Promoting EE & RE in Selected MSME Clusters in India – Morbi Cluster

DELIVERABLE 4: COMPREHENSIVE ENERGY AUDIT REPORT

UNIT CODE WT-36: SENIS CERAMIC PVT. LTD.

Submitted to

GEF-UNIDO-BEE Project Management Unit

BUREAU OF ENERGY EFFICIENCY

Submitted by

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This **Comprehensive Energy Audit Report** has been originally prepared by **Development Environergy Services Ltd.** as a part of '**Promoting EE & RE in Selected MSME Clusters in India – Morbi Cluster'** activity under the GEF-UNIDO-BEE project 'Promoting Energy Efficiency and Renewable Energy in selected MSME clusters in India'.

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Disclaimer

This **Comprehensive Energy Audit Report** is an output of an exercise undertaken by **Development Environergy Services Ltd.** (DESL) under the GEF-UNIDO-BEE project's initiative for the benefit of MSME units and is primarily intended to assist and build the capability of decision making by the management of MSME units for implementation of EE & RE technologies, BOP etc. While every effort has been made to avoid any mistakes or omissions. However, GEF, UNIDO, BEE or DESL would not be in any way liable to any person or unit or other entity by reason of any mistake/omission in the document or any decision made upon relying on this document.

ACKNOWLEDGEMENT

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1. Mr. Kennit Suresh
2. Mr. Niranjan Rao Deevela
3. Mr. Vamsi Krishna
4. Mr. Vijay Mishra

DESL is indebted to M/s. Senis Ceramic Pvt. Ltd. and their management for showing keen interest in the energy audit and their wholehearted support and cooperation for the preparation of this comprehensive energy audit report, without which the study would not have steered to its successful completion. Special thanks to following members of the unit for their diligent involvement and cooperation.

Mr. Girish Patel, Partner

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

We also acknowledge the support from Morbi Ceramics Association throughout the study.

DESL Team

Project Head	R Rajmohan, Chief Executive Officer
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ABBREVIATIONS

Abbreviations	Expansions
APFC	Automatic Power Factor Controller
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
BOP	Best operating practice
CGCRI	Central Glass and Ceramic Research Institute
CMP	Common monitor able parameters
DESL	Development Environergy Services Limited
ECM	Energy Conservation Measure
EE	Energy efficiency
FI	Financial institutions
FT	Floor tile
GEF	Global Environmental Facility
GPCB	Gujarat State Pollution Control Board
IRR	Internal Rate of Return
LPG	Liquefied Petroleum Gas
MCA	Morbi Ceramic Association
MSME	Micro, Small and Medium Enterprises
NPV	Net Present Value
PG	Producer Gas
PMU	Project Management Unit
PV	Photo Voltaic
SEC	Specific energy consumption
SP	Sanitary ware products
RE	Renewable energy
UNIDO	United Nations Industrial Development Organization
VFD	Variable frequency drive
VT	Vitrified tile
WH	Waste heat
WHR	Waste heat recovery
WT	Wall tile

UNITS AND MEASURES

Parameters	Unit of Measurement (UOM)
Calorific value	CV
Degree Centigrade	^0C
Horse power	Hp
Hour(s)	H
Hours per year	h/y
Indian Rupee	INR/Rs.
Kilo Calorie	kCal
Kilo gram	Kg
Kilo volt	kV
Kilo volt ampere	kVA
Kilo watt	kW
Kilo watt hour	kWh
Kilogram	Kg
Litre	L
Meter	M
Meter Square	m^2
Metric Ton	MT
Oil Equivalent	OE
Standard Cubic Meter	scm
Ton	T
Tons of Oil Equivalent	TOE
Ton of CO_2	tCO_2
Ton per Hour	t/h
Ton per Year	t/y
Voltage	V
Watt	W
Year(s)	Y

CONVERSION FACTORS

TOE Conversion	Value	Unit	Value	Unit
Electricity	1	kWh	0.000086	TOE/kWh
Coal	1	MT	0.45	TOE/MT
Natural Gas	1	scm	0.00089	TOE/scm
Emissions				
Electricity	1	kWh	0.00082	tCO_2/kWh
Coal	1	MT	2.116	tCO_2/t
Natural Gas	1	scm	0.001923	tCO_2/scm

EXECUTIVE SUMMARY

The Bureau of Energy Efficiency (BEE) in collaboration with United Nations Industrial Development Organization (UNIDO) is working on the Global Environment Facility (GEF) funded project titled - 'Promoting Energy Efficiency and Renewable Energy in Selected MSME Clusters in India', which aims to give impetus to the energy efficiency initiatives in the small and medium enterprises (SMEs) sector in India. The objective of the program is development and promotion of energy efficiency and enhanced use of renewable energy in 12 selected energy-intensive MSME clusters, identified on the basis of their total energy utilization and energy-intensity levels. The project will provide solutions to certain technological as well as policy level barriers in implementation of energy efficient technologies in the MSME sector. Development Environergy Services Ltd. (DESL) has been engaged to lend project development support for the Morbi Ceramic Cluster in Gujarat.

The assignment targets ceramic industries in four (4) major product categories viz. sanitary products, floor tiles, wall tiles and vitrified tiles. Based on walk through audit and questionnaire survey of several ceramic manufacturing industries, 20 units have been shortlisted by BEE and UNIDO in consultation and discussion with the Morbi Ceramic Association (MCA) to conduct detailed energy audits.

Senis Ceramic Pvt. Ltd has been selected as one of the 20 units for detailed energy audit. Senis Ceramic is a wall tile manufacturing unit. This report has been prepared as an outcome of energy audit activities carried out in the unit.

➨ INTRODUCTION OF THE UNIT

Name of the Unit	Senis Ceramic Pvt. Ltd.
Year of Establishment	2007
Address	Behind GSPL Gas Tarminal, Lakhdhirpur Road, Morbi - 363642
Products Manufactured	Wall Tiles
Name(s) of the Promoters / Directors	Mr. Girish Patel

➨ DETAILED ENERGY AUDIT

The study was conducted in three stages:

- **Stage 1:** Walk through energy audit of the plant to understand 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 unit and freezing of projects for implementation and preparation of comprehensive energy audit report

➨ PRODUCTION PROCESS OF THE UNIT

A brief description of the manufacturing process is given below. The main energy utilizing equipment is the kiln, which operates on coal gas. The temperature maintained in kiln is approximate 1,150 – 1,200°C (in the heating zone). The other equipment installed includes:

- **Storage Silo:** Raw material, clay power is coming from outside and stored in silos tank.
- **Hydraulic Press:** The required shapes of the final product are made in hydraulic press. Here the product is called biscuit.
- **Dryer:** Biscuits are sent to biscuit dryer for pre drying after it is passed through kiln-1.
- **Glaze ball mill:** For producing glazing material used on the product.
- **Kiln:** Biscuits are baked in the roller kiln at 1100-1150°C and again baked after glazing
- **Sizing:** After cutting, sizing and polishing, tiles are packed in boxes and then dispatched.

The main utility equipment installed is:

- **Air Compressor:** Pressurized air is used at several locations in a unit viz. pressing of slurry, air cleaning, glazing etc.

The detailed energy audit covered all equipment which was operational during the field study.

➨ IDENTIFIED ENERGY CONSERVATION MEASURES

The identified energy conservation measures include the following:

- Excess air control in kiln 2: Natural gas (NG) is used as fuel in kiln and oxygen content in flue gas was found to be 8.4% against desired level of 3%. It is recommended to install two separate blowers for combustion air and cooling air along with control system to regulate the excess air for proper combustion.
- Preheating of combustion air through recuperator: Presently, The recuperator is bypassed, the combustion air temperature to kiln-1 is 53°C. It is recommended to take recuperator into service to increase combustion air temperature upto 145 °C.
- PID Controller at water circulation pump for press: Cooling water pump is running continuously irrespective of the operation of the press. It is recommended to install PID based controller which will ensure that pump will start only when oil temperature is >38°C.
- Retrofit of VFD in Compressor #1: During unload condition; compressor is consuming 30% without doing work. A VFD can take care variable air demand by changing RPM of compressor and will help to save energy upto 15% of present consumption.
- Replacement of inefficient lighting systems: Conventional lights like Fluorescent Tube lights and Compact fluorescent light were present in unit which results in higher electrical consumption. It is recommended to replace the conventional lights with energy efficient LED lamps.
- Cable loss minimization: In sizing section, power factor was 0.60. It is recommended to install power factor improvement capacitors for sizing section.

- Voltage optimization in lighting circuits: The present voltage for lighting circuit was found to be 416V against desired voltage of 380V. It is recommended to install separate lighting transformer of 60kVA rating for lighting circuit.
- Contract Demand Reduction: The contract demand in kVA of plant as per electricity bill was 900 but billing demand is quiet low around 765 kVA. It is recommended to reduce in contract demand upto 700, this will cause saving of around 15 %.
- Replacement of V belt to REC belt: All blowers used in both kilns are V belt driven. These belts were consuming more power. So it is recommended to replace V belt to raw edge cogged belt which result in 3.6 % of energy saving.
- Energy Management system: Online data measurement is not done on the main incomer as well as at various electrical panels for the energy consumption and there were no proper fuel monitoring system installed at hot air generator, coal gasifier and kiln. It is recommended to install online electrical energy management systems (smart energy meters) on the main incomer and on the various electricity distribution panels and fuel monitoring system.
- Installation of 20kW solar PV has been recommended at the available roof space above administration building

The following table summarizes the quantity of resource saved, monetary savings, investment and payback period of the measures.

Table 1: Summary of ECM

Sr. No.	Energy Performance Improvement Action (EPIA)	Annual Energy Savings			Investment Cost	Monetary Energy Cost Saving	Payback Period	Annual Emission Reduction
		Electricity	NG	Total				
		kWh/y	SCM/y	TOE/y	Rs lakh	Rs. Lakh	Months	Tons of CO_2/y
1	Excess Air Control in Kiln 2	26,454	140,760	128.96	18.48	47.74	2	287
2	Combustion Air through Recuperator		71,983	64.78	-	23.46	Immediate	136
3	Temperature Controller Press CT Pump	230,850		19.85	0.30	16.38	0.2	189
4	Screw Compressor with VFD	23,952		2.06	1.47	1.70	10	20
5	General Lights to LED Lights Replacement	3,132		0.27	0.23	0.22	13	3
6	Cable loss minimization	1,122		0.10	0.27	0.17	19	1
7	Voltage optimization for Lights	38,078		3.27	1.16	2.62	5	31
8	Contract Demand Reduction				0.13	5.30	0.3	0
9	V- Belt to REC Belt Replacement in Glaze & Biscuit Kilns	10,948		0.94	0.16	0.78	2	9
10	Energy Management system	56,577	62,795	61.38	3.12	24.48	2	165
	Total	**3,91,113**	**2,75,537**	**282**	**25**	**123**	**2**	**840**

The recommendations, when implemented, will enable the following improvements:

- Reduction in energy cost by 10 %.
- Reduction in electricity consumption by 13 %
- Reduction in thermal energy consumption by 8%
- Reduction in greenhouse gas emissions by 36%

➨ FINANCIAL ANALYSIS

Summary of financial indicators of the each recommendation is summarized in the table below. The IRR and discounted payback period has been calculated considering a five-year period.

