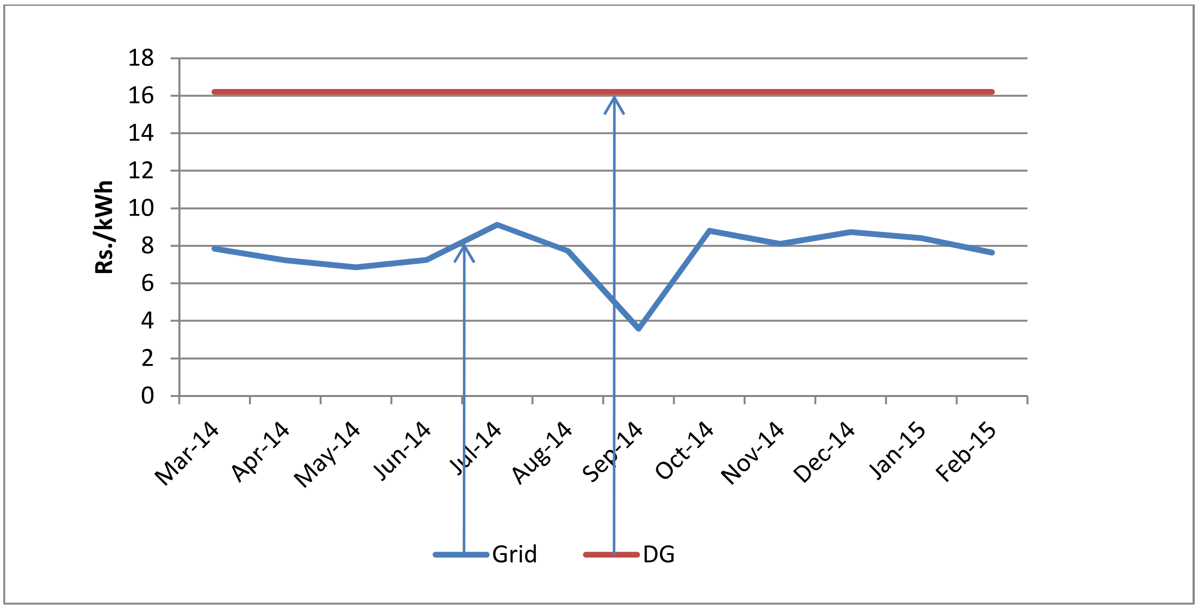


Figure 13 Average cost of power (Rs./kWh) from different sources

The above graph it clearly indicates that the cost of electrical energy from DG set is very high, which is nearly 3 times the cost of utility power.

3.5 Analysis of thermal consumption by the unit

Diesel blend is used as the fuel for firing of the ceramic materials. Diesel blend is procured from local suppliers and the average landed rate is Rs. 39.30/liter. There is no meter installed for the measurement of fuel consumption for kiln. Diesel blend consumption by kilns is 15,000 liters monthly costing Rs. 5.90 lakh.

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

3.6 Specific energy consumption

Production data was available from the unit in metric tons (MT). Based on the available information, various specific energy consumption parameters have been estimated as shown in the following table:

Table 12: Overall specific energy consumption

Parameters	Value	UoM
Annual Grid Electricity Consumption	250,102	kWh
Annual DG Generation Unit	25,058	kWh
Annual Total Electricity Consumption	275,160	kWh
HSD Consumption for Electricity Generation	7514	Litres
Annual fuel consumption in kiln (Diesel blend)	180,000	Litres
Annual Energy Consumption; MTOE	198	MTOE

Annual Energy Cost	93.91	Rs.lakh
Annual Production	1234	MT
SEC; Electricity from Grid	223	kWh/MT
SEC; Thermal	146	Litre/MT
SEC; Overall	0.161	MTOE/MT
SEC; Cost Based	7608	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 oil equivalent : 10000 kCal
- GCV of Diesel blend : 11840 kCal/ kg
- Density of diesel blend : 0.8263 kg/litre
- CO_2 Conversion factor
  - Grid : 0.89 kg/kWh
  - HSD : 3.07 tons/ ton

3.7 Identified energy conservation measures in the plant

Diagnostic Study

A detailed study was made during CEA in the unit and some observations were made along with a few ideas of EPIAs for the same. Summary of key observations is as follows:

