COMPREHENSIVE ENERGY AUDIT REPORT

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

Minhas Pottery

Industrial Estate, Khurja

18-04-2015

Submitted to

BUREAU OF ENERGY EFFICIENCY

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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. Guljeet Singh Minhas, Proprietor of the unit for showing keen interest in the energy audit and also thankful to the management of M/s Minhas Pottery 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
AGL	Adani Gas Limited
APFC	Automatic Power Factor Correction
BEE	Bureau of Energy Efficiency
CEA	Comprehensive Energy Audit
CFL	Compact Fluorescent Lamp
CRV	Chromium Vanadium
DESL	Development Environergy Services Limited
DG	Diesel Generator
EE	Energy Efficiency
EPIA	Energy Performance Improvement Action
GEF	Global Environment Facility
HSD	High Speed Diesel
HVAC	Heating Ventilation and Air Conditioning
KPMA	Khurja Pottery Manufacturers Association
LED	Light Emitting Diode
LT	Low Tension
MD	Maximum Demand
MSME	Micro, Small and Medium Enterprises
MT	Metric Tons
MTOE	Million Tons of Oil Equivalent
PF	Power Factor
PNG	Piped Natural Gas
PVVNL	Paschimanchal Vidyut Vitran Nigam Limited
R & C	Radiation & Convection
RE	Renewable Energy
SEC	Specific Energy Consumption
SEGR	Specific Energy Generation Ratio
SLD	Single Line Diagram
SME	Small and Medium Enterprises
UNIDO	United Nations Industrial Development Organization
VFD	Variable Frequency Drives

EXECUTIVE SUMMARY

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

As part of this project, DESL has been engaged to implement the project in the MSME ceramic cluster in Khurja, Uttar Pradesh. The ceramic cluster in Khurja consists of three distinct types of units based on the products that they manufacture– pottery works, insulator works and crockery works. The production process of all the three types of units are almost similar, with difference being 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 fuels 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 Minhas pottery
Constitution	Proprietorship
MSME Classification	Small
No. of years in operation	2
Address: Registered Office	C1, Industrial Area, Khurja – 203131
Administrative Office	C1, Industrial Area, Khurja – 203131
Factory	C1, Industrial Area, Khurja – 203131
Industry-sector	Ceramics
Products Manufactured	Decorative stoneware
Name(s) of the Promoters / Directors	Mr. Guljeet Singh Minhas

Comprehensive Energy Audit

The study was conducted in 3 stages:

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

The production process of the unit

The main process equipment in the unit includes the following:

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

Identified Energy Performance Improvement Actions (EPIA)

The comprehensive energy audit covered all equipments, which were operational during the field study. The main energy consuming areas in the unit are kilns, which consume more than 86% of the total energy used.

The identified energy performance improvement actions in the kilns include proper insulation on the kiln to reduce radiation and convection heat loss from kiln surface, excess air control and replacement of kiln car material. VFD application is recommended in 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 increasing contract demand to reduce the billing penalty, installing energy monitoring system. Reduction in compressed air pressure is also suggested as it is used only for cleaning purposes. The details of energy improvement actions are given in Table – 2.

Table 2 Summary of EPIA

Sl. No.	Name of the project	Estimated energy saving				Estimated investment	Simple payback period	Annual emission reductions
		PNG	Electricity	HSD	Monetary savings			
		SCM/y	kWh/y	Liter/y	Rs. lakh/y	Rs. lakh	y	tCO2/y
1	Skin loss reduction from the kiln	2356.2			1.3	0.16	0.1	4.4
2	Excess control using PID and installation of separate blower for cooling and combustion air supply	18757.0	-4299		9.6	7.00	0.7	31.5
3	Replacement of kiln car	22806.1			12.3	4.80	0.4	43.0
4	VFD installation on PUG mill		3665		0.4	0.60	1.4	3.3
5	Speed optimization and EE drive system installation on ball mill-1 (300 kg)		4191		0.5	0.70	1.4	3.7
6	Installation of LED fixture instead of T12 tube light system		7344		0.9	0.30	0.4	6.5
7	Installation of LED lighting instead of 45 watt and 23 watt CFL		1512		0.18	0.16	0.9	1.3
8	Installation of energy efficient fan instead of conventional fan		7560		0.9	1.20	1.4	6.7
9	Energy monitoring system	4035.8	2910	432.0	0.8	0.60	0.8	11.3
10	Compressed air pressure reduction		6768		0.8	0.05	0.1	6.0
11	Replacement of present burner with energy efficient burner	6726.3			3.6	0.66	0.2	12.7
	Total	54681.3	29651.3	432.0	31.2	16.2	0.5	130.6

The implementation of above suggested projects in the unit may result in energy savings of up to 36.65% and energy cost savings of 34.90%.

1 INTRODUCTION

1.1 Background and Project objective

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

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

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

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

The objectives of this project are as under:

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

1.2 Scope of work for Comprehensive Energy Audit

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

- Data Collection
  - Present energy usage (month wise) for all forms of energy from April-2014 to March-2015 (quantity and cost)
  - Data on production for corresponding period (quantity and cost)
  - Data on production cost and sales for the corresponding period (cost)
  - Mapping of process
  - Company profile including name of company, constitution, promoters, years in operation and products manufactured
  - Existing manpower and levels of expertise
  - List of major equipments and specifications
- Analysis :

    - Energy cost and trend analysis
    - Energy quantities and trend analysis
    - Specific consumption and trend analysis
    - Scope and potential for improvement in energy efficiency
- Detailed process mapping to identify major areas of energy use.
- To identify all areas for energy saving in the following areas:
    - Electrical: Power factor improvement, transformer loading, power quality tests, motor load studies, compressed air systems (including output efficiency tests), conditioned air provisions, cooling water systems, lighting load, electrical metering, monitoring and control system.
    - Thermal: Assessment to ascertain direct and indirect kiln efficiencies with intent to optimize thermal operations, heat recovery systems etc.
- Evaluate the energy consumption vis-à-vis the production levels and to identify the potential for energy savings / energy optimization (both short term requiring minor investments with attractive payback, and mid to long terms requiring moderate investments and with payback period of 1.4 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 and recommend proper "energy monitoring system" for effective monitoring and analysis of energy consumption, energy efficiency.

1.3 Methodology

1.3.1 Boundary parameters

Following boundary parameters were set on coverage of the audit.

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

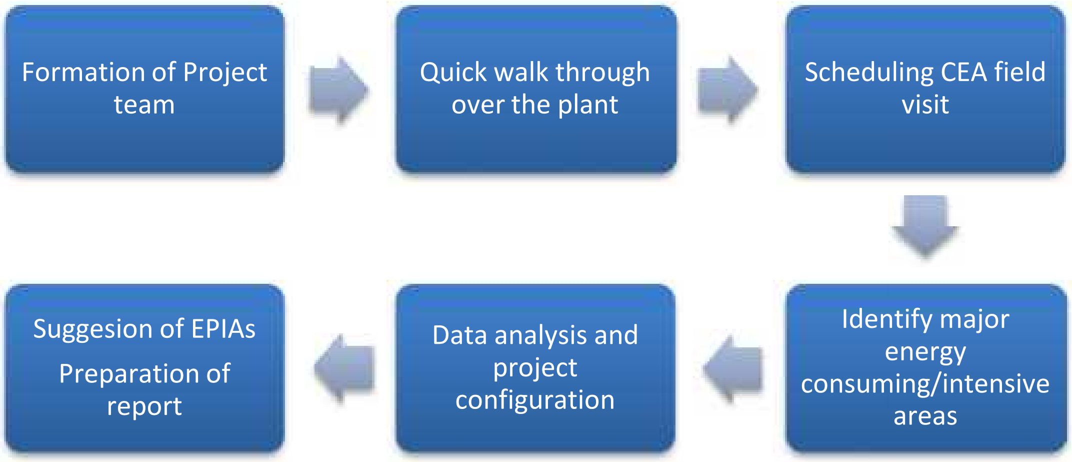


Figure 1: General methodology

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

1.3.3 Comprehensive energy audit – field assessment

A walk through was carried out before the audit with a view to:

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

The audit identified the following potential areas of study:

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

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 various instruments used during the energy audit are:

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)		Lumens

Sl. No.	Instruments	Make	Model	Parameters Measured
		and Mastech		
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 Minhas Pottery
2	Constitution	Proprietorship
3	Date of incorporation / commencement of business	2013
4	Name of the contact person Designation Mobile/Ph.No. E-mail ID	Mr. Guljeet Singh Minhas Proprietor +91 9837572245 NA
5	Address of the unit	C1, Industrial Area, G.T road, Khurja – 203131
6	Industry / sector	Ceramic
7	Products manufactured	Decorative stonewares
8	No. of operational hours/day	24
9	No. of shifts / day	3
10	No. of days of operation / year	300
11	Whether the unit is exporting its products (yes / no)	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