Table 2 Financial indicators

Sl No	Energy Conservation Measure	Investment	IRR	Discounted Payback Period
		Lakh Rs	%	Months
1	Excess Air Control in Kilns	18.48	202	1.8
2	Combustion Air through Recuperator	-	-	-
3	Temperature Controller Press CT Pump	0.30	4050	0.09
4	Screw Compressor with VFD	1.47	87	4.00
5	General Lights to LED Lights Replacement	0.23	87	4.17
6	Cable loss minimization	0.27	45	6.81
7	Voltage optimization for Lights	1.16	173	2.08
8	Contract Demand Reduction	0.13	2,946	0.12
9	V- Belt to REC Belt Replacement in Glaze & Biscuit Kilns	0.16	489	0.80
10	Energy Management system	3.12	577	0.62

1. CHAPTER -1 INTRODUCTION

1.1 Background and Project Objective

The Bureau of Energy Efficiency (BEE) in collaboration with United Nations Industrial Development Organization (UNIDO) is working on the Global Environment Facility (GEF) funded project titled - 'Promoting Energy Efficiency and Renewable Energy in Selected MSME Clusters in India', which aims to give impetus to the energy efficiency initiatives in the small and medium enterprises (SMEs) sector in India. The objective of the program is development and promotion of energy efficiency and enhanced use of renewable energy in 12 selected energy-intensive MSME clusters, identified on the basis of their total energy utilization and energy-intensity levels. The project will provide solutions to certain technological as well as policy level barriers in implementation of energy efficient technologies in the MSME sector.

The objective of the project includes:

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

1.2 About the Unit

General details of the unit are given below:

Table 3: Overview of the Unit

Description	Details		
Name of the plant	Senis Ceramic Pvt. Ltd.		
Plant Address	B//h GSPL Gas Tarminal, Lakhdhirpur Road, Morbi - 363642		
Constitution	Private limited		
Name of Promoters	Mr. Girish Patel		
Contact person	Name	Mr. Girish Patel	
	Designation	Partner	
	Tel	9909914243	
	Fax		
	Email	senisceramics@yahoo.co.in	
Year of commissioning of plant	2007		
List of products manufactured	Wall tile, 300 x 450mm (6 tiles/box)		
	Wall tile, 300 x 900 mm (4 tiles/box)		
	Wall tile, 300 x 300 mm (9 tiles/box) Wall tile, 300 x 600 mm (5 tiles/box) Wall tile, 150 x 900 mm (6 tiles/box)		
Installed Plant Capacity	13000 boxes/day (10000 boxes/day currently)		
Financial information (Lakh Rs)	2014-15	2015-16	2016-17
Turnover	Not provided by Unit		
Net profit	Not provided by Unit		

No of operational days in a year	Days/Year	300	
	Hours/Day	24	
	Shifts /Day	2	
	Shift timings	-	
Number of employees	Category	Number	
	Staff	80	
	Worker		
	Casual Labor		
Details of Energy Consumption	Source	Yes/ No	Use
	Electricity (kWh)	Yes	Entire process and utility
	Coal (kg)	No	
	Diesel (liters)	Yes	DG rarely used
	Natural Gas (scm)	Yes	Only in Kiln
	Other (specify)	No	
Have you conducted any previous energy audit?	No		

1.3 METHODOLOGY AND APPROACH

The study was conducted in 3 stages:

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

The following flow chart illustrates the methodology followed for Stage-2 and Stage-3.

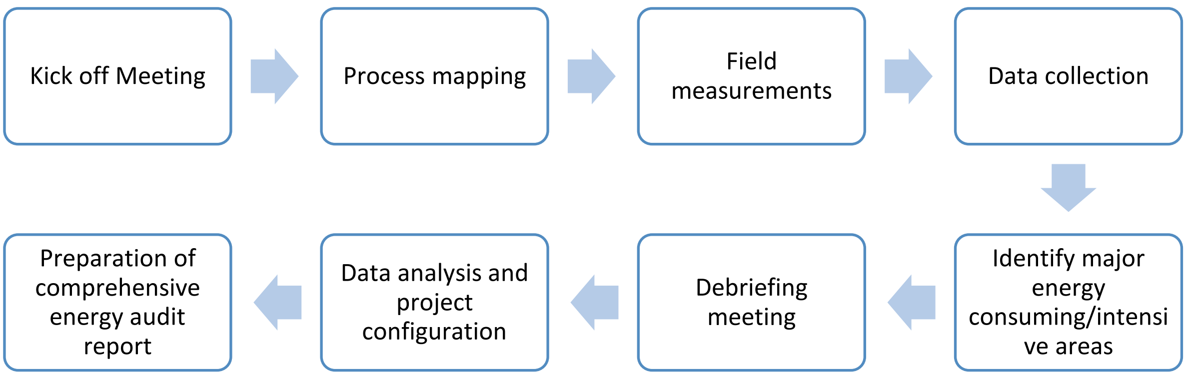


Figure 1: General methodology

The field work was carried out during 23-26th November 2018.

Stage-2: A kick-off meeting was conducted to explain to the unit the methodology of field assessment and map major areas of concern/expectation of the unit. This was followed by a process mapping to understand the manufacturing process based on which field measurement was planned in all major energy consuming areas. Field measurements were conducted as per this plan using calibrated portable measurement instruments. The audit covered all the energy intensive systems and equipment which were working during the field study. Simultaneously, process flow diagram, single line diagram, and data collection were done. At the end of the field study, a debriefing meeting was conducted to discuss initial findings and project ideas.

Stage-3: Post audit off-site work carried out included data compilation, data analysis, calculations for arriving at the savings potential, investment estimate through information available with DESL vendor database and carrying out vendor interactions as required, configuring the individual energy performance improvement actions and preparation of comprehensive energy audit report. The identified energy performance improvement actions (ECM's) normally fall under short, medium and long-term measures

1.4 INSTRUMENTS USED FOR THE STUDY

List of instruments used in energy audit are the following:

Table 4: Energy audit instruments

Sl. No.	Instruments	Parameters Measured
1	Power Analyzer – 3 Phase (for un balanced Load) with 3 CT and 3 PT	AC Current, Voltage, Power Factor, Power, Energy, Frequency, Harmonics and data recording for minimum 1 sec interval
2	Power Analyzer – 3 Phase (for balance load) with 1 CT and 2 PT	AC Current, Voltage, Power Factor, Power, Energy, Frequency, Harmonics and data recording for minimum 2 sec interval
3	Digital Multi meter	AC Amp, AC-DC Voltage, Resistance, Capacitance
4	Digital Clamp on Power Meter – 3 Phase and 1 Phase	AC Amp, AC-DC Volt, Hz, Power Factor, Power
5	Flue Gas Analyzer	O_2%, CO_2%, CO in ppm and Flue gas temperature, Ambient temperature
6	Digital Temperature and Humidity Logger	Temperature and Humidity data logging
7	Digital Temp. & Humidity meter	Temp. & Humidity
8	Digital Anemometer	Air velocity
9	Vane Type Anemometer	Air velocity
10	Digital Infrared Temperature Gun	Distant Surface Temperature
11	Contact Type Temperature Meter	Liquid and Surface temperature
12	High touch probe Temperature Meter	Temperature up to 1,300°*C*
13	Lux Meter	Lumens
14	Manometer	Differential air pressure in duct
15	Pressure Gauge	Water pressure 0 to 40 kg

1.5 STRUCTURE OF THE REPORT

This detailed energy audit report has been organized and presented sequentially as follows:

- Executive Summary of the report covers the summary list of projects along with estimated investment & energy and financial saving figures for individual projects.
- Chapter 1 (this chapter) of the report provides a brief background of the project, the scope of work and unit details and the methodology and approach for detailed energy audit.
- Chapter 2 of the report provides a description of the manufacturing process, analysis of historical energy consumption and establishment of baseline.
- Chapter 3 and 4 covers the performance evaluation of major energy consuming equipment and sections, thermal and electrical.
- Chapter 5 covers information on energy monitoring practices and best monitoring practices.
- Chapter 6 covers information on renewable energy assessment in the unit.

2. CHAPTER -2 PRODUCTION AND ENERGY CONSUMPTION

2.1 Manufacturing process with major equipment installed

A simple block diagram of the process flow is shown in the figure below:

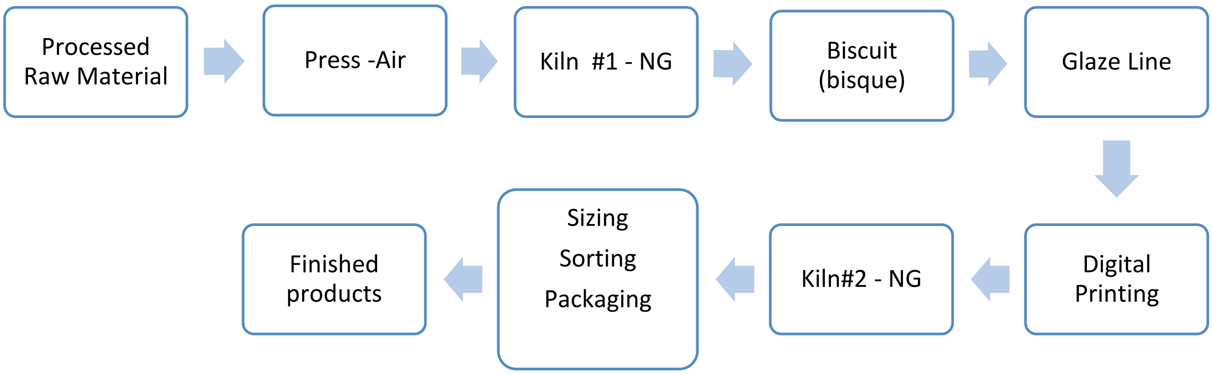


Figure 2: Process Flow Diagram

The process description is as follows:

- The raw material used is Clay Powder, is coming from outside.
- Clay in powdered form is stored in silos have capacity of 24 hours requirement and then conveyed to hydraulic press machine by conveyors where it is pressed and tiles is formed of required size, output of press is called biscuit.
- Biscuit is then baked in kiln-1 at about 1050 °C–1150 °C and then cooled to room temperature.
- This is followed by the glazing process and digital printing.
- After this the glazed product make a passage through kiln -2 at 1,150-1,200°C for final drying and hardening.
- Output of kiln is called tiles; these tiles are then passed through cutting, sizing and polishing machines to match exact dimensions required.
- After sizing tiles are packed in boxes and then dispatched.

.The major energy consuming equipment's in the plants are:

- **Glaze ball mill:** For producing glazing material used on tiles.
- **Air Compressor:** Pressurized air is used at several locations in a unit viz. instrument air, air cleaning, glazing etc.
- **Hydraulic Press:** Clay in powdered form is stored in silos for 24 hours and then conveyed to hydraulic press machine where it is pressed and tiles is formed of required size, output of press is called biscuit.
- **Kiln:** The kiln is the main energy consuming equipment where the product is passed twice, once in biscuit form and second time after glazing and printing. The kilns are about 150 m long and the temperature gradually increases up to firing zone and then decreases (in the cooling zone) with the highest temperature being 1,150°C to 1,200°C depending upon the

type of the final product. Once the tiles come out of the kiln. The materials are further gone for sizing, finishing and quality tested and packed for dispatch.

- **Sizing Machine:** Output of kiln is called tiles; these tiles are passed through cutting, sizing and polishing machines to match exact dimensions required.

A detailed mass balance diagram for the unit is included as **Annexure-1**. A detailed list of equipment is included as **Annexure-2**.

2.2 PRODUCTION DETAILS

The unit is currently manufacturing vitrified tiles of the following specifications:

Table 5 : Product Specifications

Product	Size /Piece mm×mm	Weight/box kg	Area per box m^2	Pieces per box #
Wall Tiles	300 x 450	11.5	0.81	6
Wall Tiles	600 x 900	20	1.08	4
Wall Tiles	300 x 300	11.5	0.81	9
Wall Tiles	300 x 600	14.5	0.9	5
Wall Tiles	150 x 900	11.5	0.81	6

The products are mainly sold in domestic market as well as exported. The month wise production details of various products, is given below.