3.7.1 Electricity Supply from Grid

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

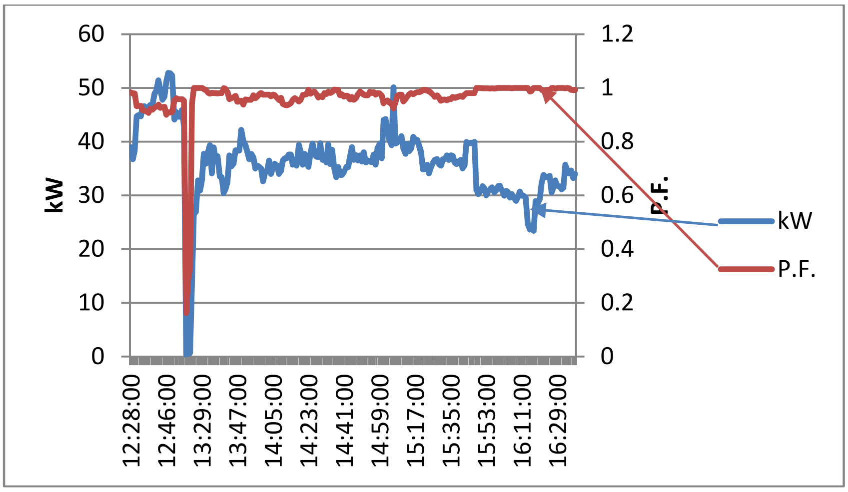


Figure 14: Load profile and power factor

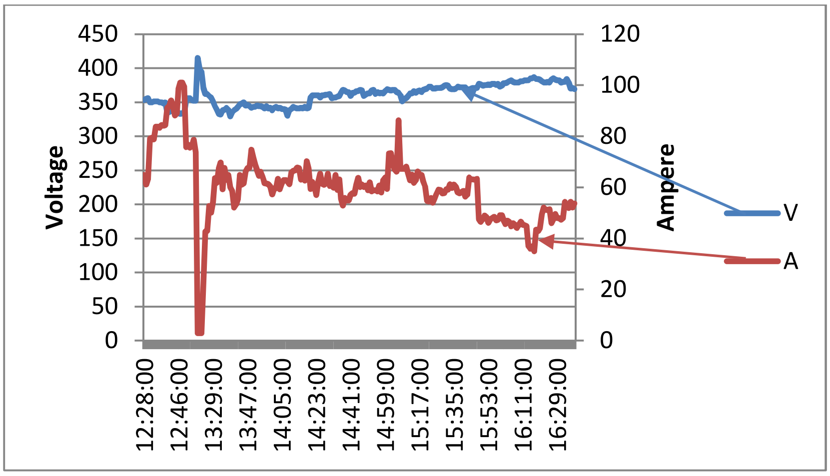


Figure 15: Voltage & current profile

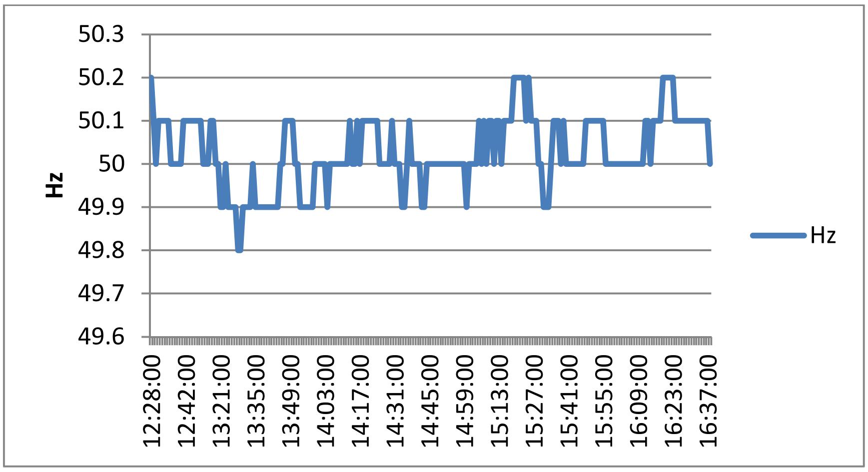


Figure 16: Harmonic Profile

Table 13: Diagnosis of electric supply

Name of Area	Present Set-up	Observations during field Study & measurements	Ideas for energy performance improvement actions
Electricity Demand	The power is fed to this unit by PVVNL through a common distribution transformer. The unit has a LT connection. The contract demand of the unit is 48 kVA.	The maximum kW recorded during study period was 52.8 kW. As per utility bill; the MD was 115.6 KVA.	Increasing contract demand has been suggested.

Power Factor	Unit has an LT connection and billing is in kVAh. The utility bills do not reflect the PF of the unit. The unit has installed capacitors on the mains to maintain PF.	The average PF found during the measurement was 0.9. And, it varied between 0.9 and 1.00.	No EPIA's were recommended.
Voltage variation	The unit has Servo stabilizers for voltage regulation.	The voltage profile of the unit was satisfactory and average voltage measured was 361 V. Maximum voltage was 415 V and minimum was 329 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 to the unit.

3.7.2 DG Performance

The unit has one DG set of 125 kVA. Performance testing was done for the DG set during the detailed energy audit. As part of the performance testing, measurements were conducted on the DG set by keeping track of the HSD consumed (by measuring the top up to the diesel tank) and recording of kWh generated in the same period. The key performance indicators of the DG sets are evaluated as follows:

Table 14: Analysis of DG set

Particulars	DG
Rated KVA	125
Specific Energy Generation Ratio (kWh/Litre)	3.33

The observations made are as under.