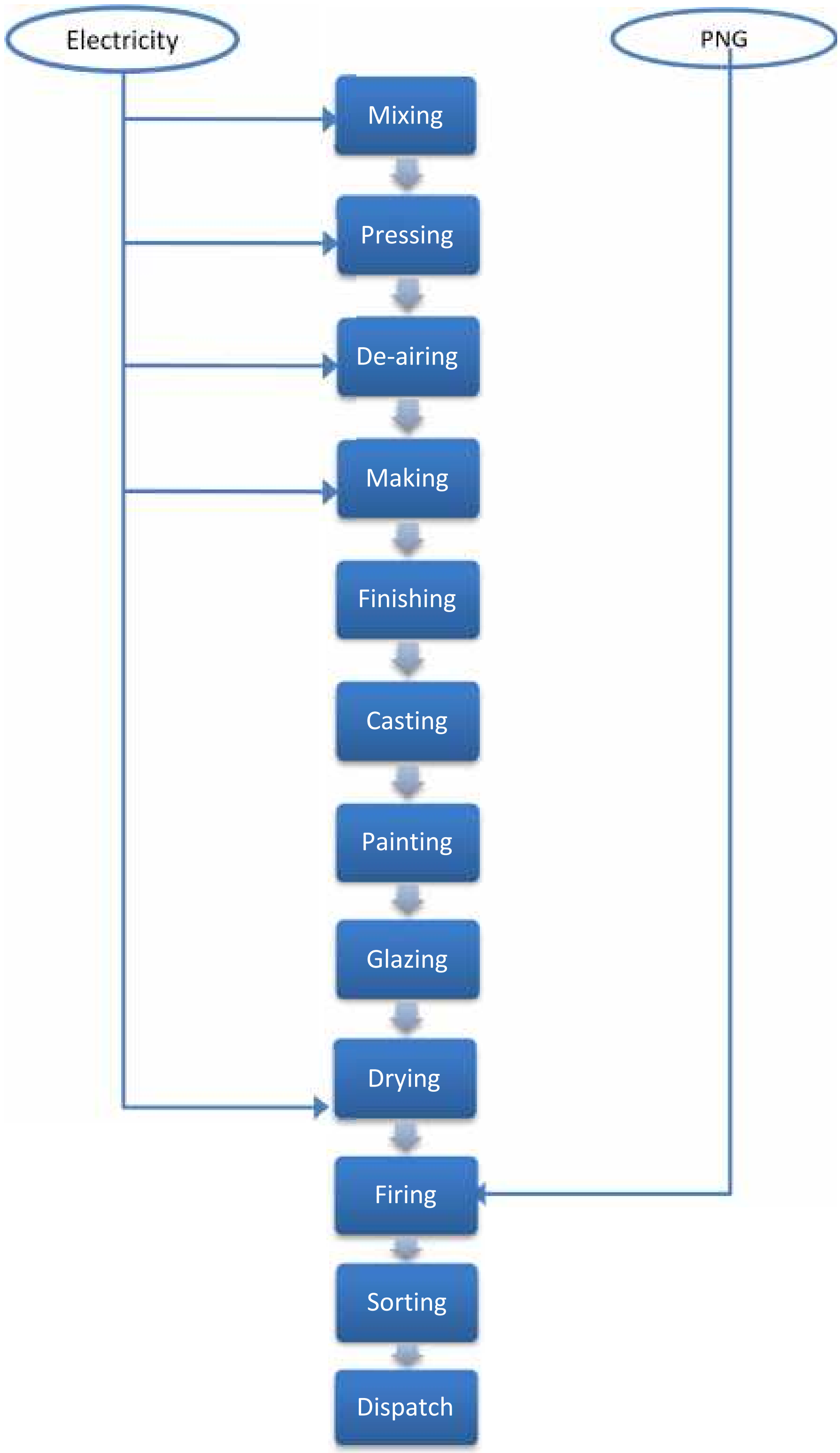


Figure 2: Process flow diagram

3.1.2 Process description

M/s Minhas Pottery is a manufacturer of ceramic decorative stone-wares and crockery items like ceramic tea mugs, pots, etc. The process description is as follows:

- The raw materials clay, feldspar and quartz are mixed with water in the ball mill for a period of 8 hours.
- This mixture is then transferred to the agitator tank for thorough mixing. With the help of diaphragm pump, the mixture is transferred to the filter press to remove water content from it.
- The dry cakes formed are then placed on the 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 required shapes using jigger jollies after which they are simply dried using fans for a few days.
- Then the materials are glazed and stacked on the kiln cars for firing to obtain strength. The firing zone temperature in the kiln is maintained at 1200^oC.
- After firing, the products are quality checked, packed and dispatched.

3.2 Inventory of process machines/equipment and utilities

Major energy consuming equipments in the plants are:

- **Ball mill:** Here the raw materials like clay, feldspar and quartz are mixed in the ratio of 2:1:1 respectively along with water to form a slurry.
- **Agitator:** The slurry after getting mixed in the ball mill is poured into a sump where an agitator is fitted for thorough mixing of the materials and for preventing it 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. Around 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 placed manually on the pug mill, which has a positive displacement conveyor connected with the vacuum pump to remove air bubbles in order to avoid pores and crack formations during firing. The output from the pug mill is cut in to small pieces and transferred to the shaping section. The moisture content is reduced by 20% in this process.
- **Jigger jollies:** The final products are given required shapes by the jigger jollies along with moulds and then dried for complete removal of moisture.
- **Tunnel Kiln:** The shaped materials are glazed and then stacked on the kiln car, 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 14 feet long and the temperature gradually increases up to the firing zone and then decreases (in the cooling zone) with the highest temperature being 1200^oC. 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 supplied from two different sources:
    - From the Utility, PVVNL (Paschimanchal Vidyut Vitran Nigam Limited)
    - Captive backup diesel generator sets for the whole plant
- Thermal energy is used for following applications :
    - Piped natural gas (PNG) for kiln from AGL (Adani Gas Limited)

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. Lakhs	% of total	MTOE	% of total
Grid – Electricity	9.12	10	8.3	5.43
HSD– DG	7.78	9	14.1	9.17
Thermal – PNG	72.44	81	131.2	85.40
Total	**89.34**	**100**	**153.6**	**100**

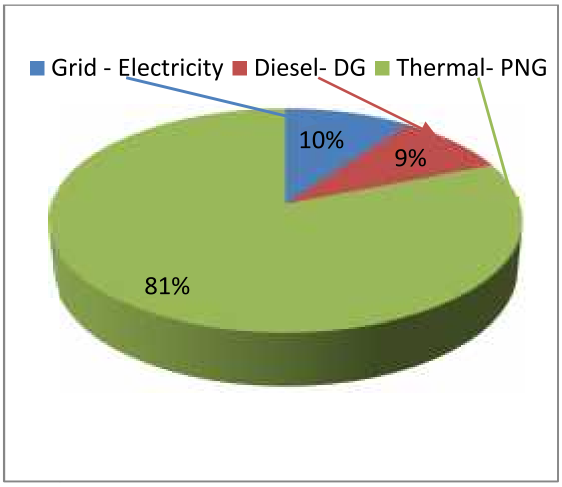


Figure 3: Energy cost share (Rs. Lakh)

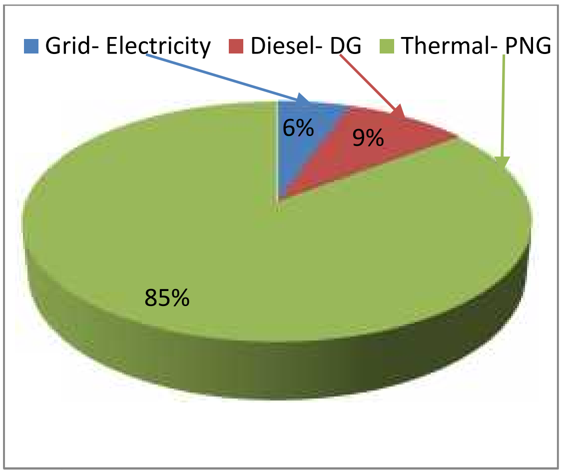


Figure 4: Energy use share (MTOE)

Major observations are as under:

- The unit uses both thermal and electrical energy for carrying out manufacturing operations. Electricity is supplied from the grid and self generated by DG sets when the grid power is not available. Thermal energy consumption is in the form of PNG, which is used for firing in the kiln.
- PNG used in kilns account for 81% of the total energy cost. HSD used in DG sets account for 9% of total energy cost and electricity used in plant process account for 10% of total energy cost.
- PNG used in kilns account for 85% of overall energy consumption. HSD used in DG sets account for 9% of overall energy consumption and electricity used in plant account for 6% of overall energy consumption.

3.4 Analysis of electricity consumption by the unit

3.4.1 Baseline parameters

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

Table 7: Baseline parameters

Electricity tariff (Excluding Rs./kVA)	6.20	Rs./ KVAH inclusive of taxes
Weighted average electricity cost	11.66	Rs./ kWh for 2014-15
Percentage of total DG based generation	34%	
Average cost of PNG	53.88	Rs./SCM
Annual operating days per year	300	Days/yr
Annual operating hours per day	24	Hr/day
Production	630	MT
GCV of HSD	11,840	kcal/ Litre
GCV of PNG	13,928	Kcal/kg

Density of HSD	0.826	kg/litre
Density of PNG	0.700	kg/SCM

3.4.2 Electricity load profile

Following observations have been made from the utility inventory:

- The plant and machinery load is 72.0 kW
- The utility load (lighting & fans) is about 9.6 kW including the single phase load
- The total connected load of plant is 81.6 kW

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

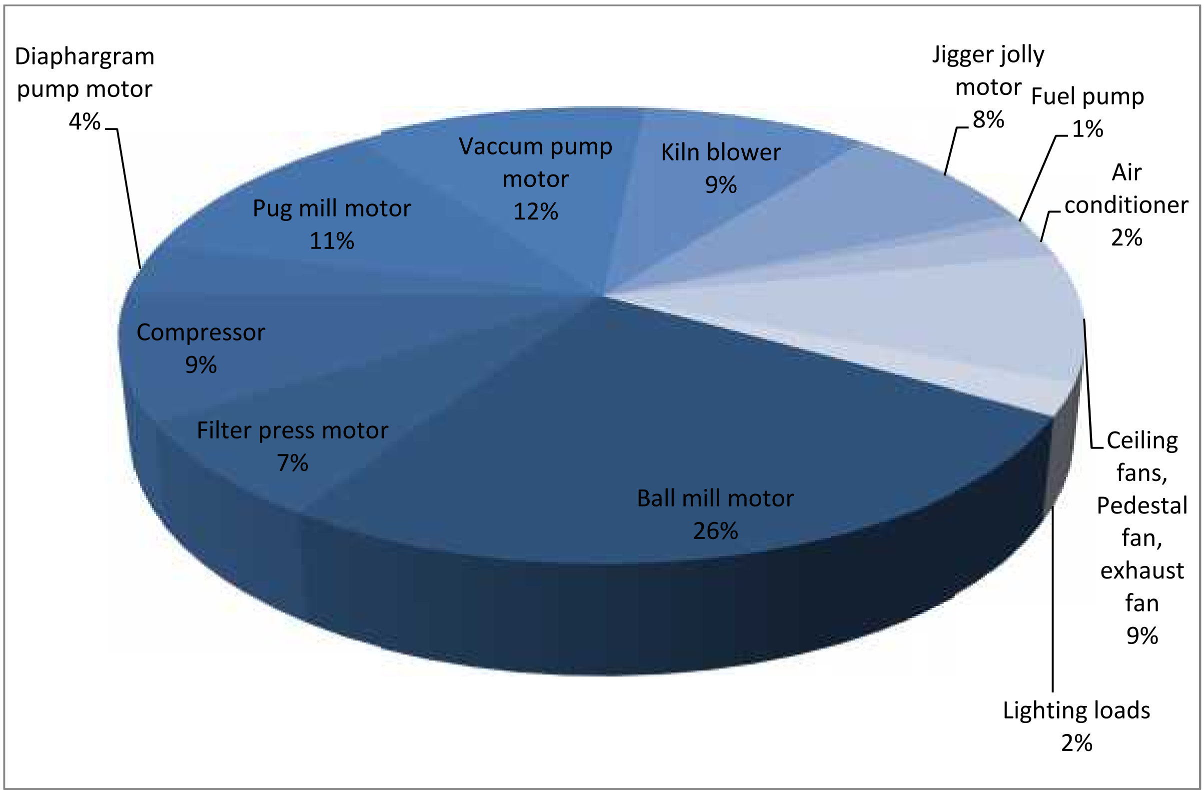


Figure 5: Details of connected load

As shown in the pie chart of connected load the maximum share of connected load is for the ball mill – 26%, followed by pug mill – 11%, filter press - 7%, vacuum pump – 12% and kiln blower - 9%. Other plant and machinery includes jigger jolly motor – 8%, fuel pump – 1%, ceiling fans and cooling loads – 11% and lighting loads accounts for 2% of the connected load.