Table 6: Month wise No. of boxes produced

Month	No. of Boxes									
	#1:Glaze tile– 12x12 (8 pcs/box)	#1:Glaze tile– 12x12 (9 pcs/box)	#2: Glaze tile – 12x18 (6 pcs/box)	#2: Glaze tile – 12x18 (10 pcs/box)	#3: Glaze tile (premium)– 12x24 (5 pcs/box)	#3: Glaze tile (premium)– 12x24 (6 pcs/box)	#3: Glaze tile (premium)– 12x24 (7 pcs/box)	#3: Glaze tile (premium)– 12x24 (8 pcs/box)	#4: Glaze tile (premium)– 12x36 (4 pcs/box)	#4: Glaze tile (premium)– 6x36 (8 pcs/box)
Jul-17	32,942		92,029		7,632				57,130	0
Aug-17	30,540		80,781		82,070				14,532	0
Sep-17	45,330		80,212		62,177				18,581	0
Oct-17	19,765		169,711		29,487				12,420	0
Nov-17	25,858		156,378		14,554				3,878	0
Dec-17	46,190		110,117		22,430				17,110	0
Jan-18	20,755		110,851		5,371				12,439	0
Jun-18		469	75,941	616	6,500	410	14,792	14,684	50,369	14
Jul-18	3,487	35,568	1,83,847		6,393	194	4,820	4,077	17,618	
Aug-18	760	22,194	1,58,045	5	18,026	8	4,835	220	25,444	
Sep-18	989	3,212	59,391		11,175	583	2,731	36,000	6,440	
Oct-18	2,554	29,275	1,59,622		1,800		5,198	4,586	24,405	

Table 7: Month wise production (Sq.m)

Months	Production (m²)										
	#1:Glaze tile– 12x12 (8 pcs/box)	#1:Glaze tile– 12x12 (9 pcs/box)	#2: Glaze tile – 12x18 (6 pcs/box)	#2: Glaze tile – 12x18 (10 pcs/box)	#3: Glaze tile (premium)– 12x24 (5 pcs/box)	#3: Glaze tile (premium)– 12x24 (6 pcs/box)	#3: Glaze tile (premium)– 12x24 (7 pcs/box)	#3: Glaze tile (premium)– 12x24 (8 pcs/box)	#4: Glaze tile (premium)– 12x36 (4 pcs/box)	#4: Glaze tile (premium)– 6x36 (8 pcs/box)	Total Tiles Area (sqm)
Jul-17	23,718	0	74,543	0	6,869	0	0	0	61,700	0	1,66,831
Aug-17	21,989	0	65,433	0	73,863	0	0	0	15,695	0	1,76,979
Sep-17	32,638	0	64,972	0	55,959	0	0	0	20,067	0	1,73,636
Oct-17	14,231	0	1,37,466	0	26,538	0	0	0	13,414	0	1,91,649
Nov-17	18,618	0	1,26,666	0	13,099	0	0	0	4,188	0	1,62,571
Dec-17	33,257	0	89,195	0	20,187	0	0	0	18,479	0	1,61,117
Jan-18	14,944	0	89,789	0	4,834	0	0	0	13,434	0	1,23,001
Jun-18	0	380	61,512	832	5,850	443	18,638	21,145	54,399	15	1,63,213
Jul-18	2,511	28,810	1,48,916	0	5,754	210	6,073	5,871	19,027	0	2,17,172
Aug-18	547	17,977	1,28,016	7	16,223	9	6,092	317	27,480	0	1,96,668
Sep-18	712	2,602	48,107	0	10,058	630	3,441	51,840	6,955	0	1,24,344
Oct-18	1,839	23,713	1,29,294	0	1,620	0	6,549	6,604	26,357	0	1,95,976
Total	165,002	73,482	1,163,909	838	240,854	1,291	40,794	85,776	281,195	15	2,053.156

Table 8: Month wise Production (Weight basis)

Months	Production (MT)										
	#1:Glaze tile– 12x12 (8 pcs/box)	#1:Glaze tile– 12x12 (9 pcs/box)	#2: Glaze tile – 12x18 (6 pcs/box)	#2: Glaze tile – 12x18 (10 pcs/box)	#3: Glaze tile (premium)– 12x24 (5 pcs/box)	#3: Glaze tile (premium)– 12x24 (6 pcs/box)	#3: Glaze tile (premium)– 12x24 (7 pcs/box)	#3: Glaze tile (premium)– 12x24 (8 pcs/box)	#4: Glaze tile (premium)– 12x36 (4 pcs/box)	#4: Glaze tile (premium)– 6x36 (8 pcs/box)	Total Tiles Weight (MT)
Jul-17	478	-	1,058	-	114	-	-	-	1,143	-	2,793
Aug-17	443	-	929	-	1,231	-	-	-	291	-	2,894
Sep-17	657	-	922	-	933	-	-	-	372	-	2,884
Oct-17	287	-	1,952	-	442	-	-	-	248	-	2,929
Nov-17	375	-	1,798	-	218	-	-	-	78	-	2,469
Dec-17	670	-	1,266	-	336	-	-	-	342	-	2,615
Jan-18	301	-	1,275	-	81	-	-	-	249	-	1,905
Jun-18	-	5	873	12	98	7	296	352	1,007	0	2,651
Jul-18	51	409	2,114	-	96	3	96	98	352	-	3,220
Aug-18	11	255	1,818	0	270	0	97	5	509	-	2,965
Sep-18	14	37	683	-	168	10	55	864	129	-	1,960
Oct-18	37	337	1,836	-	27	-	104	110	488	-	2,938
Total	3,323	1,043	16,525	12	4,014	22	648	1,430	5,207	0.280	32,223

2.3 ENERGY SCENARIO

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

- Electricity is supplied from two different sources:
    - From the Utility, Paschim Gujarat Vij Company Ltd. (PGVCL)
    - Captive backup diesel generator sets for whole plant
- Thermal energy is used for following applications :
    - Natural Gas for roller kiln
    - Natural Gas (NG) for Biscuit dryer and Glaze dryer.

Total energy consumption pattern for the period Jul-17 to Oct-18, from different sources was as follows:

Table 9: Energy use and cost distribution

Particular	Energy cost		Energy use	
	Rs Lakh	% of total	TOE	% of total
Grid – Electricity	200.71	16.4	243	7.9
Thermal – NG	1,023.09	83.6	2,826	92.1
Total	1,233.81	100	3,069	100

This is shown graphically in the figures below:

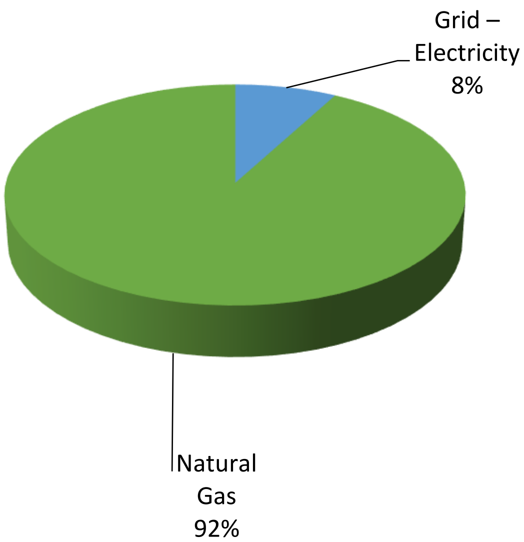


Figure 3: Energy cost share

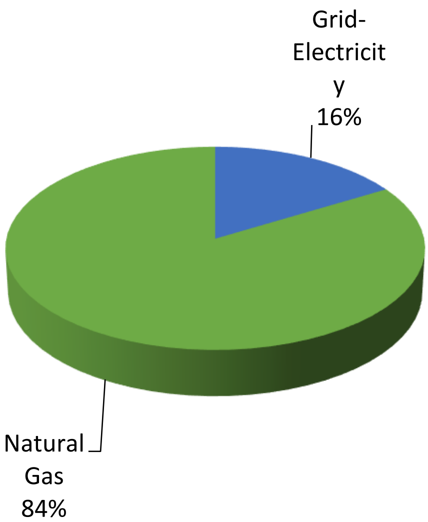


Figure 4: Energy use share

The major observations are as under:

- The unit uses both thermal and electrical energy for the manufacturing operations. Electricity is sourced from the grid.
- Electricity used in the utility and process accounts for the remaining 16% of the energy cost and 8% of the overall energy consumption.

- Source of thermal energy is from natural gas, which is used for firing in the kiln, and in the dryer.
- Natural gas used in kiln account for 84% of the total energy cost and 92% of overall energy consumption.

2.3.1 Analysis of Electricity Consumption

2.3.1.1 Supply from Utility

Electricity is supplied by the Paschim Gujarat Vij Company Ltd. (PGVCL). The unit has one electricity connection, details of which are given below:

Table 10: Details of Electricity Connection

Particulars	Description
Consumer Number	26361
Tariff Category	HTP-I
Contract Demand, kVA	900
Supply Voltage, kV	11

The tariff structure is as follows:

Table 11: Electric Tariff structure

Particulars	Tariff structure for Category HTP-1
Demand Charges (Rs./kVA)	
1st 500 kVA	150
2nd 500 kVA	260
Next 297	475
Energy Charges (Rs./kWh)	
Normal Hours	4.2
Peak Hours	0.85
Night Time	0.4
Fuel Surcharge (Rs./kVAh)	1.63
Electricity duty (% of total energy charges)	15%
Meter charges (Rs./Month)	0.00

2.3.1.2 Month wise Electricity Consumption and Cost

Month wise total electrical energy consumption is shown as under:

Table 12: Monthly electricity consumption & cost

Month	Units consumed kWh	Total Electricity cost Rs.	Average unit Cost Rs./kWh
Jul -17	2,04,984	1,431,967	7.0
Aug-17	2,10,798	1,428,277	6.8
Sep-17	2,45,355	1,663,905	6.8
Oct-17	2,03,532	1,391,897	6.8
Nov-17	1,96,461	1,347,614	6.9
Dec-17	2,14,761	1,465,587	6.8

Month	Units consumed kWh	Total Electricity cost Rs.	Average unit Cost Rs./kWh
Jan-18	1,73,007	1,194,980	6.9
June-18	2,88,955	2,118,705	7.3
July-18	2,73,530	2,013,055	7.4
Aug-18	3,16,385	2,307,725	7.3
Sep-18	1,88,795	1,438,489	7.6
Oct-18	3,12,305	2,269,269	7.3

2.3.1.3 Analysis of month-wise electricity consumption and cost.

Average electricity consumption is 2,35,739 kWh/month and cost is Rs. 16.726 Lakh per month (Jul-17 to Oct-18). The average cost of electricity is Rs. 7.09 /kWh. The figure below shows the month wise variation of electricity purchase and variation of cost of electricity.