- The SEGR of DG set is 3.33 kWh/litre
- The power factor is 0.77.
- The present average frequency of the DG set is 50.1 Hz

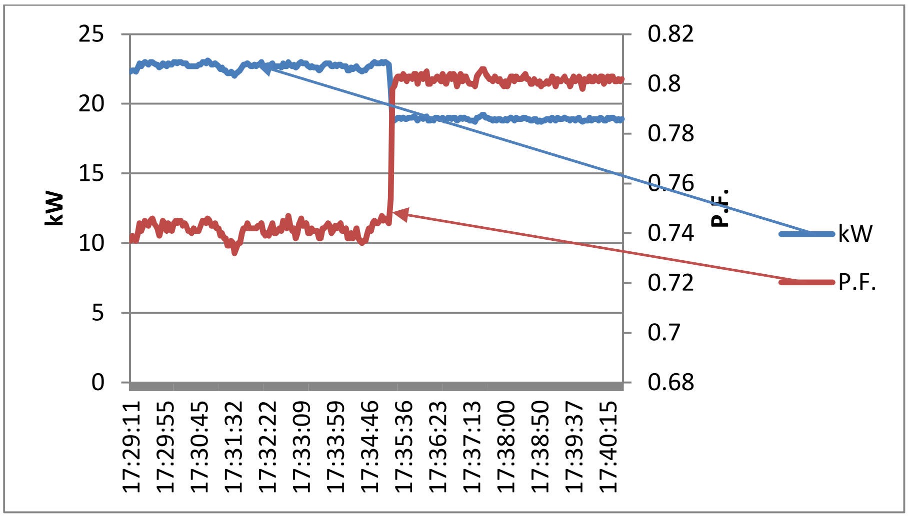


Figure 17: Load profile and power factor of DG set

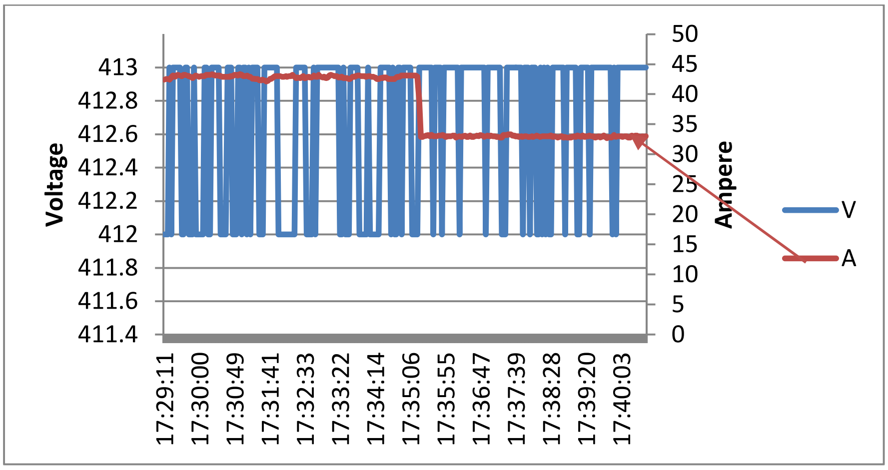


Figure 18: Voltage and current profile of DG set

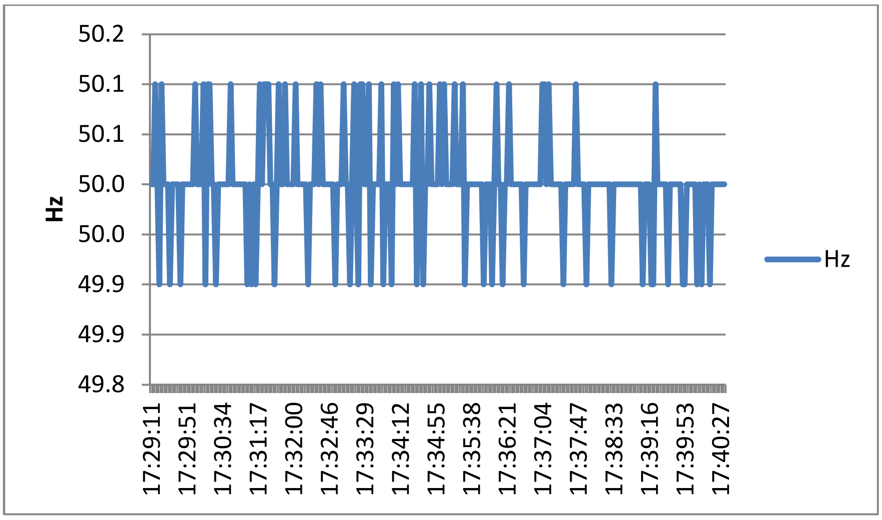


Figure 19: Harmonic profile of DG set

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

3.7.3 Electrical consumption areas

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

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

<table>
<tr><th>Name of Area</th><th>Present Set-up</th><th>Observations during field Study & measurements</th><th>Proposed Energy performance improvement actions</th></tr>
<tr><td>Ball mill</td><td>There are 5ball mills in the unit connected to each of 15 HP, 2x10 HP, 5 HP and 7.5 HP motors respectively. Ball mills account for an estimated 37.65% of overall energy consumption.</td><td>Out of the 5 ball mills 2 were operational during CEA and were studied.

The results of the study are as below:
<table><tr><td>Machine</td><td>Avg. kW</td><td>Avg. PF</td></tr><tr><td>Ball Mill</td><td>5</td><td>0.96</td></tr><tr><td>Ball Mill (small)</td><td>1.17</td><td>0.31</td></tr></table></td><td>Energy efficient drive system has been suggested since the loading of motor changes with the change in load and requirement of final product.</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 having capacity of 10 HP. The diaphragm pumps account for an estimated 16% of overall electrical energy.</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><tr><td>Diaphragm pump</td><td>1.95</td><td>0.99</td></tr></table></td><td>Due to nature of operation, no EPIA suggested.</td></tr>
<tr><td>Pug mill</td><td>There are 2 pug mills installed in the unit, out of which only one could be studied during CEA. This section accounts for about 12% of total energy consumption.</td><td>Only one pug mill was operationl during the time of CEA. Data logging was carried out on the machine to establish the power profile.