An analysis of area wise electricity consumption has been computed to quantify the electricity consumption in the individual processes. The detail of electricity consumption by the machineries in the unit is shown in the table:

Table 8: Area wise electricity consumption (estimated)

Consumption	kW	kWh/year	% of Total
Ball mill motor	3.2	10058	6.8%
Filter press motor	3.6	9668	6.5%
Compressor	4.5	9668	6.5%
Diaphragm pump motor	3.0	5371	3.6%
Pug mill motor	3.8	10309	7.0%
Vacuum pump motor	7.8	20948	14.1%
Kiln blower	6.0	12891	8.7%
Jigger jolly motor	4.7	15227	10.3%
Fuel pump	0.6	2578	1.7%
Air conditioner	1.7	6048	4.1%
Ceiling fans, Pedestal fan, exhaust fan	7.5	36173	24.4%
Lighting loads	1.9	9154	6.2%
Total	**48.2**	**148,093**	**100%**

This is represented graphically in the figure below:

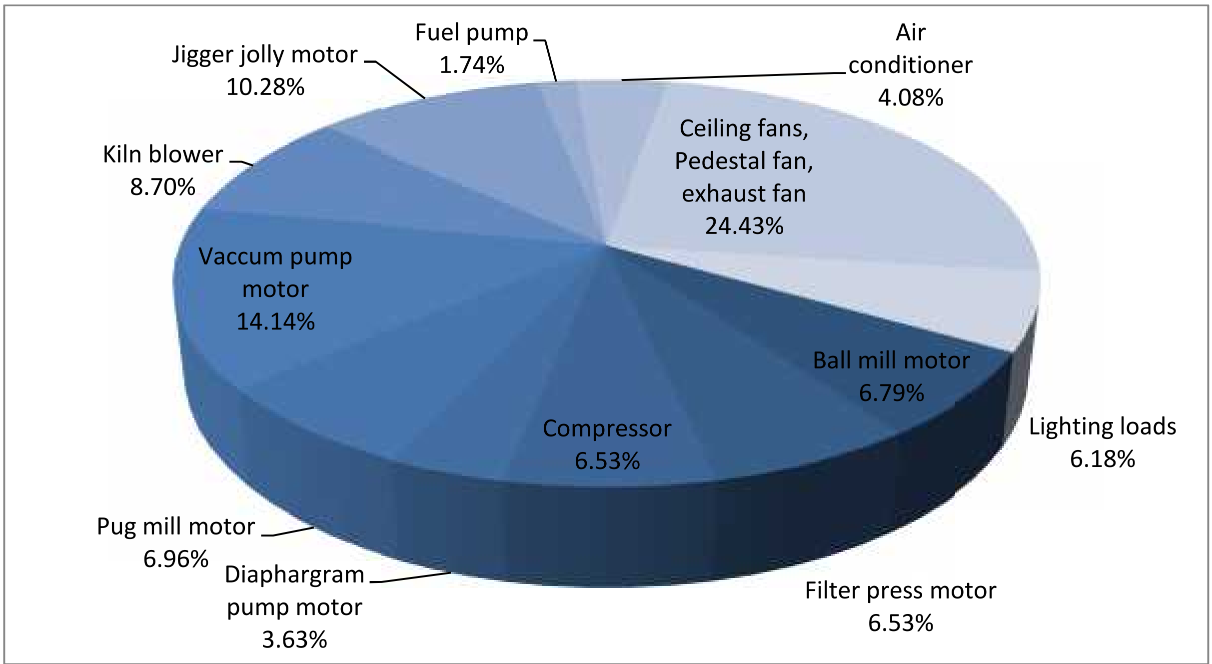


Figure 6: Area wise electricity consumption

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 maintenance).

3.4.3 Sourcing of electricity

The unit is drawing electricity from two different sources:

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

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

Table 9: Electricity share from grid and DG

	Consumption (kWh)	%	Cost (Lakh Rs.)	%
Grid Electricity	96,993	66	9.1	54
Self Generation	50,400	34	7.8	46
Total	147,393	100%	16.9	100%

This is graphically depicted as follows:

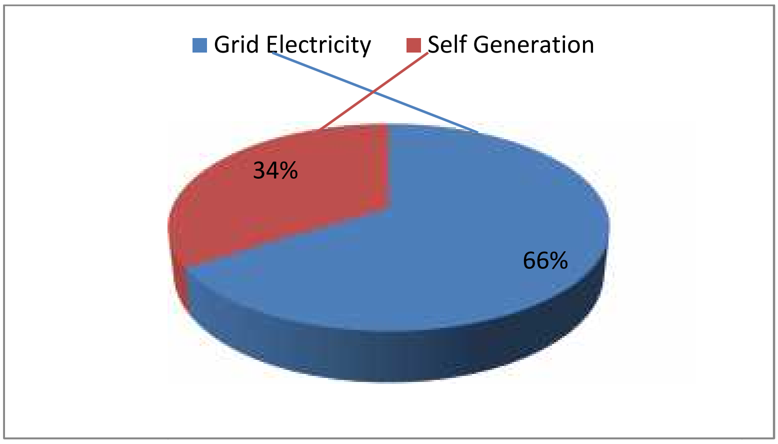


Figure 7: Share of electricity by source

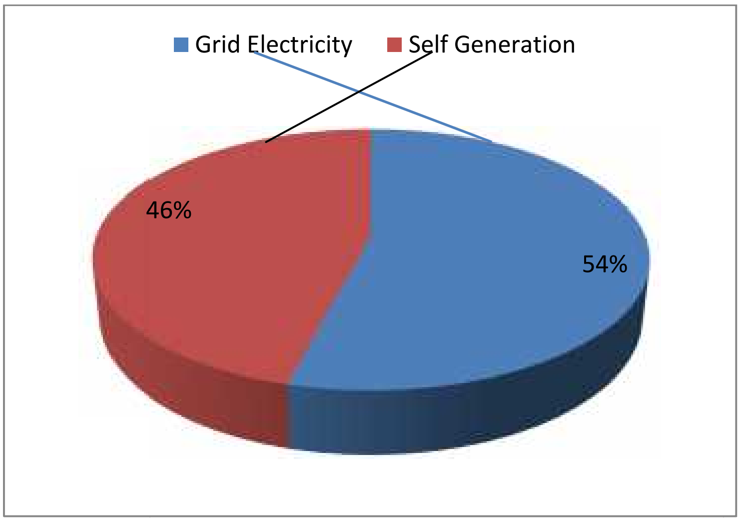


Figure 8: Share of electricity by cost

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 sets is about 34% of the total power. Although the share of power from DG sets in terms of kWh is about 34% of the total electrical power, it translates to about 46% in terms of total cost of electrical power. This indicates the high cost of DG power due to rise in the price of HSD. For economical operation of the plant, the utilization of DG sets needs to be minimized, however, it will depend upon the supply condition of grid as well as the power requirement of plant.

3.4.4 Supply from utility

Electricity is supplied by 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:

1. a) Meter K No. : 10404833
   b) Power Supply : 0.42 kV line
   c) Contract Demand : 39 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	6.20	Rs./kWh
Regulatory	0.33	Rs./kVA
Fuel Surcharge	0.00	Rs./kVAh
Electricity duty	0.53	Rs./kVAh
Municipality tax	0.00	Rs./kVAh

(As per bill for February – 15)

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

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 Amount	Electricity Duty Charge@7.5% of (Demand +Energy Charges)	Total Arrears	Total Charge
	kVA	kVA	kVA		kWh	TOD-1 (kVAh)	TOD-2 (kVAh)	TOD-3 (kVAh)	Total (kVAh)	Rs.	Rs	Rs.	Rs.	Rs.	Rs.
Apr-14	39	34	32.05	0.99	8082	1370	2827	3988	8185	50627	6896	2632	4314	11525	75996
May-14	39	34	32.05	0.99	8082	1370	2827	3988	8185	50627	6896	2632	4314	11525	75996
Jun-14	39	34	32.05	0.99	8082	1370	2827	3988	8185	50627	6896	2632	4314	11525	75996
Jul-14	39	34	32.05	0.99	8082	1370	2827	3988	8185	50627	6896	2632	4314	11525	75996
Aug-14	39	34	32.05	0.99	8082	1370	2827	3988	8185	50627	6896	2632	4314	11525	75996
Sep-14	39	39	49.80	0.98	7383	1236	2548	3760	7544	43285	7897	1453	3838	0.0	56475
Oct-14	39	39	25.48	0.98	11684	1871	3672	6341	11885	72208	7897	3177	6007	255	89547
Nov-14	39	38	38.60	0.98	8080	1468	2272	4425	8165	51516	7816	3097	4450	355	67236
Dec-14	39	29	29.02	0.99	8352	1376	3071	3957	8406	53810	5923	3118	4480	55	67387
Jan-15	39	29	28.64	0.99	6844.4	1231	3048	2629	6909	43508	5923	2580	3707	68217	123936
Feb-15	39	29	20.76	0.99	6152.8	1037	2350	2814	6202	39433	5923	2367	3401	272	51397
Mar-15	39	34	32.05	0.99	8082.73	1370	2827	3988	8185	50627	6896	2632	4314	11525	75996
Max	39	39	49.80	1.0	11684.0	1871	3672	6341	11885	72208	7897	3177	6007	68217	123936
Min	39	29	20.80	1.0	6152.8	1037	2272	2629	6202	39433	5923	1453	3401	0.0	51397
Avg	39	34	32.10	1.0	8082.7	1370	2827	3988	8185	50627	6896	2632	4314	11525	75996
Total					96992.8	16442	33925	47858	98225	607526	82761	31589	51771	138310	911959