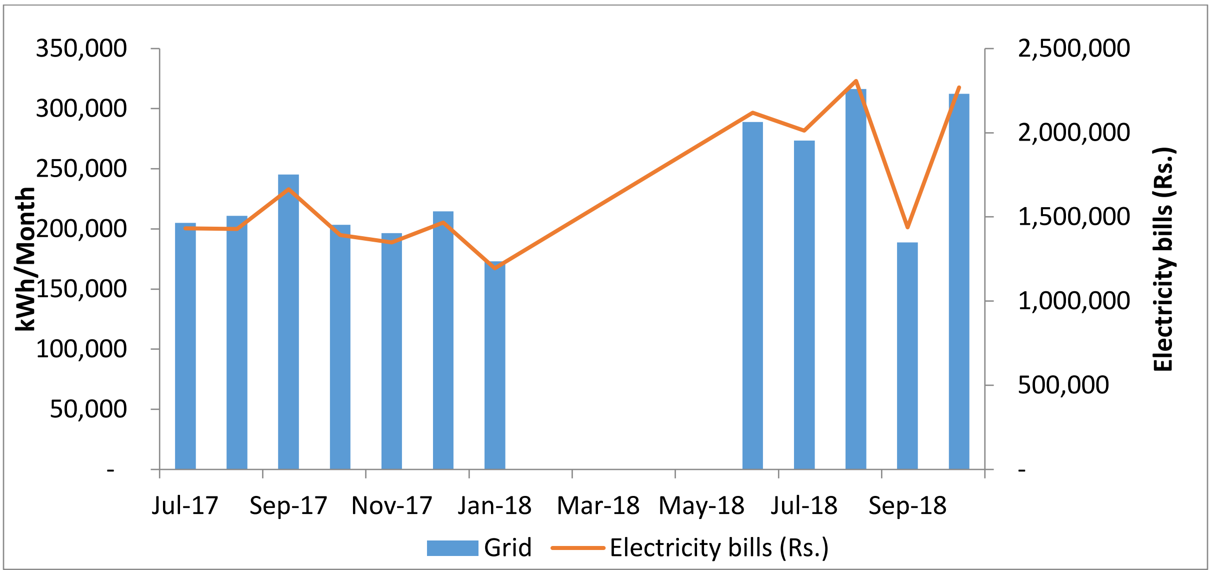


Figure 5: Month wise Variation in Electricity Consumption

Power Factor: Power factor as per electricity bills is shown below[1]:

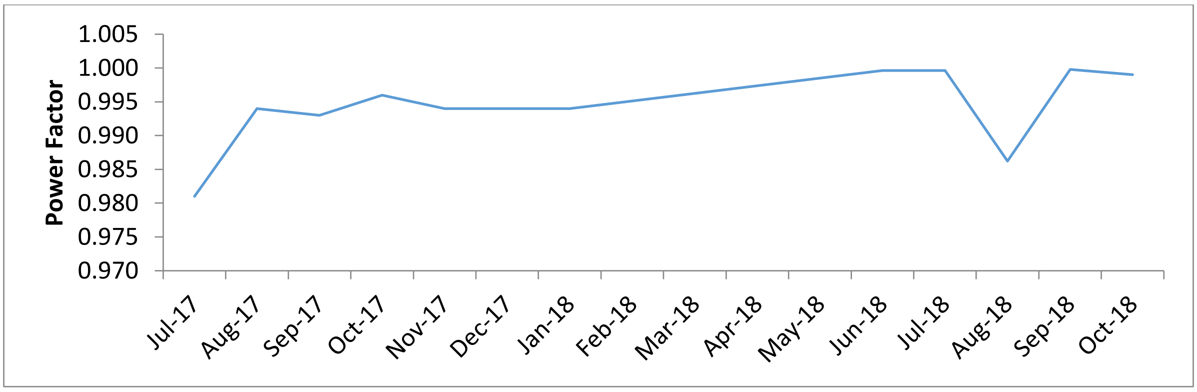


Figure 6: Month wise variation in Power Factor

[1] PF and KVA details are available in duration of Jul-17 to Oct-18

The utility bills of the unit reflect the power factor. A study was conducted by logging the electrical parameters of the main incomer using a power analyzer. The average power factor was found Proposed 0.99 and the maximum being 1.0.

Maximum Demand: Maximum demand as reflected in the utility bill is 1,271 kVA from the bill analysis.

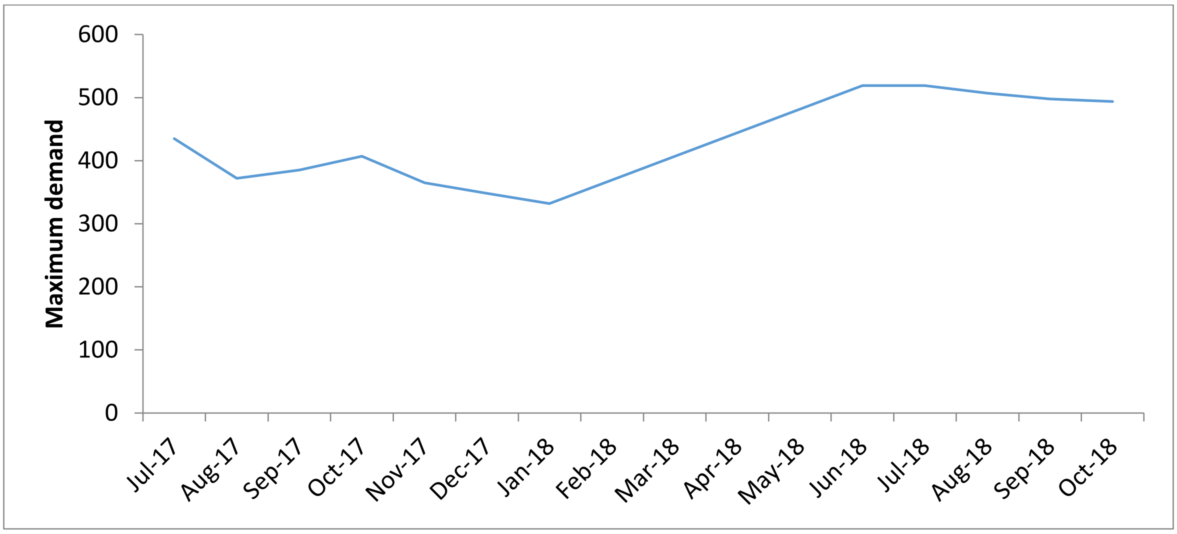


Figure 7: Month wise variation in Maximum Demand

2.3.1.4 Single Line Diagram

Single line diagram of plant is shown in figure below:

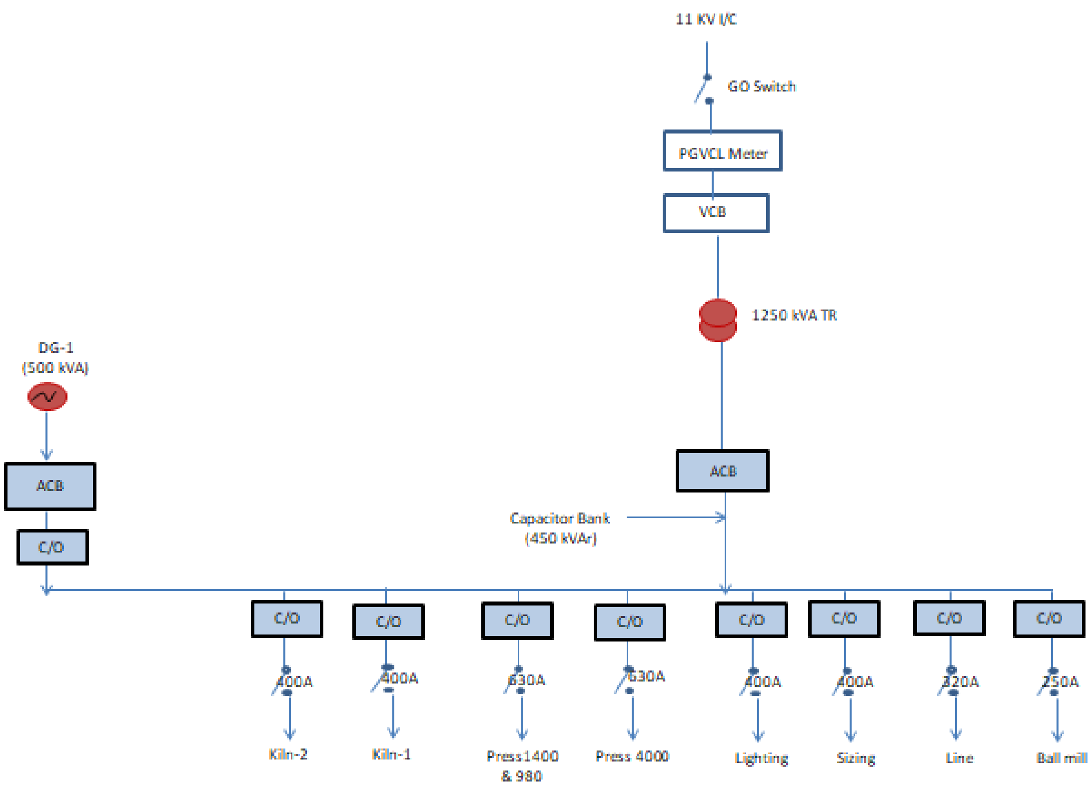


Figure 8 Single Line Diagram (SLD)

2.3.1.5 Electricity consumption areas

The plant total connected load is 1,391.84 kW, which includes:

- Plant and machinery load is 1,286 kW.
- Utility load is (lighting, air compressor and fans) about 137 kW including the single phase loads.

Table 13 : Equipment wise connected load (Estimated)

Equipment Name	Electrical Load (kW)
Press	353.10
Kilns	796.5
Glaze Ball Mills	106.24
Glaze Line	99.74
Cooling Tower	22.26
Sizing Machine	283.35
Compressors	53
Single Phase Load	30.8
Total	1,392

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

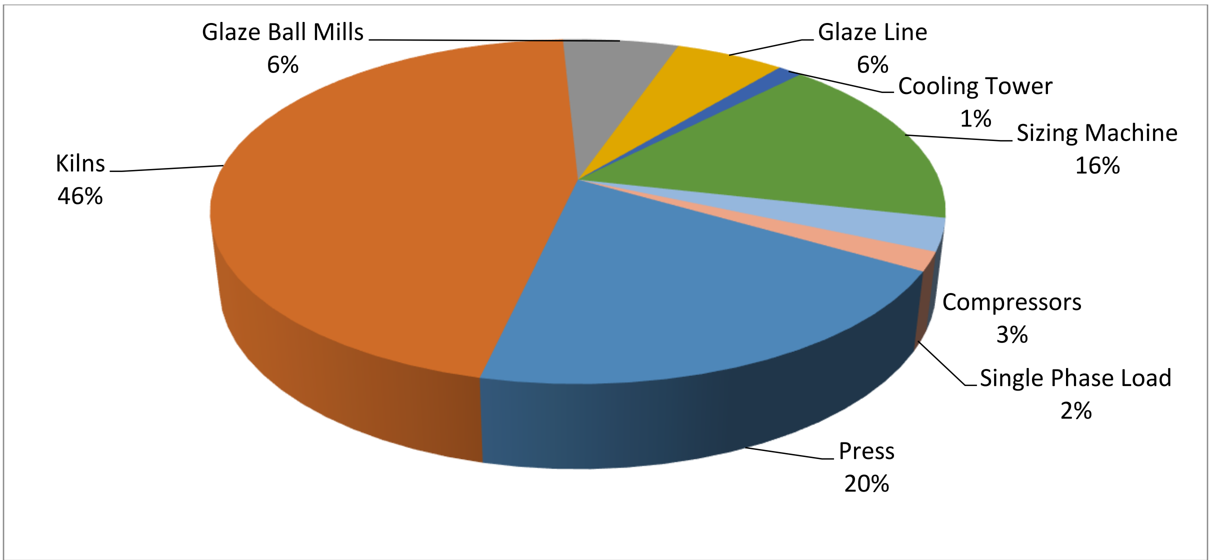


Figure 9: Details of connected load

As shown in the figure, the maximum share of connected electrical load is for Kiln 46%, for Press 20%, for sizing machine 16%, for Glaze Ball Mills 6%, for Compressor 3%, for Single Phase Load 2%, for Cooling Tower 1% and other loads.