The results of the study are as below:
<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr></table></td><td>Application of VFD has been suggested as an EPIA based on the loading and unloading operation power consumption.</td></tr>
</table>

<table>
<tr><td></td><td></td><td><table><tr><td>Pug mill</td><td>1.26</td><td>0.27</td></tr></table></td><td></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 machines 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>5.73</td><td>0.788</td></tr></table></td><td>Excess air control by PID controller has been suggested as EPIA.</td></tr>
</table>

3.7.4 Thermal consumption areas

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

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

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

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

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

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

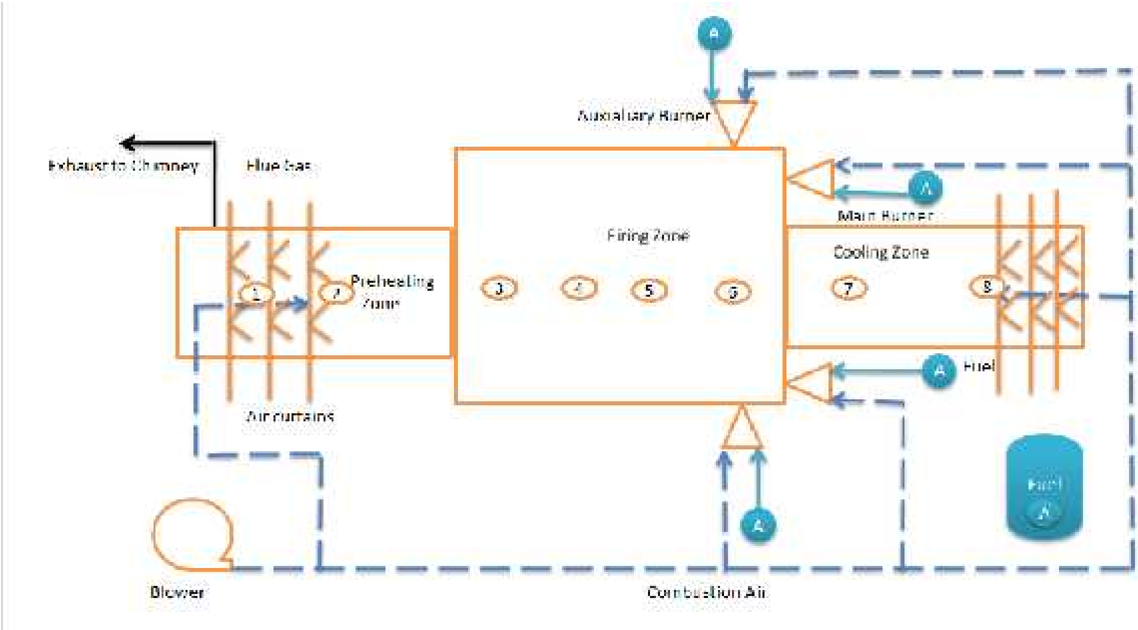


Figure 20: Tunnel kiln

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

Table 15: Temperatures at various sections of tunnel kiln

Section of kiln	Temperature
1	235 °C
2	745 °C
3	1117 °C
4	1120 °C
5	1117 °C
6	1118 °C
7	730 °C
8	260 °C

Table 16: Dimensions of kiln

Zone	Length	Width	Height
Pre-heating	1219 cm	137 cm	201 cm
Firing	853 cm	288 cm	201 cm
Cooling	1950 cm	137 cm	201 cm

Table 17: Observations in kiln during field study and proposed EPIA

<table>
<tr><th>Observations during field Study & measurements</th><th>Proposed Energy performance improvement actions</th></tr>
<tr><td>
Fuel consumption of the kiln was identified by dip stick method, as no metering system was available.
<table>
<tr><th>Machine</th><th>Oxygen Level measured in Flue Gas</th><th>Ambient Air Temp</th><th>Exhaust Temperature of Flue Gas</th></tr>
<tr><td>Tunnel kiln</td><td>12%</td><td>35.2°C</td><td>203°C</td></tr>
</table>
From the above table, it is very clear that the oxygen level measured in flue gas is in excess.
The inlet temperature of raw material in all the four furnaces is in the range of 35 – 42°C which was the ambient air temperature.
The exhaust temperature of flue gas in the kiln through chimney after the effect of air curtains is in the range of 198 - 205°C whereas near the firing zone it is found to be 860 – 926°C during CEA study.
</td><td>
No recommendation has been suggested, as the exit flue gas temperature is minimum and cannot be used for waste heat recovery
Reducing the skin losses by improving insulation is recommended in firing zone of kiln.
Reducing opening losses in kiln is recommended.
</td></tr>
</table>

4 EE TECHNOLOGY OPTIONS AND TECHNO – ECONOMIC FEASIBILTY

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

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

4.1 EPIA 1: Skin loss reduction

Technology description

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

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

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

Study and investigation

There are three different zones in the kiln, i.e. pre- heating, firing and cooling zones in which the skin temperature of all the three zones were observed. The average temperature has to be in the range of 50 - 60°C, however, it was observed to be 66.24°C. Hence, proper insulation needs to be done to keep the surface temperature within the specified range.