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

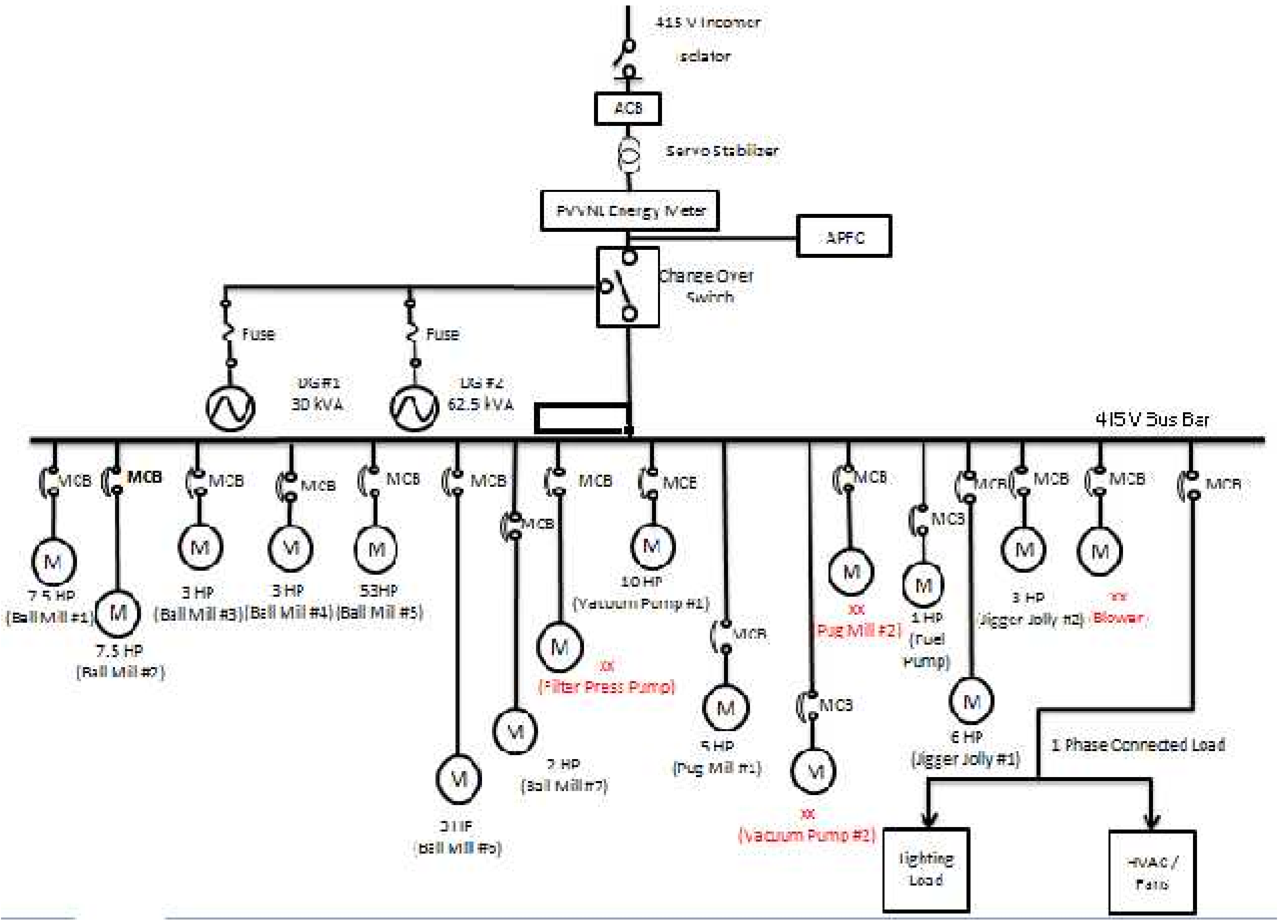


Figure 9: SLD of electrical load

Power factor

The utility bills of the unit reflect the power factor. A study was conducted by logging the electrical parameters of the main incomer using a power analyzer. The average power factor was measured to be 0.99.

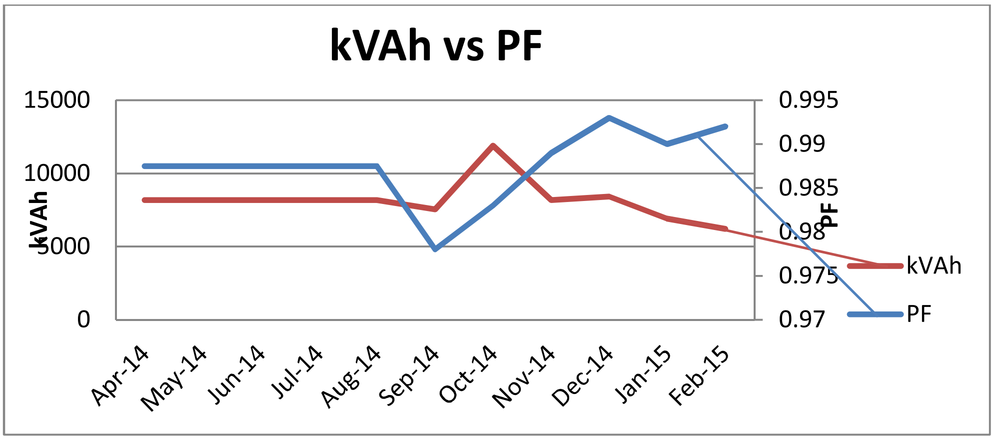


Figure 10: Monthly trend of PF

Maximum demand

Maximum demand as reflected in the utility bill is 49.8 kVA whereas the contract demand is only 39 kVA from the bill analysis.

3.4.5 Self-generation

The unit has two DG sets of 62.5 kVA and 30 kVA rating. The unit does not have a system for monitoring the energy generation and fuel usage in the DG sets. HSD purchase records are, however, maintained by the unit. In order to evaluate the month wise energy contribution by 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 the 62.5 kVA DG set and the specific energy generation ratio (SEGR) was calculated as 4 kWh/litre. HSD consumption by the DG sets is 14,400 litres annually costing Rs. 7.78 lakh with a power generation of 50,400 kWh.

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

3.4.6 Month wise electricity consumption

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

Table 12: Electricity consumption & cost

Months	Electricity Used (kWh)			Electricity Cost, Rs.		
	Grid[1]	DG	Total	Grid	DG	Total
	kWh	kWh	kWh	Rs	Rs.	Rs.
Apr-14	8,083	4,200	12,283	75,997	64,800	140,797
May-14	8,083	4,200	12,283	75,997	64,800	140,797

[1] Bills were not provided by the unit from month Apr-14 to Jul-14

Jun-14	8,083	4,200	12,283	75,997	64,800	140,797
Jul-14	8,083	4,200	12,283	75,997	64,800	140,797
Aug-14	8,083	4,200	12,283	75,997	64,800	140,797
Sep-14	7,383	4,200	11,583	56,476	64,800	121,276
Oct-14	11,684	4,200	15,884	89,547	64,800	154,347
Nov-14	8,080	4,200	12,280	67,236	64,800	132,036
Dec-14	8,352	4,200	12,552	67,387	64,800	132,187
Jan-15	6,844	4,200	11,044	123,936	64,800	188,736
Feb-15	6,153	4,200	10,353	51,398	64,800	116,198
Mar-15	8,083	4,200	12,283	75,997	64,800	140,797
Total	**96,993**	**50,400**	**147,393**	**911,960**	**777,600**	**1,689,560**

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

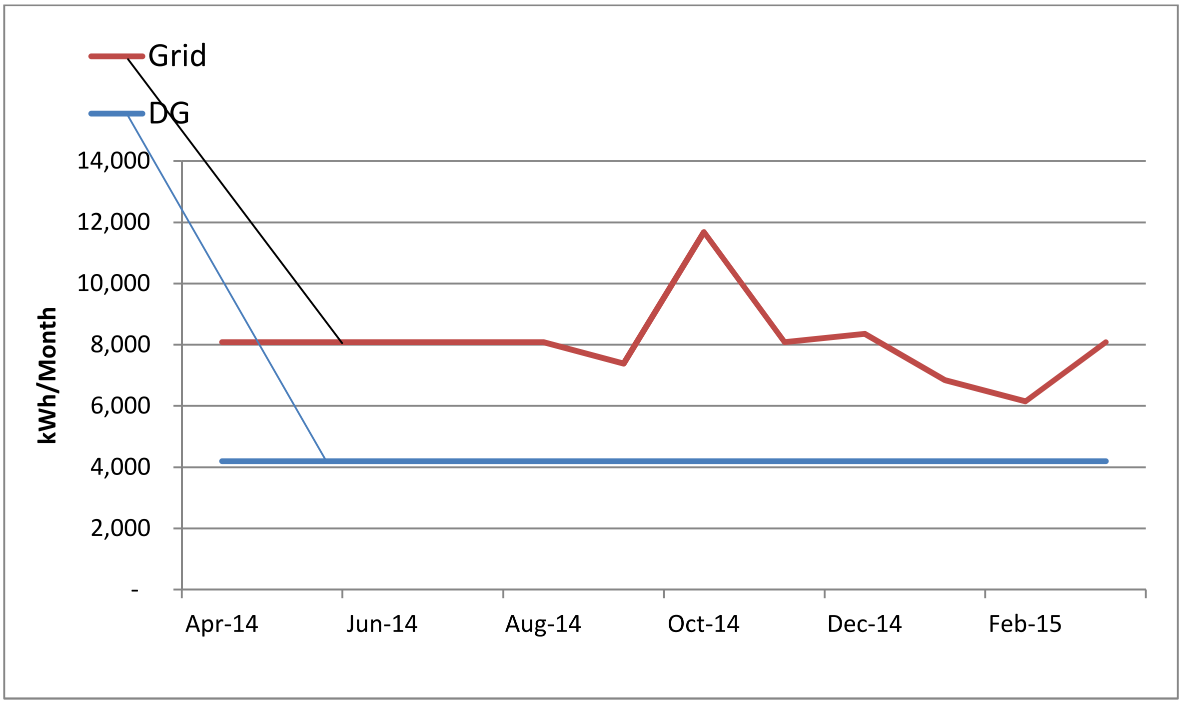


Figure 11: Month wise variation in electricity consumption from different sources

As seen from the figure above the consumption of electrical energy was high in October 2014 and low in February 2015, and was almost constant during other months. This leads to a conclusion that the production was more or less constant throughout the year except in October-2014, when production might have been high. The monthly production data was not provided by the plant.