2.3.1.6 Specific electricity consumption

The month wise variation of specific electricity consumption (kWh/m^2 of production) is shown in the figure below:

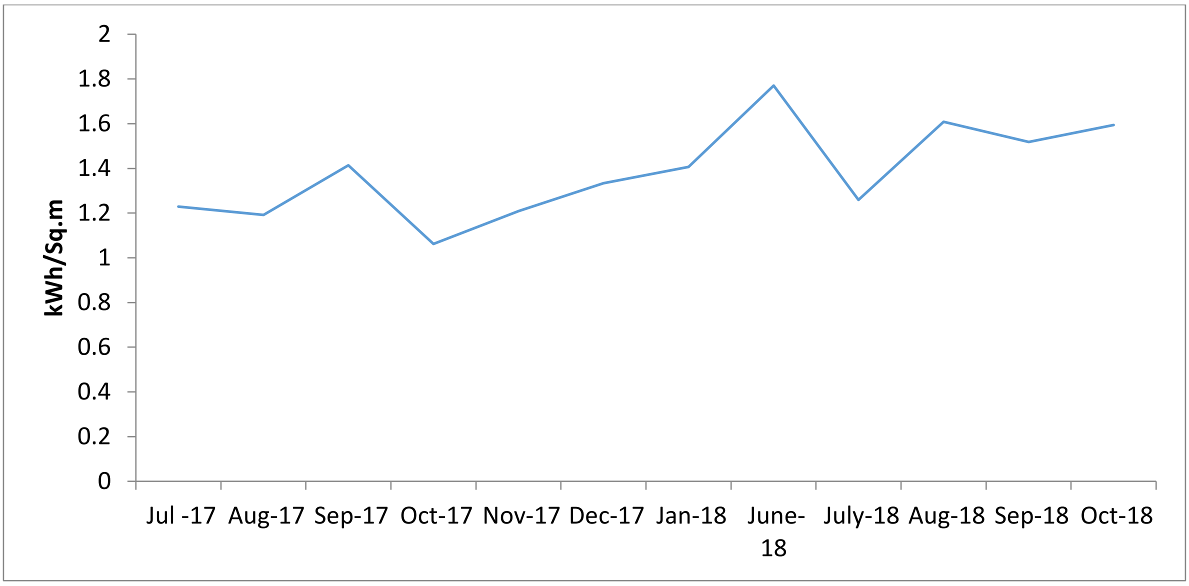


Figure 10: Month wise variation in Specific Electricity Consumption

The maximum and minimum values are within ±25% of the average SEC of 1.38 kWh/m^2 indicating that electricity consumption follows the production. Sub-metering is not available in the plant; and the only metering available is for PGVCL supply. Implementation of sub-metering will help establish section wise SEC. Sub-metering and monitoring is required in press section, biscuits kiln, glaze kiln, utility like compressor, pumps etc.

2.3.2 Analysis of Thermal Consumption

2.3.2.1 Month wise Fuel Consumption and Cost

The thermal consumption areas are the Kiln-1, Kiln-2, Biscuit dryer and Glaze dryer. Natural Gas used as the fuel for firing in the kiln. Natural Gas purchased from GSPC (Gujarat State Petroleum Corporation) and used in the Biscuit dryer and Glaze dryer. Based on the gas bill shared for the month of Jul -17 to Oct-18 annual fuel cost has been derived as under. Annual fuel consumption and cost are summarized below:

Table 14: Month Wise Fuel Consumption and Cost

	NG Used in Kiln		
Month	NG Use	NG Cost	NG Cost
	scm	Rs/month	Rs./scm
Jul-17	2,78,519	83,99,572	30.16
Aug-17	2,93,152	87,74,156	29.93
Sep-17	2,83,918	80,42,416	28.33
Oct-17	2,79,530	78,26,408	28.00
Nov-17	2,47,972	70,33,191	28.36
Dec-17	2,65,527	76,25,725	28.72
Jan-18	1,77,834	66,34,929	37.31
Jun-18	2,69,211	92,06,759	34.20
Jul-18	2,97,770	1,03,95,389	34.91
Aug-18	2,67,260	95,98,715	35.92
Sep-18	1,93,254	71,59,722	37.05
Oct-18	2,85,779	1,16,12,495	40.63

Average monthly natural gas consumption is 2,61,644 scm and average cost Rs. 85 Lakh/month

2.3.2.2 Specific Fuel Consumption.

The month wise variation of specific fuel consumption (SFC- GJ/m^2 of production) is shown in figure below:

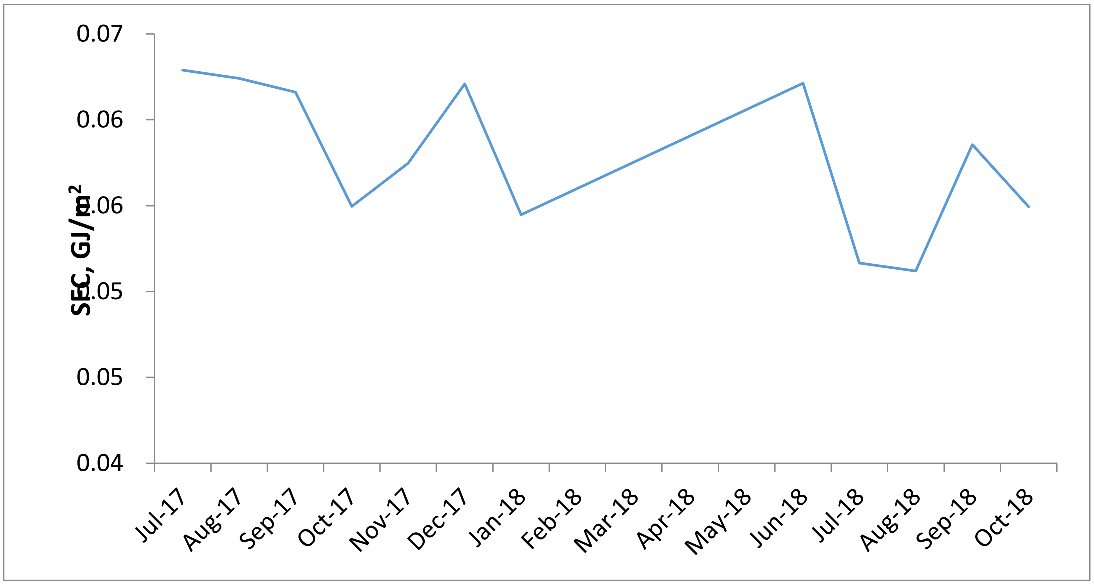


Figure 11: Month wise variation in Specific Fuel Consumption

The average SFC is 0.06 GJ/m^2. SFC is almost same in every month. During Feb-18 to May-18 data was not available as the plant was under renovation. Metering for NG is recorded, for better quality information, sub-metering /data logging is required at kiln and dryers are required.

2.3.3 Specific energy consumption

2.3.3.1 Based on data collected during EA.

Specific energy consumption (SEC) on the basis of data collected during energy audit is shown in below table:

Table 15: Specific energy consumption

Particulars	Units	Value
Average production	m^2/h	237.6
Power consumption	kW	327.4
NG consumption	scm/h	363.4
Energy consumption	TOE/h	0.36
SEC of plant	TOE/m^2	0.0015

2.3.3.2 Section wise specific energy consumption

Specific electricity consumption section wise (major areas) based on CEA is as follows. This is determined on weight basis, since mass data could be collected at each stage.

Table 16: Section wise specific energy consumption (per unit production)

Particulars	SEC	
	NG (scm/t)	Electricity (kWh/t)
Press		12.73
Kilns	43.0	3.82
Glaze Ball Mill		62.2
Glaze Line		6.29
Sizing Machine		4.50

The detailed mass balance diagram based on which the above has been arrived at is included as Annexure 1.

2.3.3.3 *Based on yearly data furnished by unit*

Based on the available information, various specific energy consumption (SEC) parameters have been estimated as shown in the following table:

Table 17: Overall: specific energy consumption

Parameters	Unit	UOM
Annual Grid Electricity Consumption	kWh	2,828,868
Annual DG Generation Unit	kWh	-
Annual Total Electricity Consumption	kWh	2,828,868
Diesel Consumption for Electricity Generation	Liters	-
Annual Thermal Energy Consumption (Coal)	MT	-
Annual Thermal Energy Consumption (NG)	SCM	939,748
Annual Total Energy Consumption	TOE	3,069
Annual water Consumption	kl	1,260
Annual Water Cost	Lakh Rs	0.1
Annual Energy Cost	Lakh Rs	1,224
Annual Production	Sq.m	20,53,156
	MT	32,223
SEC; Electrical	kWh/m^2	1.38
	kWh/MT	87.79
SEC; Thermal	GJ/m^2	0.06
	GJ/MT	3.67
SEC; Water	kl/m^2	0.001
	kl/t	0.04
SEC; Overall	TOE/m^2	0.00
	TOE/t	0.10
SEC; Cost Based	$Rs./m^2$	59.61
	Rs./t	3,797.92

(Annual data based on the period Jul -17 to Oct-18)

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
- GCV of NG : 9,000 kcal/scm

- CO_2 Conversion factor
  - Grid : 0.82 kg/kWh
  - NG : 0.001923 tCO_2/scm

2.3.3.4 Baseline parameters

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

Table 18: Baseline parameters

Particular	Unit	Value
Cost of Electricity	Rs./kWh (Oct-18)	7.27
Cost of NG	Rs./scm	33
Operating Hours per day	h/d	24
Annual Operating Days per year	d/y	300
Annual production	m^2	20,53,156

2.4 WATER USAGE AND DISTRIBUTION

Water requirement is met using bore well pump (7.5 hp). The pump lift water from ground and which is collected in Overhead tank. From this Overhead tank, water is distributed to various sections as per requirement through gravity. There is no metering available to monitor the exact water consumption.

Water distribution diagram is shown below.

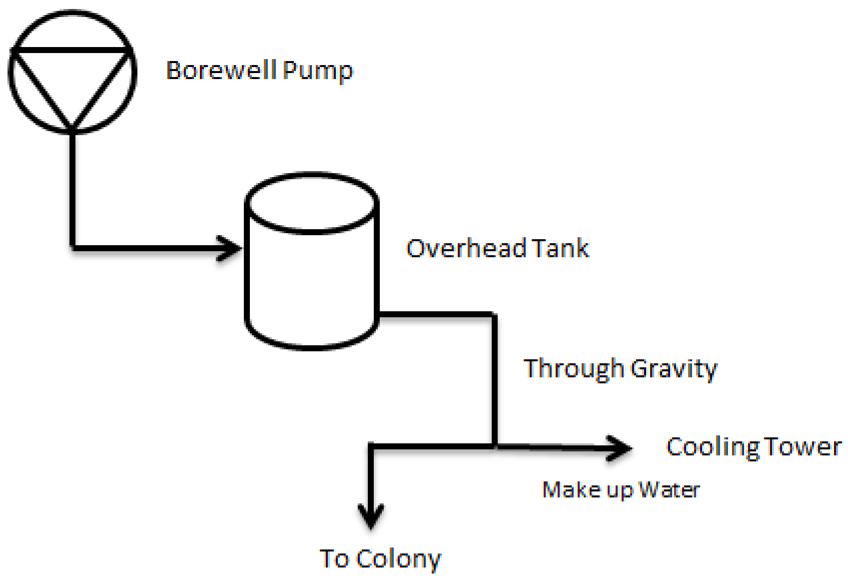


Figure 12: Water Distribution Diagram

There are two cooling tower pumps present in unit under press section used to circulate water in oil cooling purpose. The details of all pumps present in plant are given below:

Table 19: Pump present in plant

Parameters	Unit	Submersible Pump
Make	-	-
Motor rating	kW	5.5
RPM	rpm	2,900
Quantity	#	4

Factory does not have any water treatment plant. It is recommended to install meters, to monitor and control water consumption.