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

Recommended action

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

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

Table 18: R & C losses

Total radiation and convection heat loss per hour	Units	Value
Pre-Heating Zone	kcal / h	2,482
Firing Zone	kcal / h	6,626
Cooling Zone	kcal / h	2,767
Total R&C loss	kcal / h	11,874

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

Table 19: Cost benefit analysis (EPIA 1)

Parameters	UoM	Value
Present average skin temperature of Firing zone	deg. C	66.24
Recommended skin temperature of Firing Zone	deg. C	50.00
Present heat loss due to Radiation & Convection from Work side wall	kcal / h	6,626
Recommended heat loss due to Radiation & Convection from Firing zone	W / m2	88.80
	kcal / m2	76.37
	kcal / h	2621
Total reduction in heat loss due to Radiation & convection by limiting skin temperature at Firing zone	kcal / h	4004
Calorific value of Fuel	kcal / kg	11,178
Equivalent savings in Fuel	kg / h	0.36
	Nm3 / h	
Plant running time	days /y	300
	h / day	24
Annual savings in Fuel	litre/y	3121
Cost of fuel	Rs. / litre	39
Annual Monitory savings	Rs. / y	122675
	Rs. Lakhs / y	1.23
Estimated investment	Rs. Lakhs	0.42
Simple payback	y	0.34

4.2 EPIA 2: Excess air control

Technology description

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

Study and investigation

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

Recommended action

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

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

Table 20: Cost benefit analysis (EPIA 2)

Parameters	UOM	Present	Proposed
Oxygen level in flue gas	%	12.00	3.50
Excess air control	%	133.33	20.00
Dry flue gas loss	%	11.47	
Saving in fuel	With every 10% reduction in excess air leads to a saving in specific fuel consumption by 1%		
Specific fuel consumption	Liter/t	165.72	146.94
Saving in specific fuel consumption	Liter/h		2.83
Savings in fuel cost	Rs. Lakh/y		8.02
Installed capacity of blower	kW	7.46	7.83
Running load of the blower	kW	5.74	5.48
Operating hours	hrs/y	7200.00	7200.00
Electrical energy consumed	kWh/y	41295.41	39478.32
Savings in electrical energy	kWh/y		1817.09
Cost of increased electrical energy	Rs. Lakh/y	3.50	3.34

Savings in terms of energy cost	Rs. Lakh/Y	8.17
Estimated investment	Rs. lakh	7.00
Simple payback	y	0.86

4.3 EPIA 3: Energy efficient fans

Technology description

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

Study and investigation

The unit is having about 60 fans which are very old.

Recommended action

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

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

Table 21: Cost benefit analysis (EPIA 3)

Data & Assumptions	UOM	Present	Proposed
Number of Ceiling fans in the plant	Nos	60	60
Running hours per day (average) - for fans	h / day	18	18
Power consumption at Maximum speed	kW	0.07	0.04
Number of working days/year	days / y	300	300
Tariff for Unit of electricity	Rs. / kWh	8.47	8.47
Fan unit price	Rs./piece	1500	3000
Electricity consumption:			
Electricity demand	kW	4.20	2.10
Power consumption by fans in a year	kWh/y	22680	11340
Savings in terms of power consumption	kWh/y		11340
Savings in terms of cost	Rs. Lakh/y		0.96
Estimated investment	Rs. Lakh/y		1.80
Pay back period	y		1.87

4.4 EPIA 4: Energy efficient light fixture

Technology description

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

Study and investigation

The unit is having about 62 T12 tube light with its fittings.

Recommended action

The T5 light fixtures have to be replaced with energy saving LED lamps which can reduce energy consumption immensely.

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

Table 22: Cost benefit analysis (EPIA 4)

Parameters	UoM	Present	Proposed
Fixture		T-12	18 Watt LED tube light
Power consumed by T8	W	40	18
Power consumed by Ballast	W	12	0
Total power consumption	W	52	18
Operating Hours/day	Hr	24	24
Annual days of operation	Day	300	300
Energy Used per year/fixture	kWh	374	130
Energy Rate	Rs./kWh	8.47	8.47
No. of Fixture	Unit	62	62
Power consumption per year	kWh/y	23213	8035
Operating cost per year	Rs. Lakh/y	1.97	0.68
Saving in terms of electrical energy	kWh/y		15178
Savings in terms of cost	Rs. Lakh/y		1.28
Investment per fixture of LED	Rs. Lakh		0.0075
Investment of project	Rs. Lakh		0.465
Payback period	y		0.36

4.5 EPIA 5: VFD on pug mill motor

Technology description

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

Study and investigation

The existing pug mill draws more current even during unloading.