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

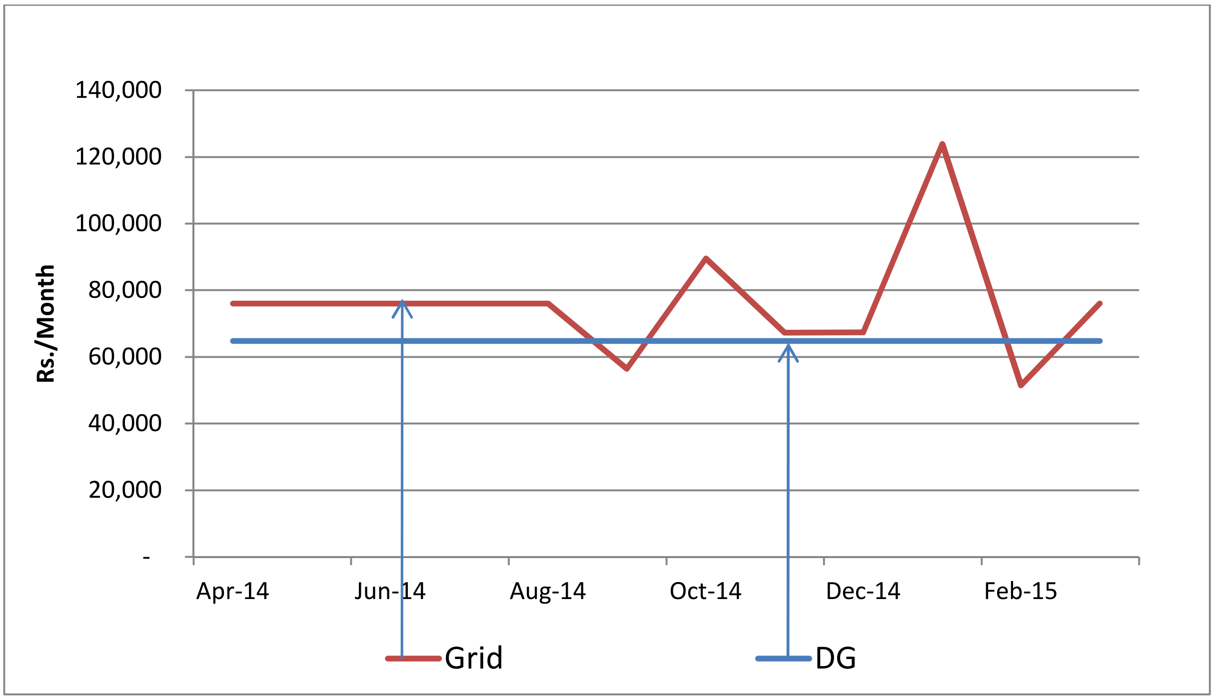


Figure 12: Month wise variation in electricity cost from different sources

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

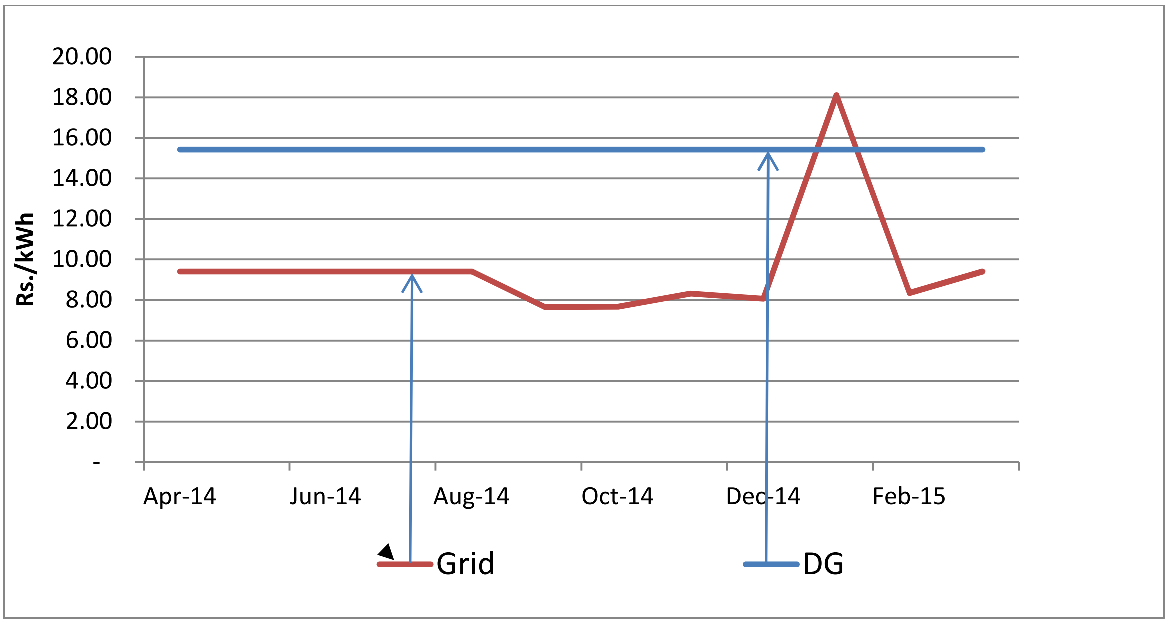


Figure 13: Average cost of power (Rs./kWh) from different sources

3.5 Analysis of thermal consumption by the unit

PNG is used as the fuel for firing ceramic materials in the kiln. PNG is supplied through pipeline from Adani Gas Limited and the average landed rate is Rs. 54/SCM. A gas flow meter is installed to measure the fuel (NG) consumption in the kiln. The data of fuel consumption and cost is given below:

Table 13: PNG used as fuel

Month	Fuel Consumption (SCM/Month)[2]	Rs/Month
Aug-14	11,210	606,934
Sep-14	13,228	716,146
Oct-14	11,401	617,252
Nov-14	10,972	594,022
Dec-14	11,512	623,241
Jan-15	12,069	653,440
Feb-15	10,162	555,644
Mar-15	9,130	450,081
Total	**89,684**	**4,816,760**

3.6 Specific energy consumption

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

Table 14: Overall specific energy consumption

Parameters	Value	UoM
Annual Grid Electricity Consumption	96,993	kWh
Annual DG Generation Unit	50,400	kWh
Annual Total Electricity Consumption	147,393	kWh
HSD Consumption for Electricity Generation	14,400	Litres
Annual Thermal Energy Consumption (PNG)	134,526	SCM
Annual Energy Consumption; MTOE	153.58	MTOE
Annual Energy Cost	89.34	Lakh Rs.
Annual Production	630	MT
SEC; Electricity from Grid	234	kWh/MT
SEC; Thermal	214	Litre/MT
SEC; Overall	0.244	MTOE/MT
SEC; Cost Based	14,181	Rs./MT

Basis for estimation of energy consumption in terms of tons of oil equivalent are as follows:

[2] Bills were not available for prior months.

- Conversion Factors
  - Electricity from the Grid : 860 kCal/Kwh
  - 1koe : 10,000 kCal
- GCV of HSD : 11,840 kCal/ kg
- Density of HSD : 0.8263 kg/litre
- GCV of PNG : 9,000 kCal/scm
- Density of PNG : 0.7 kg/scm
- CO_2 Conversion factor
  - Grid : 0.89 kg/kWh
  - HSD : 3.07 tons/ ton

3.7 Identified energy conservation measures in the plant

Diagnostic Study

A detailed study was conducted in the unit during CEA, observations on energy performance of equipments were made, and a few ideas for development of EPIAs were generated. Summary of key observations is as follows:

3.7.1 Electricity Supply from Grid

The electrical parameters at the main incomer feeder from PVVNL were recorded for 8 hours using the portable power analyzer. Following observation were made:

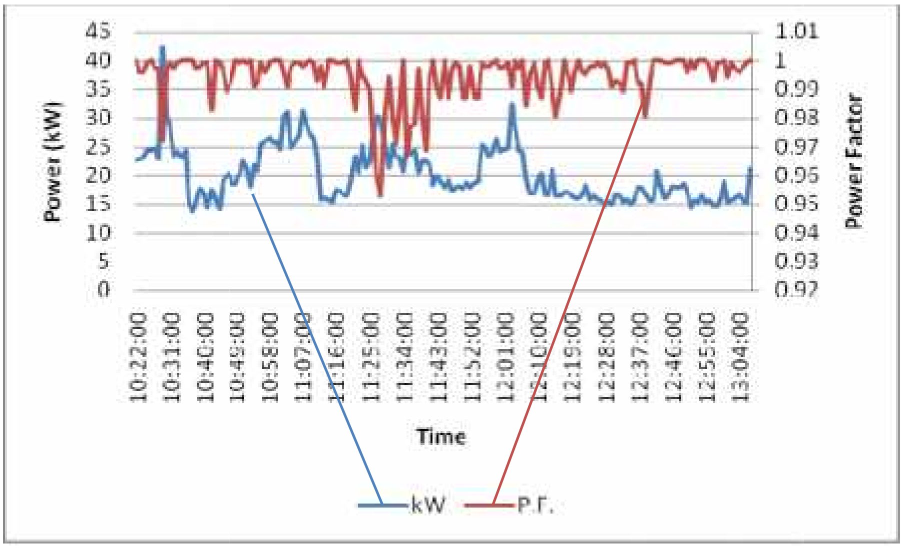


Figure 14: Load profile and power factor

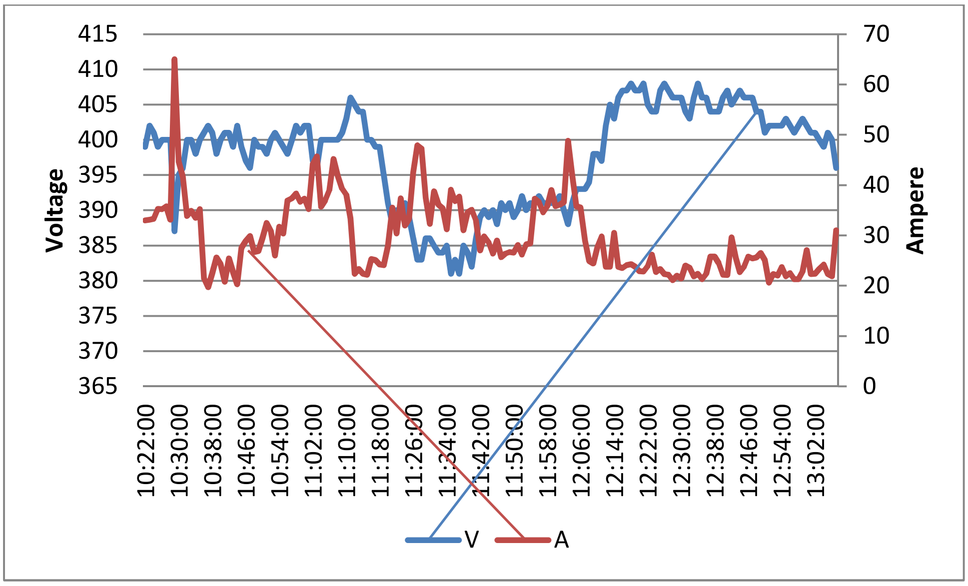


Figure 15: Voltage and current profile

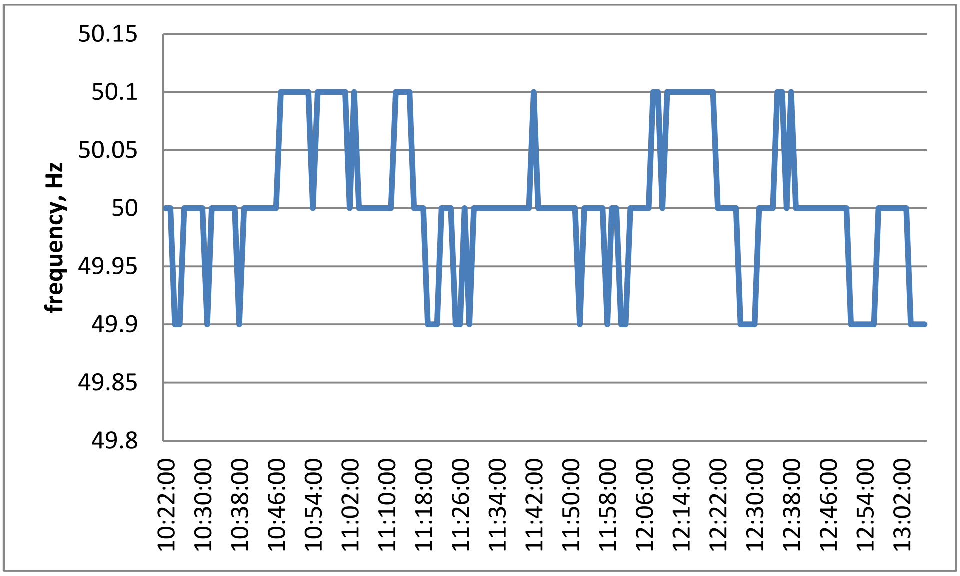


Figure 16: Harmonic profile

Table 15: Diagnosis of electric supply

Name of Area	Present Set-up	Observations during field study & measurements	Ideas for energy performance improvement actions
Electricity Demand	Power supplied to this unit is from PVVNL through a distribution transformer. The unit has one LT connection. The contract demand of the	The maximum kW recorded during study period was 42.3 kW. As per utility bill, the MD was 49.8 kVA.	No EPIAs were suggested, as only once when the production was high the demand

	unit is 39 kVA.		exceeded maximum demand limit.
Power Factor	Unit has a LT connection and billing is in kVA. The utility bills reflect the PF of the unit. The unit has installed automatic power factor correction panel for stabilizing the power factor.	The average PF found during the measurement was 0.994. And, it varied between 0.95 and 1.	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 397.9 V. Maximum voltage was 408 V and minimum was 381 V.	No EPIA's were recommended.