3. CHAPTER -3 PERFORMANCE EVALUATION OF THERMAL EQUIPMENT

3.1 KILN

3.1.1 Specifications

Natural gas is used as a fuel in the kiln to heat the ceramic tiles to the required temperature. The required air for fuel combustion is supplied by a blower (FD fan). Final cooling blower and rapid cooling blowers are used for cooling the tiles after combustion zone to get required tile quality and at the starting point, a smoke blower is installed which preheats the tiles before combustion zone of kiln.

Biscuit Kiln consists 355 kW electrical load of which 10 kW for roller, 44 kW for smoke blower, 60 kW for combustion blowers, 44 kW for rapid cooling, 55 kW for Hot air blower, 30 kW for final cooling blower, 30 kW for final exhaust blower, 22 kW for blower to dryer, 37 kW for dryer exhaust & 23 kW for conveyer.

Glaze Kiln consists 260 kW electrical load of which 60 kW for smoke blower, 44 kW for combustion blowers, 22 kW for rapid cooling, 22 kW for Hot air blower, 30 kW for final cooling blower & 27 kW for final exhaust blower.

Table 20: Biscuit Kiln Details

Sr. No	Parameter	Unit	Kiln 1	Kiln 2
	Make		Modena	Modena
1	Kiln operating time	h	24	24
2	Fuel consumption	scm/h	422	391
3	Number of burner to left	-	86	60
4	Number of burner to right	-	86	60
5	Cycle Time	Minutes	50	50
6	Pressure in firing zone	mmWC	50	50
7	Maximum temperature	°C	1,082	1,019.3
8	Waste Heat recovery option		Yes	Yes
9	Kiln Dimensions (Length X Width X Height)			
	Preheating Zone	m	21 x 3.6 x 0.8	16.8 x 3.6 x 0.8
	Firing Zone	m	48.3 x 3.6 x 0.8	29.4 x 3.6 x 0.8
	Rapid Cooling Zone	m	6.3 x 3.6 x 0.8	4.2 x 3.6 x 0.8
	Indirect cooling Zone	m	18.9 x 3.6 x 0.8	12.6 x 3.6 x 0.8
	Final cooling zone	m	18.9x 3.6x 0.8	23.1x 3.6x 0.8

3.1.2 Field measurement and analysis

During CEA, measurement of power consumption for all blowers, surface temperature of kiln, flue gas analysis, air flow measurement of blowers and section wise temperature profile of kiln were done. Natural gas used at both kiln and the drier; therefore, the consumption in kiln has been calculated based on heat load of the kiln during CEA. Flue gas analysis (FGA) study was conducted and result of same is summarized in the table below:

Table 21 : FGA Study of Kiln

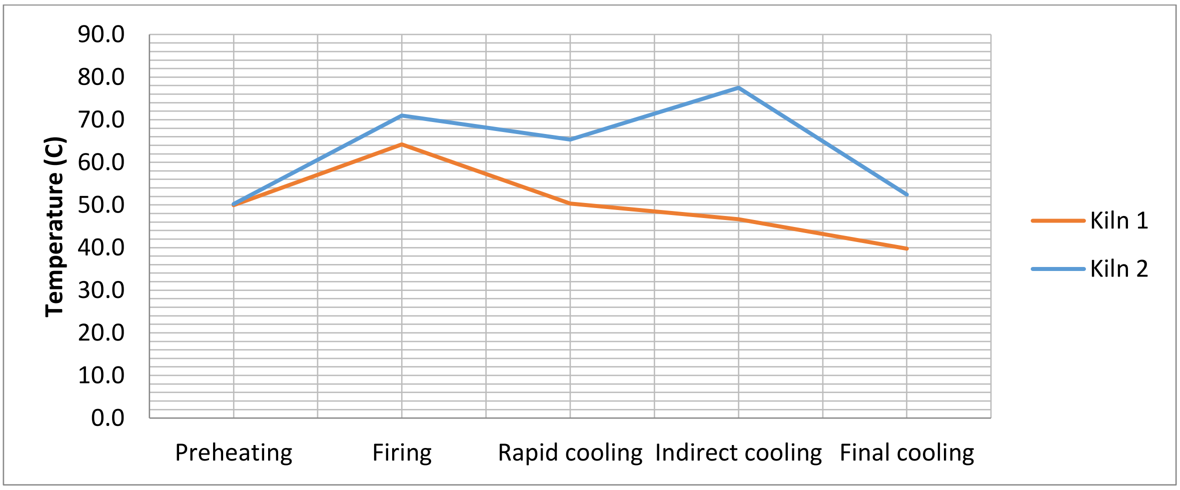
Parameter	Biscuit Kiln	Glaze Kiln
Oxygen Level measured in Flue Gas (%)	5.8	8.40
Ambient Air Temperature(°C)	40.2	40.2
Exhaust Temperature of Flue Gas (°C)	169	169

From the above table, it is clear that the oxygen level measured in flue gas from Biscuit Kiln was not so high while in Glaze Kiln was high. The inlet temperature of raw material in kiln was in the range of 60-65°C .Surface temperature was high, throughout the surface of the kiln as shown in the table below:

Table 22: Surface temperature of Biscuit and Glaze kiln

Zone	Kiln 1 (Biscuit)	Kiln 2 (Glaze)
Ambient Temperature	38	38
Pre-heating zone Average Surface Temperature	49.9	50.2
Heating zone Average Surface Temperature	64.2	71.0
Rapid cooling zone Average Surface Temperature	50.3	65.3
Indirect cooling zone Average Surface Temperature	46.7	77.5
Final cooling zone Average Surface Temperature	39.8	52.4

The temperature profile of the kiln-1 and kiln-2 is shown below:



igure 13 : Temperature Profile of Kiln

Measured data of power for all blowers is given in below table, details are provided in Annexure - 4.

Table 23: Power measurements of all blowers in Biscuit kiln

Equipment	Biscuit Kiln		Glaze Kiln	
	Average Power (kW)	Power factor	Average Power (kW)	Power factor
Smoke Blower	5.62	0.98	2.883	0.98
Combustion Blower	4.4	0.99	5.592	0.98
Hot Air Blower	9.01	0.99	3.48	0.99
Dryer Suction Blower	4.2	0.98		
Final Cooling			4.05	0.99
Rapid Cooling Blower	10.9	0.98	1.88	0.98

3.1.3 Observations and performance assessment

Kiln efficiency has been calculated based on the flue gas analysis study conducted during visit. Overall efficiency of the Biscuit kiln is 55.7% & for Glaze Kiln is 57 %. Summary of all losses is shown in below figure:

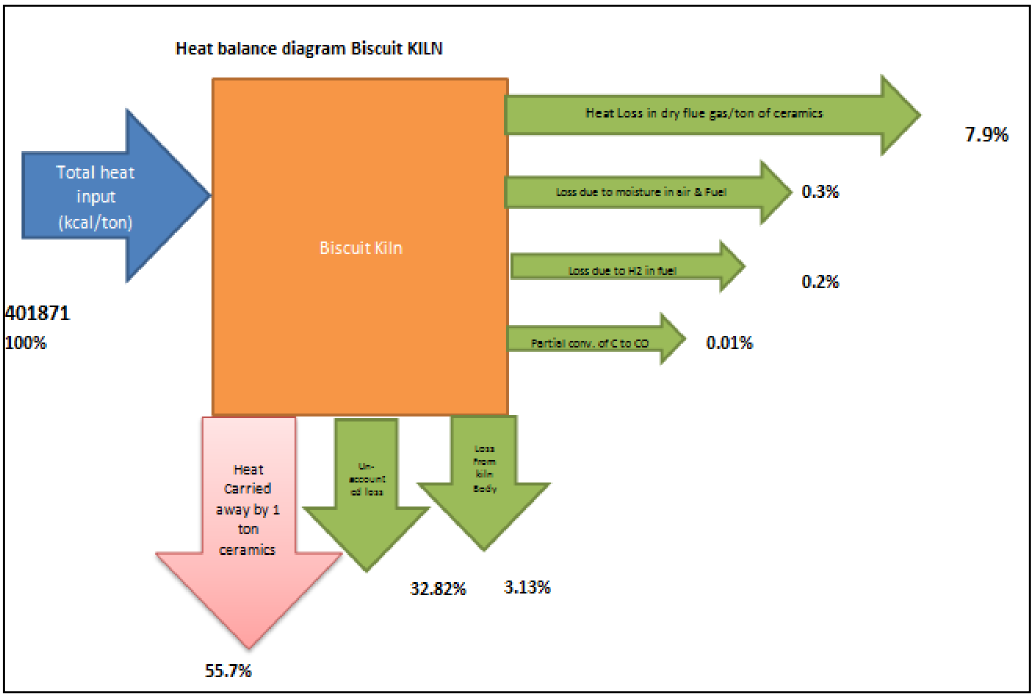


Figure 14 Heat balance diagram of Kiln 1

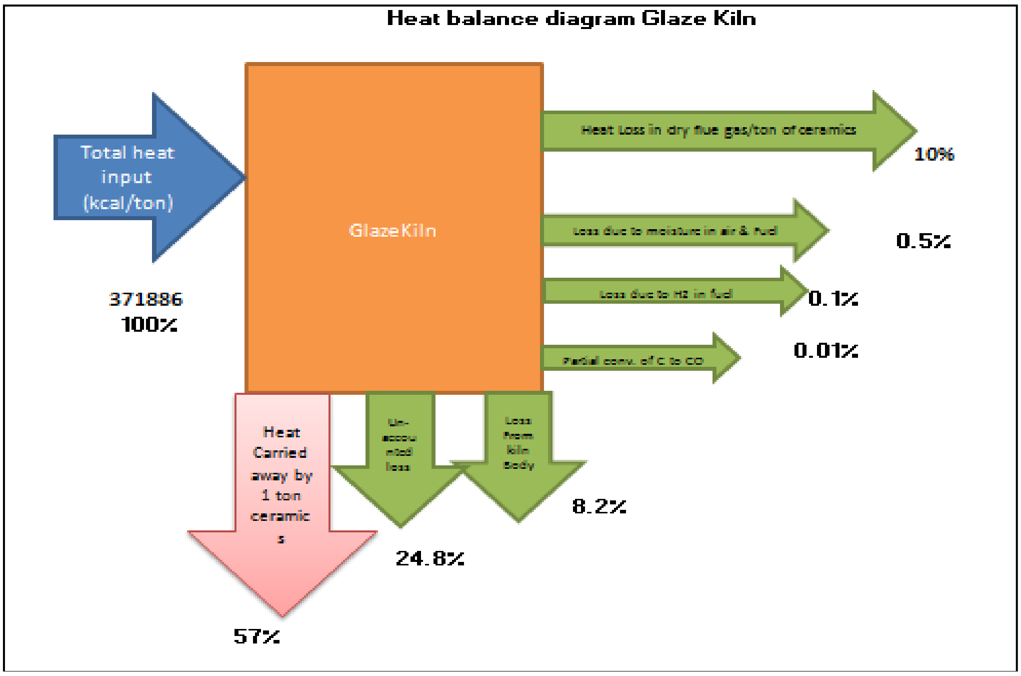


Figure 15 : Heat balance diagram of Kiln 2

The unaccounted loss occurred in kiln -1 and kiln-2 includes heat gained by rollers, small openings at side of kiln causes loss in heat and Fan body are at higher temperature causing loss in heat. Detailed calculation is included in Annexure - 5.