Recommended action

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

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

Table 23: Cost benefit analysis (EPIA 5)

Parameters	Unit	Present	Proposed
Installed capacity of motor	kW	6	5.595
Estimated energy savings by installing VFD on (Pug-Mill motor)	%		20.0
Average power consumption	kW	1.27	1.01
No of operating hrs per day	h	20	20
Operating Days per Year	Days	300	300
Average electricity consumption per year	kWh	7605	6084
Annual electricity savings	kWh/y		1521
Average electricity tariff	Rs./kWh	8.47	8.47
Annual savings in terms of cost	Lakhs Rs.		0.13
Estimated investment	Lakh Rs		0.3
Simple Payback	y		2.3

4.6 EPIA 6: Change in DG operating frequency

Technology description

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

Study and investigation

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

Recommended action

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

The cost benefit analysis for this project is given below:

Table 24: Cost benefit analysis (EPIA 6)

Parameters	Unit	Present	Proposed
Present average frequency of the DG sets	Hz	50.00	49.5
Average load on DG	kW	20.9	20.9
Specific Fuel Consumption	Litre/kWh	0.30	0.30
Centrifugal Load	%	80%	80%
Possible power savings	kW	-	0.5
Possible savings	Litres/h	-	0.1
Operation hours per day	h/day	3	3.0
DG operating hours	h/y	900	900.0
Annual HSD savings	Litres/y	-	134.4
HSD 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

4.7 EPIA 7: Electrical energy monitoring system

Technology description

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

Study and investigation

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

Recommended action

It is recommended to install energy monitoring online system for the main incomer & metering instruments on the electricity distribution panels inside the plant to reduce overall energy consumption by 3%.

The savings assessment has been given in the table below:

Table 25: Cost benefit analysis (EPIA 7 – Diesel Blend)

Parameters	Unit	Present	Proposed
Energy monitoring savings	%		3.00
Energy consumption of major machines per year	kWh/y	250,102	242,599
Annual electricity saving per year	kWh/y		7,503
W. Average Electricity Tariff	Rs./kWh		8.47
Annual monetary savings	lakh Rs./y		0.64
Estimate of Investment	Lakh Rs.		0.25
Simple Payback	Months		4.72
Energy monitoring savings	%		3.00
Current diesel blend consumption	Litre/y	180,000	174,600
Annual fuel saving per year	Litre/y		5,400
Unit Cost of Diesel Blend	Rs./Litre		39.30
Annual monetary savings	lakh Rs./y		2.12
Estimate of Investment	Lakh Rs.		0.20
Simple Payback	y		0.09

The energy monitoring system can also be installed for monitoring the fuel consumption in the DG set. The cost benefit analysis is given below:

Table 26: Cost benefit analysis (EPIA 7 - DG)

Parameters	UoM	Present	Proposed
Current fuel consumption in DG	Litre/y	7,514	7,289
Annual fuel saving per year	Litre/y		225
Unit Cost of HSD-2 fuel	Rs./Litre		54.00
Annual monetary savings	Lakhs Rs/y		0.12
Estimate of Investment	Lakhs Rs		0.15

4.8 EPIA 8: Power factor improvement

Technology description

The term power factor plays an important role in electricity consumption in industries. If proper power factor is not maintained, it may lead to penalty in the electricity billing. For maintaining the power factor according to the load factor, proper capacity of capacitors is to be connected. The value of capacitors to be connected will vary with respect to load and its existing PF and can be controlled using APFC.

Study and investigation

The average power factor maintained in the unit was found to be 0.94 during the study.

Recommended action

The power factor has to be maintained at 0.99 to avoid penalty from the utility and so proper sizing of capacitors has to be made which is given in the table:

Table 27: Sizing of capacitor banks

Parameters	Unit	Value
Present Minimum PF	Cos ø	0.88
Present Maximum PF	Cos ø	0.97
Present Average PF	Cos ø	0.94
Minimum Load	kW	0.3
Maximum Load	kW	52.8
Average Load	kW	36.1
Target Average Power Factor		0.99
Capacitor Bank Capacity at Average Load and Average PF	kVAR	7.5
Capacitor Bank Capacity at Maximum Load and Average PF	kVAR	11.0
Capacitor Bank Capacity at Maximum Load and Minimum PF	kVAR	19.5
Capacitor Bank Capacity at Minimum Load and Minimum PF	kVAR	0.1
Required capacitor bank for PF at Unity	kVAR	19.5
APFC Panel (Rating) for maintaining optimum PF	kVAR	19

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	0.88	0.99
Maximum PF	Cos ø	0.97	0.99
Average PF	Cos ø	0.94	0.99
Maximum Load	kW	52.8	52.80
Average Load	kW	36.09	36.09
Capacitor Bank	kVAR	100.0	119.5
Annual Grid Electricity Consumption	kVAh/y	263310.5	250181.3
	kWh/y	247679.5	247679.5
Annual Grid Electricity Savings	kVAh/y	-	13129.26
Electricity Tariff	Rs./kVAh	7.2	7.2
Annual Monetary Savings	Lakh Rs./y	-	0.95
Investment	Lakh Rs.	-	0.50
Payback Period	Months	-	0.53

4.9 EPIA 9: Increasing the contract demand

Technology description

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

Study and investigation

From the electricity bills for a year, it is noted that the contract demand for the unit is only 48 kVA and the recorded maximum demand was found to be always higher with minimum value of 53.6 kVA and maximum value of 115.6 kVA for which demand penalty has been reflected in the utility bill by PVVNL. It is an additional cost incurred other than energy usage cost.

Recommended action

The maximum demand recorded is 115 kVA and it is advised to increase the demand to 120 kVA for which no investment will be required and the savings will be immediate.