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

3.7.2 Electrical consumption areas

The section-wise consumption of electrical energy was developed in consultation with the unit. This is indicated in Table 6. Over 89% of energy consumption is for manufacturing operations and about 11% is in utilities.

The details of the observations, measurements conducted and 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 7 ball mills in the unit. The rated powers of these are 2 x 7.5 HP, 4 x 3 HP, 1 x 2 HP motors respectively. Ball mills account for an estimated 26% of overall energy consumption.</td><td>Out of the 7 ball mills 4 were operational during CEA and were studied.

The results of the study are below:
<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Ball Mill (100 kg)</td><td>0.5</td><td>0.48</td></tr><tr><td>Ball Mill (300 kg)</td><td>0.19</td><td>0.49</td></tr><tr><td>Ball Mill</td><td>1.50</td><td>0.99</td></tr></table></td><td>Speed optimization and energy efficient drive system has been suggested as an EPIA in the ball mill.</td></tr>
</table>

<table>
<tr>
<td></td>
<td></td>
<td><table><tr><td>(300 kg)</td><td></td><td></td></tr><tr><td>Ball Mill (100 kg)</td><td>0.96</td><td>0.99</td></tr></table></td>
<td></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 11% of total energy consumption.</td>
<td>Only one pug mill was in operation during the time of CEA. Data logging was carried out on the machine to establish the power profile.

The results of the study are as below:<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Pug mill</td><td>3.82</td><td>0.94</td></tr></table></td>
<td>Application of VFD has been suggested as an EPIA based on the loading and unloading patterns observed.</td>
</tr>
<tr>
<td>Vacuum pump</td>
<td>There are 2 vacuum pumps in the unit out of which only one could be studied during CEA. This section accounts for 11% of the total electrical energy consumption in the plant.</td>
<td>Only one vacuum pump was in operation along with the pug mill and data logging was carried out on the machine to establish the power profile.

The results of the study are as below:<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Vacuum pump</td><td>0.75</td><td>0.98</td></tr></table></td>
<td>No EPIAs were suggested for its application.</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 9% of the total electricity consumption.</td>
<td>Data logging was carried out on the blower to establish the power profile.

The results of the study are as below:<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Blower</td><td>3.58</td><td>0.99</td></tr></table></td>
<td>Excess air control by PID controller has been suggested as EPIA.</td>
</tr>
</table>

<table>
<tr>
<td>Diaphragm pump</td>
<td>The unit has 2 diaphragm pumps out of which one could be studied during the CEA. This accounts for 4% of the total electricity consumption.</td>
<td>Data logging was carried out on the diaphragm pump to establish the power profile.

The results of the study are below:
<table>
<tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr>
<tr><td>Diaphragm pump</td><td>1.02</td><td>0.99</td></tr>
</table>
</td>
<td>No EPIAs were suggested for diaphragm pump.</td>
</tr>
</table>

3.7.3 Thermal consumption areas

As discussed in the earlier section, about 76% of energy cost and 85% of energy consumption was in the tunnel 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 Minhas Pottery is PNG fired (PNG supplied by Adani Gas). The kiln has three zones as below:

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

- **Firing Zone**: Where fuel is fed and combustion happens. The temperature in firing zone is around 1220 °C to 1250 °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.

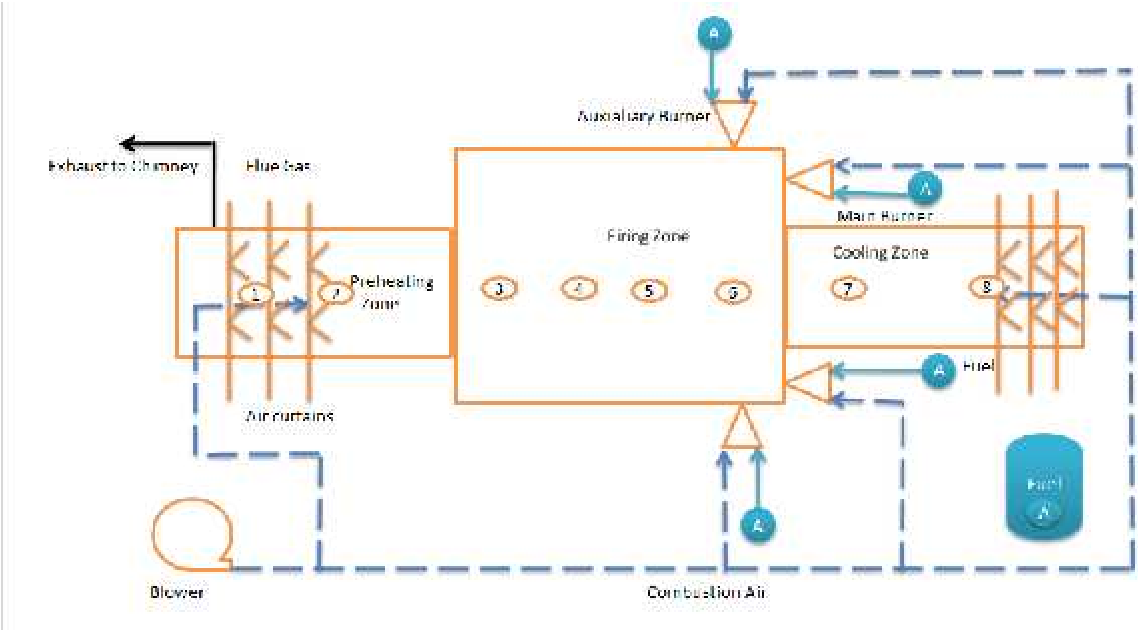


Figure 17: Tunnel Kiln

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

Table 16: Temperatures at various sections of tunnel kiln

Section of kiln	Temperature
1	216 °C
2	391 °C
3	1098 °C
4	1168 °C
5	1189 °C
6	1193 °C
7	838 °C
8	236 °C

Table 17: Dimensions of kiln

Zone	Length	Width	Height
Pre-heating	1225 cm	143 cm	138 cm
Firing	486 cm	279 cm	138 cm
Cooling	1960 cm	143 cm	138 cm

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

Observations during field Study & measurements	Proposed Energy performance

The fuel consumption of kiln has been identified by the gas meter provided by AGL.

Machine	Oxygen Level measured in Flue Gas	Ambient Air Temp	Exhaust Temperature of Flue Gas
Tunnel kiln	12.8%	37.8°C	204°C

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

The inlet temperature of raw material in the kiln was in the range of 35 – 42**°C** which was the ambient air temperature.

The exhaust temperature of flue gas in the kiln through chimney after the effect of air curtains was in the range of 95 - 205**°C** whereas just at the exit of the firing zone it was found to be 860 – 926**°C** during the CEA study.

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

improvement actions

No recommendations have been suggested, as the exit flue gas temperature is minimum and cannot be used for waste heat recovery.

Reducing the radiation and convection losses from surface of kiln by improving insulation is recommended in firing zone of kiln.

Reducing opening losses in the kiln is recommended.

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

4 EE TECHNOLOGY OPTIONS AND TECHNO – ECONOMIC FEASIBILTY

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

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

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

Technology description

A significant portion of the losses in a kiln occurs as radiation and convection loss from the kiln walls and the roof. These losses are substantially higher in areas of openings or in case of infiltration of cold air. Ideally, optimum amount of refractory and insulation should be provided on the kiln walls and the roof to maintain the skin temperature of the furnace at around 45-50°Cin order 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 th range of radiative influence.

Kiln walls are designed in combination of refractories and insulation layers, with the objective of retaining maximum heat inside the kiln and 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 all 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, but on measurement it was found to be 81.63°C. Hence, the kiln surface needs to be properly insulated to keep the surface temperature within the specified range.

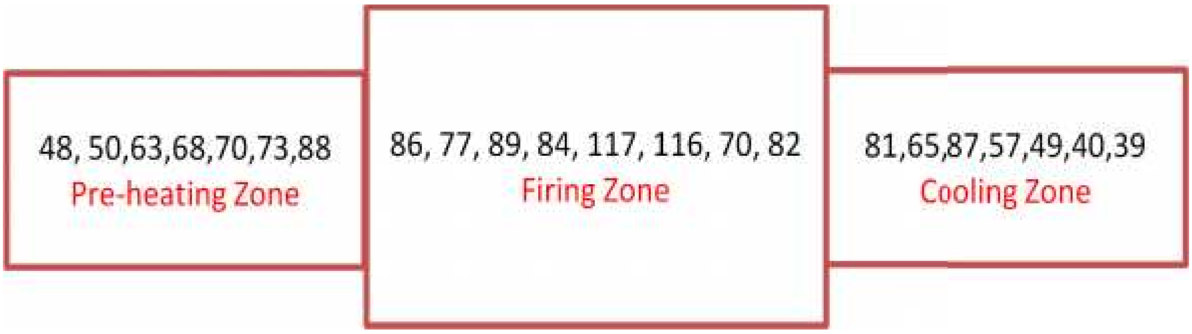


Figure 18: Masured skin temperatures of kiln (deg C)

Recommended action

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

Table 19: R & C losses

Total radiation and convection heat loss per hour	Units	Value
Pre-Heating Zone	kCal / hr	2,356
Firing Zone	kCal / hr	3,995
Cooling Zone	kCal / hr	6,915
Total R&C loss	kCal / hr	13,267

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

Table 20: Cost benefit analysis (EPIA 1)

Parameters	UoM	Value
Present average skin temperature of Firing zone	deg. C	81.63
Recommended skin temperature of Firing Zone	deg. C	50.00
Present heat loss due to Radiation & Convection from Work side wall	kCal / hr	3,995
Recommended heat loss due to Radiation & Convection from Firing zone	W / m2	69.78
	kCal / m2	60.01
	kCal / hr	805
Total reduction in heat loss due to Radiation & convection by limiting skin temperature at Firing zone	kCal / hr	3190
Calorific value of Fuel	kCal / SCM	13,928
Equivalent savings in Fuel	kg / hr	0.23
	Nm3 / hr	
Plant running time	days / y	300

	hrs / day	24
Annual savings in Fuel	kg/y	1649
Cost of fuel	Rs /kg	76.97
Annual Monitory savings	Rs/y	126946
	Rs. Lakhs/y	1.27
Estimated investment	Rs. Lakhs	0.16

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 whereas 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. This also results in the formation of excess GHG emissions.