3.1.4 Energy conservation measures (ECM)

Energy conservation measures are described in below sections:

3.1.4.1 Energy conservation measures (ECM) - ECM #1: Excess air control system in kiln-2 (Glaze)

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 Proposed maintained at optimum levels, as too much of excess air results in excessive heat loss through the flue gases. On the other hand, too little excess air results in incomplete combustion of fuel and formation of black colored smoke in flue gases.

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

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

Study and investigation

At the time of CEA, the oxygen content in the flue gas analysis of Biscuit kiln was within the permissible limits so that's why no ECM has been proposed. While, in case of Glaze Kiln oxygen content was high also there was no proper automation and control system installed in the Glaze 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.

Flue gas analysis of kiln is given in below table:

Table 24: Flue gas analysis

Parameters	Units	Biscuit Kiln	Glaze Kiln
O_2 in flue gas	%	5.8	8.4
CO_2 in flue gas	%	8.65	7
CO in flue gas	ppm	9	23

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. Every 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 25: Cost benefit analysis of kiln Excess Air Control (ECM-1)

Parameters	UOM	Glaze Kiln	
		Present	Proposed
Oxygen level in flue gas just before firing zone	%	8.4	3.0
Excess air percentage in flue gas	%	66.7	16.7
Dry flue gas loss	%	0.57	
Fuel saving 1% in 10% reduction in excess air: Specific fuel consumption	scm/t	41	39
Average production in Kiln	t/h	9.5	9.5
Saving in specific fuel consumption	scm/h		19.55
Operating hours per day	h/d		300
Annual operating days	d/y		24
Annual fuel saving	scm/y		1,40,760
Fuel cost	Rs/scm		33
Annual fuel cost saving	Lakh Rs/y		45.9
Power saving in combustion blower			
Mass flow rate of air	t/h	0.62	0.44
Density of air	kg/m3	1.23	1.23
Mass flow rate of air	m^3/s	0.1	0.1
Measured power of blower	kW	5.59	1.92
Total power saving	kW		3.67
Operating days per year	d/y		300
Operating hours per day	h/d		24
Annual energy saving	kWh/y		26,454
Weighted electricity cost	Rs/kWh	7.10	7.10
Annual energy cost saving	Lakh Rs/y		1.88
energy cost saving	Lakh Rs/y		47.74
Estimated investment	Lakh Rs		6.93
Overall energy cost saving	Lakh Rs	47.74	
Total Estimated investment	Lakh Rs	6.93	
Payback period	Months	1.74	
IRR	%	525%	
Discounted rate of return	Months	0.70	

3.1.4.2 Energy conservation measures (ECM) - ECM #2 Preheating of combustion air through recuperator

Technology description

The recuperator is present just after the firing zone. Recuperator is used to utilize heat from the flue gas to preheat the combustion air before entering in firing zone.

Study and investigation

During energy audit, it was found that the recuperator was bypassed. So, 80% of combustion air was entered in firing zone at 200 °C and only 20% was preheated in recuperator.

Recommended action

It is recommended to take recuperator into service to increase combustion air temperature upto 265 °C by changing bypass valve position to 80%. The cost benefit analysis is given below:

Table 26: Cost benefit analysis of Combustion air through Recuperator [ECM-2]

Parameters	UoM	Present	Proposed
Equipment	#	Biscuit Kiln	
Blower Capacity	CFM	7,575	7,575
Measured air velocity	m/s	9.89	9.89
Blower air inlet area	m^2	0.18	0.18
Actual volume of supplied air	m^3/s	1.78	1.78
Actual air delivered	CFM	3,787	3,787
Hot air damper opening % to combustion blower	%	0	100
Combustion air temperature	°C	200	265
Ambient air temperature	°C	41	41
Specific heat of air	kCal/kg °C	0.24	0.24
Density of air	kg/m^3	0.90	0.90
GCV of NG	kcal/scm	9,000	9,000
NG Saving	scm/h		10
Operating hours per day	h/d	24	24
Annual operating days	d/y	300	300
Annual fuel saving in Kiln	scm/y		71,983
Annual fuel cost saving	Lakh Rs/y		23.46
Estimated investment	Lakh Rs		Nil
Payback period	months		Immediate
IRR	%	Nil	
Discounted rate of return	Months	-	

4. CHAPTER: 4 PERFORMANCE EVALUATION OF ELECTRICAL EQUIPMENT

4.1 HYDRAULIC PRESSES

4.1.1 Specifications

Hydraulic presses give shape for powder that is coming from storage in tiles form by pressing powder with high pressure. Hydraulic oil gets heated when pressed so that it is required Proposed cooled in heat exchanger where water circulates as cold media. The specifications of presses and its accessories are given below:

Table 27: Specifications of hydraulic press

Particular	Units	Press 1	Press 2
Cycle (stock) per min	N/m	7	7
Nos. of tiles per stock		2	2
Tile size	mm × mm	300 × 450	300 X 600
Tile thickness	mm		
Tiles weight	kg	2.16	3.13
Power rating	kW	53.5	66.4
Water Circulation Pump	#	1	1

4.1.2 Field measurement and analysis

During CEA, the following measurements were done:

- Power consumption of all water circulation pumps
- Count of tiles processed as per Table 27.

Average power consumption of water circulation pump 1 is 8.84 kW (PF 0.82), water circulation pump 2 is 5.23 kW (PF 0.84).

4.1.3 Observation and performance assessment

Both circulation pumps operates 24 hours in a day while press has frequent shut down. So it is suggested that pump operation must be controlled by sensing return oil temperature from press.

Performances of hydraulic presses can measures in terms of specific energy consumption (power consumed for preparation of 1 ton of tile). Based on observations during CEA, the specific energy consumption of press was 7.97 kW/ton.

4.1.4 Energy conservation measures (ECM)

4.1.4.1 Energy conservation measures (ECM) - ECM #3: Temperature Control in CT Pumps

Technology description

Cooling water is circulated in heat exchanger of press machine for oil cooling. A PID controller for cooling water pump will ensure operation of pump only when it is required based on temperature set point.

Study and investigation

It was observed that cooling water pump is running continuously irrespective of the operation of the press this pump is drawing 8.84 kW. It was also observed that even when press is not in operation pump is running.

Recommended action

It is recommended to install PID based controller which will ensure that pump will start only when oil temperature is >38°C; and once this temperature is maintained, pump will stop automatically. The cost benefit analysis for this project is given below:

Table 28: Cost benefit analysis of Temperature Control in CT Pump [ECM-3]

Parameters	UOM	Present	Proposed
No. of cooling tower	#	3	3
No. of Pumps	#	3	3
Rated power of Shower Pump	kW	5.0	5.0
Operating power	kW	4.5	4.5
Operating hours/day	h/d	24	15
Operating days/year	d/y	300	300
Annual energy consumption	kWh/y	97,200	60,750
Annual electricity saving	kWh/y		36,450
Unit cost of electricity	Rs/kWh		7.10
Annual monetary savings	Lakh Rs/y		2.59
Estimated Investment	Lakh Rs		0.30
Payback Period	Months		2
IRR	%		649%
Discounted Payback period	Months		0.55

4.2 GLAZING

4.2.1 Specifications

Ceramic glaze is an impervious layer or coating of a vitreous substance which is fused to a ceramic body through firing. Glaze can serve to color, decorate or waterproof an item. It also gives a tougher surface. Glaze is also used on stoneware and porcelain. In addition to their functionality, glazes can form a variety of surface finishes, including degrees of glossy or matte finish and color. Glazes may also enhance the underlying design or texture unmodified or inscribed, carved or painted.

Glazes need to include a ceramic flux which functions by promoting partial liquefaction in the clay bodies and the other glaze materials. Fluxes lower the high melting point of the glass formers silica, and sometimes boron trioxide. These glass formers may be included in the glaze materials, or may be drawn from the clay beneath.

Raw materials of ceramic glazes generally include silica, which will be the main glass former. Various metal oxides, such as sodium, potassium, and calcium, act as flux and therefore lower the melting temperature. Alumina, often derived from clay, stiffens the molten glaze to prevent it from running off the piece. Colorants, such as iron oxide, copper carbonate, or cobalt carbonate and sometimes opacifiers like tin oxide or zirconium oxide, are used to modify the visual appearance of the fired glaze.

The specifications of glazing mills are given below:

Table 29 Specifications of glazing machine

Particular	Units	New sizing
Numbers of glazing mills	Nos.	7
Capacity of glazing mills	kW	41

Glazing mills were not in operation during CEA so measurement and observation are not given in report.

4.3 SIZING

4.3.1 Specifications

There were two sizing unit which comprising many grinders. The specifications of sizing machines are given below:

Table 30 Specifications of sizing machine

Particular	Units	Sizing Machine 1	Sizing Machine 2	Sizing Machine 3	Sizing Machine 4
Numbers of grinders	Nos.	20	20	14	14
Capacity of grinders	kW	3	3	3	3

4.3.2 Field measurement and analysis

During CEA, the following measurements were done:

- Power consumption of sizing machines
- Daily tiles production from sizing machines are 4,367 pcs/h.

Average power consumption and boxes production from sizing machines are tabulated below:

Table 31 Measured Parameters of sizing machine

Equipment	Average Power (kW)
Sizing machine-1	22.4
Sizing machine-2	21.9
Sizing machine-3	20.2
Sizing machine-4	21

4.3.3 Observation and performance assessment

Based on observations during CEA, the specific energy consumption were 4.50 kW/t.

4.4 AIR COMPRESSORS

4.4.1 Specifications

Three air compressors are installed in plant. The specifications of presses are given below:

Table 32 Specifications of compressors

Particular	Units	Screw compressor	Reciprocating compressor 1	Reciprocating Compressor 2
Power rating	kW	30	11.5	11.5
Maximum pressure	bar (a)	7	-	-
Air handling capacity	m^3/m	5.8	-	-

4.4.2 Field measurement and analysis

During CEA, the following measurements were done:

- Power consumption of running compressor
- Air flow measurement of running compressor

Average power consumption and air flow rate of the compressors is given below:

Table 33 Measured Parameters of Compressors

Equipment	Average Power (kW)	PF	Air flow rate (m^3/min)	% of time on load
Screw compressor	23.43	0.67	5.8	34
Reciprocating compressor 1	Standby	-	-	-
Reciprocating Compressor 2	Standby	-	-	-

FAD of compressors could not be conducted as there was only one receiver for whole plant.

4.4.3 Energy conservation measures (ECM) - ECM #4: VFD installation for Screw compressor

Technology description

In any industry, compressor requirement keeps on varying based on the production demand and hence air compressor will run in load/unload sequence as per demand. During the unload condition air compressor will consume about 30% power without doing any work. A VFD can take care of this variable air demand by changing the RPM of compressor motor based on pressure feedback received from pressure sensor. As the demand reduces, pressure will increase, hence compressor RPM will reduce. Similarly, when there is high demand pressure will reduce during this period VFD will raise the RPM of motor to meet the demand.

Study and investigation

Power cycles of screw compressors were captured to understand unload/load pattern of air compressor it was found that screw compressor is getting unloaded for 66% of the time. There was only one receiver and it was not possible to conduct FAD test for compressor.