EPIA analysis is given in the table below:

Table 29: Cost benefit analysis (EPIA 9)

Parameters	Unit	Present	Proposed
Contract Demand	kVA	48	120.00
Demand Charges	Rs./kVA		202.5
Demand Charges	Rs	168,775	218,700
Maximum Demand Penalty	Rs	104,269	0
Total Cost	Rs	273,044	218,700
Estimated Savings	Rs. lakhs		0.543
Estimated investment	lakh Rs.		0.0
Simple Payback	y		Immediate

4.10 EPIA 10: Replacement of Kiln car material

Technology description

The existing kiln car consists of refractory bricks and tiles which are very heavy and it will increase the dead weight of the car carrying away the useful heat required in the kilns. This will reduce the kiln efficiency. Instead the material called ultralite[2] can be used in the kiln car construction, which will reduce the dead weight of the kiln, thereby reducing the fuel consumption as the material has lesser specific heat.

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

Study and investigation

The dead weight of the kiln with materials of HFK bricks, quadrite tiles and pillars alone contribute to the weight of 495 kg in a kiln car. These materials have different Cp values and each gain certain amount of height into them which becomes waste heat as it is not utilized for the useful heating of materials stacked in the kiln. This resulted in more fuel consumption.

Recommended action

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

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

Table 30: Cost benefit analysis (EPIA 10)

Parameters	UoM	Present	Proposed
Present Production of kiln	tph	0.15	0.15
Weight of existing kiln car	kg	495	347
Total number of kiln cars inside kiln	Nos.	24	24
Initial temperature of kiln car	Deg c	35.2	35.2
Final temperature of kiln car	Deg c	1119	1119
Estimated percentage saving by replacing present kiln car with new EE kiln car	%		30
Heat carried away by the kiln material	kcal/h	102,936	72,055
Reduction in the heat carried by the new EE kiln car	kcal/h		30,881
Operating hours of kiln	hrs	7200	7200
Savings in terms of fuel consumption	Litre/y		19,890
Savings in terms of cost	Rs. lakh/y		7.8
Estimated investment of kiln car material	Rs. lakh/y		4.80
Payback period	y		0.6

4.11 EPIA 11: Energy efficient drive system

Technology description

All 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. If the rotating speed is above or below the nominal operating speed, a variable frequency drive can be installed to the drive for regulating the speed of rotation which can reduce electricity consumption.

Study and investigation

It was observed during the CEA that the speed of rotation of ball mill was more than the normal operating speed.

Recommended action

VFD has to be installed for controlling the speed of the ball mill and to reduce the electricity consumption.

The cost benefit analysis of energy efficient drive system is given in the table below:

Table 31: Cost benefit analysis (EPIA 11)

Parameters	UoM	Present	Proposed
Ball Mill ID	m	2.50	2.5
Ball Mill ID	ft	8.2	8.2
Ball Mill critical speed	rpm		27
Ball Mill speed	rpm	20	19
Installed capacity of motor	kW	11.19	11.19
Average power consumption	kW	5.0	4
No of operating hrs per day	hrs	20	20
Operating Days per Year	days	300.00	300
Average electricity consumption per year	kWh	30043.33	24685
Annual electricity saving	kWh/y		5359
Average electricity tariff	Rs./kWh	8.47	8.47
Annual saving in terms of cost	lakh Rs.		0.45
Estimated investment	lakh Rs.		0.7
Simple payback	y		1.5

4.12 EPIA 12: Replacement of present inefficient burners with new EE burners

Technology description

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

Study and investigation

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

Recommended action

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

Table 32 Cost benefit analysis (EPIA 12)

Sl. No.	Replacing persent burners with energy efficient burners		Kiln	
	Parameters	Unit	Present	Proposed
1	Production rate of the kiln	kg/hr	151	151
2	Total number of main burner	Nos.	1.0	1.0
3	Total number of auxilary burner	Nos.	2.0	2
4	Total numbers of energy efficient burner required	Nos.	3.0	3.0
5	Estimated saving by energy effcient burner	%		5.0
6	Current fuel firing in kiln	kg/hr	22	21
7	Savings in fuel per hours	kg/hr		1.10
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		7945
10	Unit cost of fuel	Rs./kg		44.52
11	Cost savings per year	Lakh Rs./yr		3.54
12	Estimated investment for all burners	Lakh Rs.		0.7
13	Payback period	Yr		0.2

5 ANNEXURE

Participation of the unit in this project

T I N 09767700741 dt. 1.4.02
C S T No. KJ-5035793 dt. 19.4.02

Mobile : 9837051107

R. K. POTTERIES

Manufacturers & Suppliers of Crockery, Electrical Goods, Saggars, Scientific & Hospital Wares, H. T. Insulators, Earthen Pots etc.

Junction Road, KHURJA 203131 (U.P.)