A PID controller, if installed, will measure the oxygen levels in the flue gases at the exit of the kiln and based on that the combustion air flow from FD fan (blower) can be regulated. Subsequently, proper temperature and optimum excess air for combustion can be attained in the kiln.

Study and investigation

At the time of CEA, there was no proper automation and control system installed in the kiln to monitor and maintain optimum excess air levels. Fuel was fired from the existing burner system and no air flow control mechanism was in place for maintaining proper combustion of the fuel. The combustion air and cooling air (through air curtains) were being supplied from the same FD fan. The pressures required for combustion and for cooling air were different and supplying both 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 energy conservation measure is given below:

Table 21: Cost benefit analysis (EPIA 2)

Parameters	UOM	Present	Proposed
Oxygen level in flue gas	%	12.80	3.00
Excess air control	%	156.10	16.67
Dry flue gas loss	%	13.32	
Saving in fuel	With every 10% reduction in excess air leads to a saving in specific fuel consumption by 1%		
Specific fuel consumption	kg/t	149.47	128.63
Saving in specific fuel consumption	kg/h		1.82
Saving in fuel conumption per year	kg/y		13130
Savings in fuel cost	Rs. Lakh/y		10.11
Installed capacity of blower	kW	7.46	5.97
Running load of blower	kW	3.58	4.18
Operating hours	hrs/y	7200.00	7200.00
Electrical energy consumed	kWh/y	25779.75	30078.72
Savings in electrical energy	kWh/y		-4299
Cost of electrical energy	Rs. Lakh/y	3.01	3.51
Savings in terms of energy cost	Rs. Lakh/Y		9.60
Estimated investment	Rs. lakh		7.00
Simple payback	y		0.73

4.3 EPIA 3: Replacement of kiln car

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, which reduces the kiln efficiency. Instead of the present kiln car material, a new material called ultralite[3] can be used in the kiln car construction, which will help in reducing its dead weight. This will also help in reducing kiln losses due to useful heat carried away by the kiln car, as this material has lesser specific heat.

Study and investigation

Presently, the kiln car used in the unit is made up of HFK bricks, quadrite tiles and pillars. All these materials contribute to a dead weight (of kiln car) of 426 kg. The ceramic materials to be fired are placed on the kiln car on make-shift racks and this kiln car travels all along the length of the kiln from pre-heating zone to heating (or firing) zone to cooling zone. The kiln car also gains useful heat that is supplied by fuel to heat the ceramic materials and they carry the same with them out of the kiln. The heat gained by kiln car is wastage of useful heat supplied, as the heat is being supplied to heat the

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

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 a 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 in reducing the dead weight of the kiln car, thereby reducing the heat gained by the same and also help in reduction in fuel consumption in the kiln by approximately 30%. The cost benefit analysis for the EPIA is given in the table below:

Table 22: Cost benefit analysis (EPIA 3)

Parameters	UoM	Present	Proposed
Present Production of kiln	tph	0.09	0.09
Weight of existing kiln car	kg	426	298
Total number of kiln cars inside kiln[4]	Nos.	24	24
Initial temperature of kiln car	Deg c	37.8	37.8
Final temperature of kiln car	Deg c	1,168	1,168
Estimated percentage saving by replacing present kiln car with new EE kiln car	%		30
Heat carried away by the kiln material	kcal/h	102,938	72,057
Reduction in heat carried by the new EE kiln car	kcal/h		30,881
Operating hours of kiln	h	7,200	7,200
Savings in terms of fuel consumption	Litre/y		15,964
Savings in terms of cost	Rs. lakh/y		12.3
Estimated investment of kiln car material	Rs. lakh/y		4.80
Payback period	y		0.4

4.4 EPIA 4: VFD on pug mill motor

Technology description

For fluctuating loads it is always recommended to install a variable frequency drive (VFD) to control the speed of the motor. A VFD will reduce the power consumption according to the load variation in the motor. During loading periods, the current drawn by the pug mill is high. During no load / unloading periods, the pug mill motor draws higher current than required. Installation of a VFD will

[4] Residence time for each kiln car inside the kiln is 24 hours.

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:

Table 23: Cost benefit analysis (EPIA 4)

Parameters	Unit	Present	Proposed
Installed capacity of motor	kW	6	5.60
Estimated energy saving by installing VFD on (Pug-Mill motor)	%		20
Average power consumption	kW	3.8	3.0
No of operating hrs per day	h	16	16
Operating Days per Year	Days	300	300
Average electricity consumption per year	kWh	18,327	14,662
Annual electricity savings	kWh/y		3,665
Average electricity tariff	Rs/kWh	11.66	11.66
Annual savings in terms of cost	Rs.lakh		0.43
Estimated investment	Rs.lakh		0.6
Simple Payback	y		1.4

4.5 EPIA 5: Energy efficient drive system

Technology description

All ball mills 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 of ceramic industry.

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. This will help in reducing electricity consumption.

Study and investigation

It was observed during the CEA that the critical speed of ball mill (with motor rating of 7.5 HP) was more than the normal operating speed.

Recommended action

It is recommended to install VFD on the ball mill to control its speed based on its loading. This will ensure reduction in energy consumption. The cost benefit analysis of installing VFD on ball mills and the resulting energy savings due to the same is given in the table below:

Table 24: Cost benefit analysis (EPIA 5)

Parameters	UoM	Present	Proposed
Ball Mill ID	m	2.50	2.50
Ball Mill ID	ft	8.20	8.20
Ball Mill critical speed	rpm		27
Ball Mill speed	rpm	20	19
Installed capacity of motor	kW	5.60	5.595
Average power consumption	kW	3.9	3.0
No of operating hours per day	hrs	20	20
Operating Days per Year	days	300	300
Average electricity consumption per year	kWh	23,499	19,308
Annual electricity savings	kWh/y		4,191
Average electricity tariff	Rs./kWh	11.66	11.66
Annual saving in terms of cost	lakh Rs.		0.49
Estimated investment	lakh Rs.		0.7
Simple payback	y		1.4

4.6 EPIA 6 & 7: Energy efficient light fixture

Technology description

Replacing conventional lights like T-12s, T-8s, CFLs, incandescent lamps, etc with LED lights helps in reducing power consumption and also results in higher illumination (lux) levels for the same power consumption. Maintaining proper illumination levels is very much essential in pottery, crockery and stone-ware manufacturing ceramic units, as the work involves precise hand paintings by artisans. Maintaining good illumination levels will result in proper visibility for the workers and will help in reduction of faulty hand paintings, etc thus reducing wastages of materials.

Study and investigation

The unit is having 40 T12 tube lights, 5 numbers of 45 W CFLs and 10 numbers of 23 W CFLs.

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 25: Cost benefit analysis (EPIA 6 – Tube light replacement)

Parameters	UoM	Present	Proposed
Fixture		T12 tube light	LED tube light
Power consumed by T12	W	40	18
Power consumed by Ballast	W	12	0
Total power consumption	W	52	18
Operating Hours/day	Hr	18	18
Annual days of operation	Day	300	300
Energy Used per year/fixture	kWh	281	97
Energy Rate	Rs/kWh	11.66	11.66
No. of Fixture	Unit	40	40
Power consumption per year	kWh/y	11,232	3,888
Operating cost per year	Rs. Lakh/y	1.31	0.45
Savings in terms of electrical energy	kWh/y		7,344
Savings in terms of cost	Rs. Lakh/y		0.86
Investment per fixture of LED	Rs. Lakh		0.0075
Investment of project	Rs. Lakh		0.3
Payback period	y		0.35

Table 26: Cost benefit analysis (EPIA 7- CFL replacement)

Parameters	UoM	Present	Proposed
Fixture		CFL	LED tube light
Power consumed by CFL (45 W)	W	45	15
No. of fixtures	Nos	5	5
Power consumed by CFL (23 W)	W	23	10
No. of fixtures	Nos.	10	10
Total power consumption	kW	0.46	0.18
Operating Hours/day	Hr	18	18
Annual days of operation	Day	300	300
Energy Used per year/fixture	kWh	2,457	945
Energy Rate	Rs/kWh	11.66	11.66
Operating cost per year	Rs. Lakh/y	0.29	0.11
Saving in terms of electrical energy	kWh/y		1512

Savings in terms of cost	Rs. Lakh/y	0.18
Investment per fixture of LED	Rs. Lakh	0.16
Investment of project	Rs. Lakh	0.16
Payback period	y	0.88

4.7 EPIA 8: Replacing conventional ceiling fans with Energy efficient fans

Technology description

Replacing old fans of conventional types installed in various sections of the plant with energy efficient fans will reduce 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 ceiling fans are used in the ceramic units for drying purposes, the energy efficient fans can be best suited for energy conservation.

Study and investigation

The unit is having about 40 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 27: Cost benefit analysis (EPIA 8)

Data & Assumptions	UOM	Present	Proposed
Number of ceiling fans in the plant	Nos	40	40
Running hours per day (avg.) - for fans	h / 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	11.66	11.66
Fan unit price	Rs./piece	1,500	3,000
Electricity consumption			
Electricity demand	kW	2.80	1.40
Power consumption by fans in a year	kWh/y	15,120	7,560
Savings in terms of power consumption	kWh/y		7,560
Savings in terms of cost	Rs. Lakh/y		0.88
Estimated investment	Rs. Lakh/y		1.20
Payback period	y		1.36

4.8 EPIA 9: Energy monitoring system

Technology description

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

Study and investigation

It was observed during the audit that, online data measurement is not done on the main incomer as well as at various electrical panels for the energy consumption. It was also noticed that there were no proper fuel monitoring systems 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. 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 28: Cost benefit analysis (EPIA 9 – fuel)

Parameters	Unit	Present	Proposed
Energy monitoring saving for electrical system	%		3.00
Energy consumption of major machines per year	kWh/y	96,993	94,083
Annual electricity savings per year	kWh/y		2,910
W. Average Electricity Tariff	Rs/kWh		11.66
Annual monetary savings	Rs. lakh/y		0.34
Estimate of Investment	Rs. lakh		0.25
Simple Payback	Y		0.74
Current fuel mix consumption	kg/y	94,168	91,343
Annual fuel savings per year	kg/y		2,825
Unit Cost of PNG	Rs./kg		76.97
Annual monetary savings	Rs. lakh/y		2.17
Estimate of Investment	Rs. lakh		0.20
Simple Payback	y		0.09

Table 29: Cost benefit analysis (EPIA 9 - DG)

Parameters	Unit	Present	Proposed

Energy monitoring savings for DG fuel consumption meter	%		3.00
Current fuel consumption	litrer/y	14,400	13,968
Annual fuel savings per year	litre/y		432
HSD cost per unit	Rs./litre	54	54
Savings in terms of cost	Rs. Lakh		0.23
Investment for the DG fuel consumption meter	Rs. Lakh		0.15

4.9 EPIA 10: Reduction in compressed air generation pressure

Technology description

Compressed air is one of the most costly utility for any production process. In ceramic industry, compressors are used to generate compressed air for cleaning the materials before they are glazed to remove dust particles from them. For the purpose of cleaning, very high pressure compressed air is not necessary. Further, the pressure difference between cut-in (loading) and cut-out (unloading) pressures should be set at an optimum value of 1 to 1.02 kg/cm2. Too low pressure difference would lead to motor burn-outs and too high pressure difference would lead to higher energy consumption. A pressure difference setting between cut-in and cut-out pressure of 1.02 kg / cm2 could result in energy savings of up to 6%.

Study and investigation

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

Recommended action

As a good energy efficient practice, a pressure difference of 1.02 kg/cm2 needs to be maintained between cut-in and cut-out compressed air pressures. This will result in reduced energy consumption for compressed air generation. It is recommended that the existing cut-out pressure setting of 7.5 kg/cm2 be lowered to 6 kg/cm2 which will reduce the energy consumption by 9% (approx.) as per BEE guidelines. The cost benefit analysis is given in the table below:

Table 30: Cost benefit analysis (EPIA 10)

Parameters	UoM	Present	Proposed
Operating Pressure Required	kg/cm^2	10	8
Cut off pressure	kg/cm^2	14	10
Reduction in pressure	kg/cm^2		4
% of energy savings	%	-	24
Average load	kW	5.2	3.97
Average working of compressor hours in a day	h	18	18
Average working days of compressor in a year	days	300	300
Energy consumption	kWh	28,199	21,431

Energy savings	kWh	-	6,768
W. Avg cost of electricity	Rs./kWh		11.66
Monetary savings	Lakh Rs./y	-	0.79
Investment	Lakh Rs.	-	0.05
Payback	y		0.06

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

Technology description

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

Study and investigation

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

Recommended action

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

Table 31 Cost benefit analysis (EPIA 11)

Sl. No.	Replacing persent burners with energy efficient burners		Kiln	
	Parameters	Unit	Present	Proposed
1	Production rate of the kiln	kg/hr	88	88
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	13	12
7	Savings in fuel per hours	kg/hr		0.65
7	Number of operating days	days	300	300
8	Number of operating hours per day	hrs	24	24
9	Total savings per year into fuel firing	kg/yr		4708
10	Unit cost of fuel	Rs./kg		76.97
11	Cost savings per year	Lakh Rs./yr		3.62
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

MINHAS POTTERY

C-1 INDUSTRIAL ESTATE, G. T. ROAD, KHURJA 203131 (U.P.) INDIA

Date: 6/04/2015

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,

FOR MINHAS POTTERY

PROPRIETOR

Name & signature of unit head

Phones : (05738) 294200 FAX : 05738-249685 E-mail : mguljeet@yahoo.com / sales@khurjaceramics.com
Visit us at : www.khurjaceramics.com

Kiln efficiency calculations

Input parameters

Parameters	Value	UoM
Tunnel Kiln Operating temperature (Firing Zone)	1,168	*Deg C*
Initial temperature of kiln car	37.8	*Deg C*
Avg. fuel Consumption	13.1	*kg/hr*
Flue Gas Details		
Flue gas temperature after APH	204	*deg C*
Preheated air temperature/Ambient	37.8	*deg C*
O2 in flue gas	12.8	*%*
CO2 in flue gas	8.1	*%*
CO in flue gas	24	*ppm*
Atmospheric Air		
Ambient Temperature	37.8	*Deg C*
Relative Humidity	47	*%*
Humidity in ambient air	0.03	*kg/kgdry air*
Fuel Analysis		
C	*74.57*	%
H	*24.70*	%
N	*0.72*	%
O	*0.00*	%
S	*0.01*	%
Moisture	*0.0*	%
Ash	*0.00*	%
GCV of PNG	*13,928*	kcal/kg
Ash Analysis		
Unburnt in bottom ash	*0.00*	%
Unburnt in fly ash	*0.00*	%
GCV of bottom ash	*0*	kcal/kg
GCV of fly ash	*0*	kcal/kg
Material and flue gas data		
Weight of Kiln car material	426	*Kg/Hr*
Weight of ceramic material being fired in Kiln	88	*Kg/Hr*
Weight of Stock	88	*kg/hr*
Specific heat of clay material	0.22	*Kcal/kgdegC*
Specific heat of kiln car material	0.21	*Kcal/kgdegC*
Avg. specific heat of fuel	0.559	*Kcal/kgdegC*

fuel temp[5]	37.8	*deg C*
Specific heat of flue gas	0.26	*Kcal/kgdegC*
Specific heat of superheated vapour	0.45	*Kcal/kgdegC*
Heat loss from surfaces of various zones		
Radiation and from preheating zone surface	2,356	*kcal/hr*
Radiation and from firing zone surface	3,995	*kcal/hr*
Radiation and from cooling zone surface	6,915	*kcal/hr*
Heat loss from all zones	13,267	*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	*m2*
Coefficient based on profile of kiln opening	0.7	
Max operating temp. of kiln	338	*deg K*

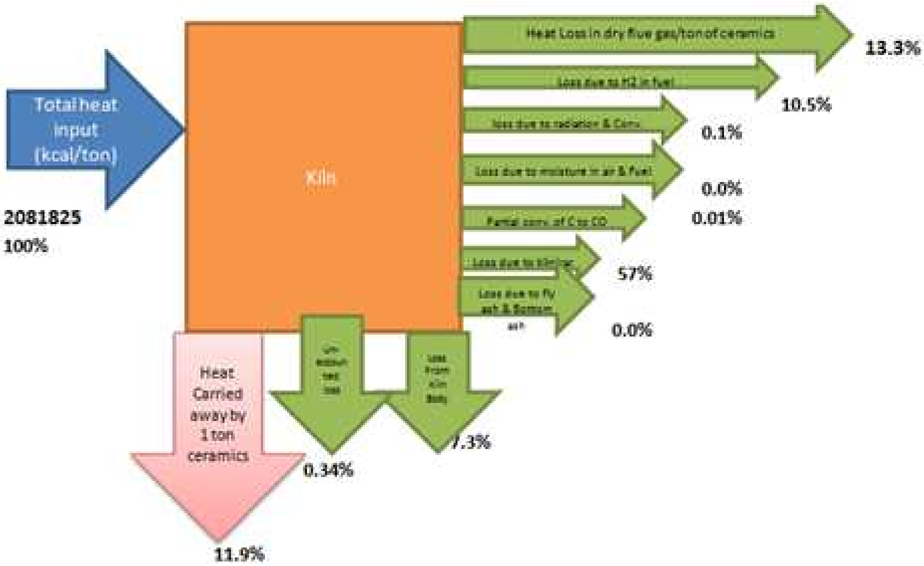
Efficiency calculations

Calculations	Values	UoM
Theoretical Air Required	17.25	*kg/kg of fuel*
Excess Air supplied	156.10	*%*
Actual Mass of Supplied Air	44.17	*kg/kg of fuel*
Mass of dry flue gas	42.94	*kg/kg of fuel*
Amount of Wet flue gas	45.17	*Kg of flue gas/kg of fuel*
Amount of water vapour in flue gas	2.22	*Kg of H2O/kg of fuel*
Amount of dry flue gas	42.94	*kg/kg of fuel*
Specific Fuel consumption	149.47	*kg of fuel/ton of ceramics*
Heat Input Calculations		
Total heat input	2,081,825	*Kcal/ton of ceramics*
Heat Output Calculations		
Heat carried away by 1 ton of ceramics (useful heat)	248,644	*Kcal/ton of ceramics*
Heat loss in dry flue gas per ton of ceramics	277,376	*Kcal/ton of ceramics*
Loss due to H2 in fuel	218,901	*Kcal/ton of ceramics*
Loss due to moisture in combustion air	99	*Kcal/ton of ceramics*
Loss due to partial conversion of C to CO	187	*Kcal/ton of ceramics*

[5] 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.

Loss due to convection and radiation (openings in kiln - inlet & outlet of kiln car)	1,453	*Kcal/ton of ceramics*
Loss Due to Evaporation of Moisture Present in Fuel	0.0	*Kcal/ton of ceramics*
Total heat loss from kiln (surface) body	151,617	*Kcal/ton of ceramics*
Heat loss due to unburnts in Fly ash	0	*Kcal/ton of ceramics*
Heat loss due to unburnts in bottom ash	0	*Kcal/ton of ceramics*
Heat loss due to kiln car	1,176,438	*Kcal/ton of ceramics*
Unaccounted heat losses	7110	*Kcal/ton of ceramics*
Heat loss from kiln body and other sections		
Total heat loss from kiln	151,617	*Kcal/tons*
Kiln Efficiency	**11.9**	*%*

Sankey diagram



6 LIST OF VENDORS

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

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

EPIA 2: Excess Air Control

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

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

EPIA 3: Replacement of kiln car material

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	INTERKILN INDUSTRIES LTD.	Sanghavi Chambers, Beside Canara Bank, Navrangpura ,Ahmedabad	+91-79-30911069 079-6438180	ik@interkiln.com

EPIA 4: VFD on pug mill motor

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

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

EPIA 6 & 7: Energy efficient light

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Osram Electricals Contact Person: Mr. Vinay Bharti	OSRAM India Private Limited,Signature Towers, 11th Floor,Tower B, South City - 1,122001 Gurgaon, Haryana	Phone: 011-30416390 Mob: 9560215888	vinay.bharti@osram.com
2	Philips Electronics Contact Person: Mr. R. Nandakishore	1st Floor Watika Atrium, DLF Golf Course Road, Sector 53, Sector 53 Gurgaon, Haryana 122002	9810997486, 9818712322(Yogesh-Area Manager), 9810495473(Sandeep-Faridabad)	r.nandakishore@phillips.com, sandeep.raina@phillips.com
3	Bajaj Electricals Contact Person: Mr. Kushgra Kishore	Bajaj Electricals Ltd,1/10, Asaf Ali Road, New Delhi 110 002	9717100273, 011-25804644 Fax : 011-23230214 ,011-23503700, 9811801341(Mr.Rahul Khare), (9899660832)Mr.Atul Baluja, Garving Gaur(9717100273),9810461907(Kapil)	kushagra.kishore@bajajelectricals.com, kushagrakishore@gmail.com; sanjay.adlakha@bajajelectricals.com

EPIA 8: Replacing conventional ceiling fans with energy efficient fans

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

EPIA 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 11: Installation of EE Burners

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

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