Dated 6/4/2015

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,

(Shiv Kr. Singhania)
Name & signature of unit head

Kiln efficiency calculation

Input parameters

Parameters	Value	UoM
Tunnel Kiln Operating temperature (Firing Zone)	1119	*Deg C*
Final temperature of material (at outlet of Firing zone)	1000	*Deg C*
Initial temperature of kiln car	35.2	*Deg C*
Avg. fuel Consumption	22.1	*Kg/hr*
Flue Gas Details		
Flue gas temp. after APH (in chimney; No APH installed)	203	*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	24	*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	*11178*	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)	495	*Kg/Hr*
Weight of ceramic material (Raw material) being fired in Kiln	151	*Kg/Hr*
Weight of Stock	151	*kg/hr*
Specific heat of clay material	0.22	*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 zones		
Radiation and Convection from preheating zone surface	2482	*kcal/hr*
Radiation and Convection from firing zone surface	6626	*kcal/hr*
Radiation and Convection from cooling zone surface	2767	*kcal/hr*
Heat loss from all zones	11874	*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*
Co-efficient based on profile of kiln opening	0.7	
Max operating temp. of kiln	343	*deg K*

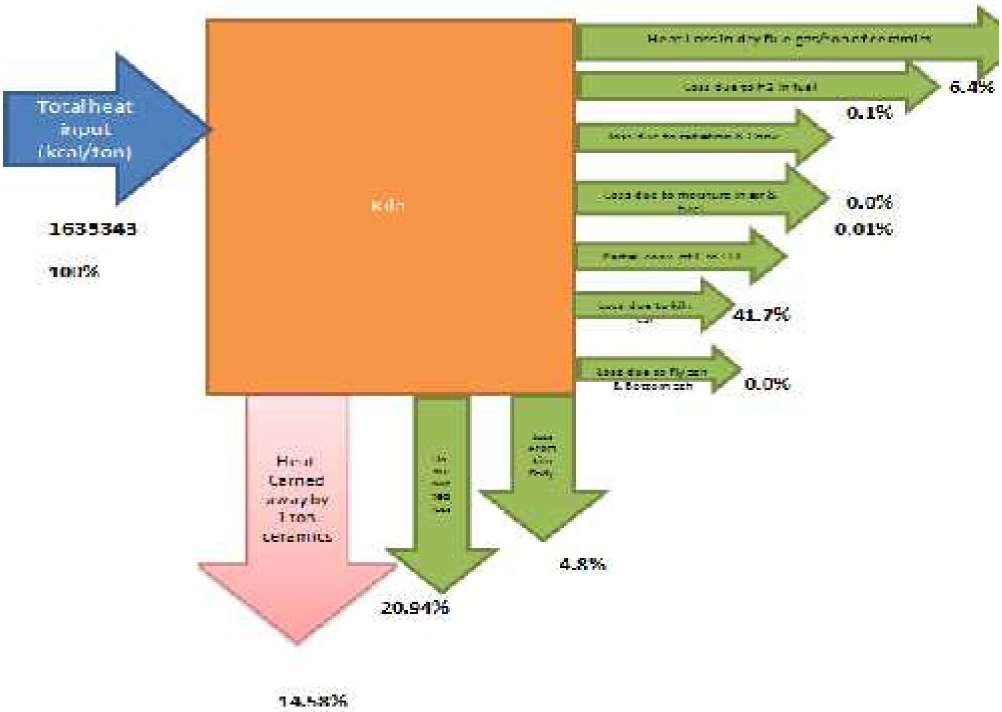
Efficiency calculation

Calculations	Values	Unit
Theoretical Air Required for combustion of fuel-mix	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	146.30	*kg of fuel / ton of ceramic material (raw material)*
Heat Input Calculation		
Total heat input	1,635,343	*Kcal/ton of ceramic material*
Heat Output Calculation		
Heat carried away by 1 ton of ceramics (useful heat)	238,436	*Kcal/ton of ceramic material*
Heat loss in dry flue gas per ton of Raw material (Stock); Ceramic Material	187,583	*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 H2 in fuel	104,202	*Kcal/ton of ceramic material*
Loss due to moisture in combustion air	67	*Kcal/ton of ceramic material*
Loss due to partial conversion of C to CO	172	*Kcal/ton of ceramic material*
Loss due to convection and radiation (openings in kiln - inlet & outlet of kiln car)	1,344	*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	78,714	*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	682,344	*Kcal/ton of ceramic material*
Unaccounted heat losses	342,481	*Kcal/ton of ceramic material*
Heat loss from Kiln body and ceilings		
Total heat loss from kiln due to radiation and convection from kiln body	78,714	*Kcal/tons*
Kiln Efficiency	**14.58**	*%*

Sankey diagram



6 LIST OF VENDORS

EPIA 1: Skin Loss Reduction

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

EPIA 2: Excess Air Control

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
Automation				
1	Delta Energy Nature Contact Person Gurinder Jeet Singh, Director	F-187, Indl. Area, Phase-VIII-Bm Mohali-160059	Tel.: 0172-4004213/ 3097657/ 2268197 Mobile: 9316523651 9814014144 9316523651	dengjss@yahoo.com den8353@yahoo.com
2	International	# 1698, First Floor,	Office: +91-161-	Email: interautoinc@yaho

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

EPIA 3: 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.co m
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.panas onic.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 12: Installation of EE Burners

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
Automation				
1	ENCON Thermal	297, Sector-21 B	Tel.:	sales@encon.co.in

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
	Engineers (P) Ltd Contact Person: Mr V B Mahendra, Managing Director Mr. Puneet Mahendra, Director	Faridabad – 121001 Haryana	+91 129 4041185 Fax: +91 129 4044355 Mobile: +919810063702 +919971499079	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