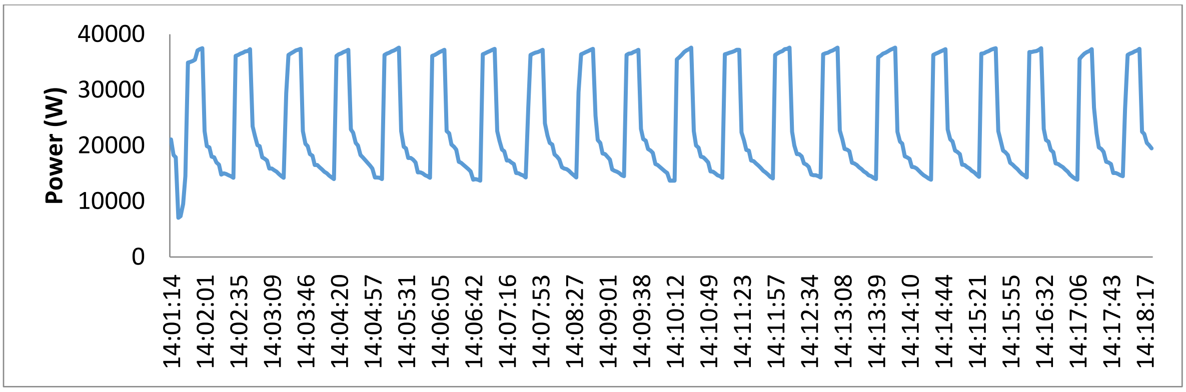


Figure 16: Load/Unload pattern of Screw Compressor

Recommended action

It is recommended to install VFD on screw compressor which will cater to the variable air demand of the plant whereas other two compressors will run to meet the base load. The cost benefit analysis for this project is given below:

Table 34: Cost benefit analysis of VFD for compressor 1 [ECM-4]

Parameters	UOM	Present	Proposed
Compressor motor rating	kW	30	30
Average power consumption during loading	kW	37.4	-
Average power consumption during unloading	kW	14.5	-
On load time in percentage	%	33.53	-
Off load time in percentage	%	66.47	-
Average power consumption	kW	22.18	18.85
Operating hours/day	h/d	24	24
Operating days/year	d/y	300	300
Annual energy consumption	kWh/y	159,683	135,730
Annual energy saving	kWh/y		23,952
Unit cost of electricity	Rs/kWh		7.10
Annual monetary savings	Lakh Rs/y		1.70
Estimated Investment	Lakh Rs		1.47
Payback period	Months		10.35
IRR	%		87%
Discounted Payback period	Months		4

4.5 LIGHTING SYSTEM

4.5.1 Specifications

The plant lighting system includes:

Table 35 Specifications of lighting load

Particular	Units	Fluorescent Tube Light		MH Lamp
		T-8	T-5	
Power consumption of each fixture	W	36	36	150
Numbers of fixtures	#	12	15	4

4.5.2 Field measurement and analysis

During CEA, the following measurements were done:

- Recording Inventory
- Recording Lux Levels

Table 36 Lux measurement at site

Particular	Units	Value
Press	Lumen/m^2	80
Glaze	Lumen/m^2	85
Kiln	Lumen/m^2	72
Sizing	Lumen/m^2	65
Outside Area	Lumen/m^2	45
Old Office	Lumen/m^2	120
New Office	Lumen/m^2	145
First Floor	Lumen/m^2	265

4.5.3 Observations and performance assessment

Adequate day lighting is used wherever possible. There is scope to replace luminaries with more energy efficient types which are currently available.

4.5.4 Energy conservation measures (ECM)

4.5.4.1 Energy conservation measures (ECM) - ECM #5: Replacement of inefficient light

Technology description

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

Study and investigation

The unit is having 27 FTL and 4 MH Lamps.

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 ECM is given below:

Table 37: Replacement of 36 W FTL T8 watt to retrofit 20 W LED T8 [ECM-5]

Parameter	Unit	PRESENT	PROPOSED	PRESENT	PROPOSED	PRESENT	PROPOSED
Type of fixture		FTL T8	LED T8	MH Lights	Flood LED	FTL T5	LED T5
Type of choke if applicable		Magnetic	Driver	NA	Driver	Magnetic	Driver
Number of fixtures	#	12	12	4	4	15	15
Rated power of fixture	W/Unit	36	20	150	60	36	20
Consumption of choke	W	12	0	0	0	12	0

Parameter	Unit	PRESENT	PROPOSED	PRESENT	PROPOSED	PRESENT	PROPOSED
Operating power	W/fixture	48	20	150	60	48	20
Operating hours/day	h/d	15	15	15	15	15	15
Operating days/year	d/y	300	300	300	300	300	300
Annual energy consumption	kWh/y	2,592	1,080	2,700	1,080	3,240	1,350
Annual energy saving	kWh/y		1,512		1,620		1,890
Total Energy savings	kWh/y	5,022					
Unit cost of electricity	Rs/kWh	7.10					
Annual monetary savings	Lakh Rs/y	0.36					
Estimated Investment	Lakh Rs	0.23					
Payback Period	Months	8					
IRR	%	134%					
Discounted payback period	Months	2.77					

4.6 Electrical Distribution System

4.6.1 Specifications

Unit demand is catered by a HT supply (11kV) which is converted into LT supply (433V) by step down transformer (1250 KVA).Capacitor bank of capacity 450KVAr was connected in series with the main line. There was one DG (capacity of 500 KVA) installed in main LT room for emergency purpose which are connected by means of change over. Power is distributed in plant by feeder which is shown in Fig.

4.6.2 Field measurement and analysis

During CEA, the following measurements were done:

- Whole plant load measurement by installing power analyzer at new and old plant main incomer feeder

4.6.3 Observations and performance assessment

After analyzing both feeders power profiling, it is observed that the maximum kVA recorded during study period was **496.2 kVA**.

The voltage profile of the unit is satisfactory and average voltage measured was **432.75 V.** Maximum voltage was **443.7 V** and minimum was **417.6 V**.

Average total voltage and current Harmonics distortion found **5.8%** & 8.5**%** respectively during power profile recording.

There is one electricity meter in the plant at the main incomer, with no sub-metering.

It is observed that some of the outgoing feeders to sizing and press section has very poor power factor. Poor power factor leads to cable losses (I^2R) in the electrical distribution system.

4.6.4 Energy conservation measures (ECM)

4.6.4.1 Energy conservation measures (ECM) - ECM #6: Cable loss minimization

Technology description

It was observed that some of the outgoing feeders to sizing and press section has very poor factor.

Study and investigation

Electrical parameters were logged in these feeders and it was noted in sizing section power factor was between 0.5-0.58.

Recommended action

It is recommended to install power factor improvement capacitors for sizing.

The cost benefit analysis for this project is given below:

Table 38 : Cost benefit analysis of Cable Loss minimization [ECM-6]:

Particulars	UOM	Sizing Machine-1 Value	Sizing Machine-2 Value
Existing Power Factor		0.58	0.5
Proposed Power Factor		0.99	0.99
Existing load	kW	22.4	20.2
Cable Losses	Watts	123	95
Capacitor Required	kVAr	29	29
Annual Energy Saving	kWh/y	637	485
Savings Estimated	Rs. Lakh/y	0.13	0.03
Total Energy Saving	kWh/y	1,121.75	
Total Savings	Rs. Lakh/y	0.17	
Investment	Rs. Lakh	0.27	
Simple Payback Period	Months	19	
IRR	%	45%	
Discounted rate of return	Months	7	

4.6.4.2 Energy conservation measures (ECM) - ECM #7: Voltage Optimization for Lights

Technology description

In most of the industries, lighting load varies between 2-10%. Most of the problems faced by lighting equipment and the gears are due to the voltage fluctuations. Hence, the lighting circuit should be isolated from the power feeders. This provided a better voltage regulation for the lighting. This will reduce the voltage related problems, which in turn increases the efficiency of the lighting system. In many industries, night time grid voltages are higher than normal; hence reduction in voltage can save energy and also provide the rated light output.

A large number of industries have used these devices and have saved to the tune of 5-15%. Industries having a problem of higher night time voltage can get an additional benefit of reduced premature failure of lamps.

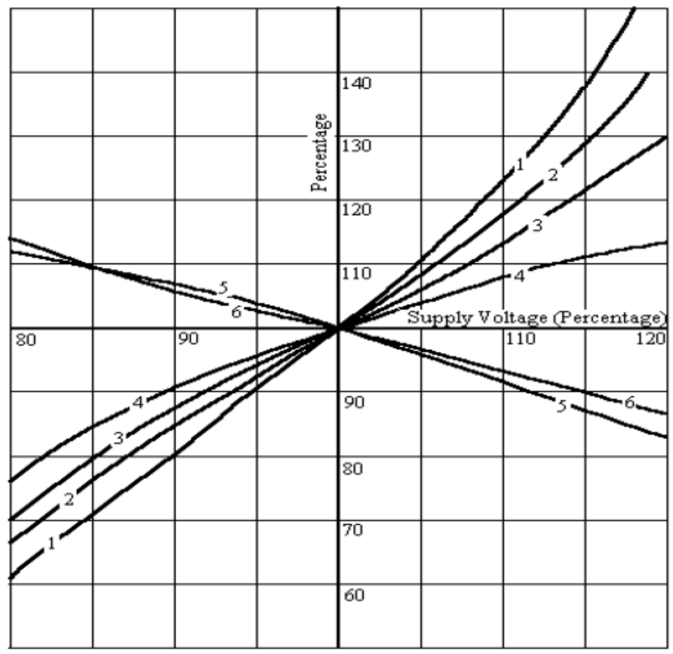


Figure 17: Effect of supply voltage on lamp parameters

Study and investigation

Lighting feeder measurements were carried out to estimate existing lighting load and the voltage level in the lighting circuit. Present lighting load of plant is 26 kW and measured voltage level is 433 V.

Recommended action

It is recommended to install separate lighting transformer of 35 kVA rating for lighting circuit to save energy, optimize voltage and also reduce premature failure of lamps. The cost benefit analysis for this project is given below:

Table 39: Cost benefit analysis of voltage Optimization in lighting circuit [ECM-7]

Parameter	UOM	Present	Proposed
Maximum load	kW	26	26
Maximum load	KVA	26.16	26.16
Maximum Line Voltage	V	444	380
Maximum voltage	V	256	219
Average Phase Voltage	V	433	380
Average voltage	V	250	220
% reduction in voltage	%	11.9	
% reduction in energy consumption	%	22.47	

Parameter	UOM	Present	Proposed
Average power factor		0.99	0.99
Annual lighting energy consumption	kWh/y	181,507	
Savings estimate from lighting EPIAs	kWh/y		3,132
Actual energy considered for voltage regulation	kWh/y		178,375
Actual energy consumption after voltage regulation	kWh/y		138,293
Efficiency of Servo Stabilizer	%		95
Assumption : Period for which voltage regulation is required	Months/y		12
Net saving from voltage regulation	kWh/y		38,078
Electricity tariff from grid only	Rs/kWh	6.88	
Annual monetary saving	Lakh Rs	2.6	
Sizing of servo stabilizer	kVA	28	
Rating of servo stabilizer	kVA	35	
Estimate investment	Lakh Rs	1.16	
Simple payback period	Months	5	
IRR	%	173%	
Discounted rate of return	Months	2.08	

4.6.4.3 Energy conservation measures (ECM) - ECM # 8: Reduction in Contract Demand

Technology description

The contract demand presently in the plant is 900 kVA and billing demand is 85 % of contract demand which is 765 kVA as per electricity bills.

Study and investigation

However as per the electricity bill the maximum demand during the whole year was 516 kVA only.

Recommended action

It is recommended to reduce the contract demand upto 700 kVA such that. The billing demand (85%) for the same will be 595 KVA. The cost benefit analysis for this project is given below:

Table 40: Cost benefit Cable Loss minimization [ECM-8]

Parameter	Unit	Present	Proposed
Contract Demand	kVA	900	700
Billing Demand	kVA	765	595
Monthly Demand Charges (1st 500 kVA)	Rs./kVA	150	150
Additional Monthly Demand Charges (above 500 kVA)	Rs./kVA	260	260
Demand Charges Paid (Oct-17 to Sept-18)	Lakh Rs/y	17.27	11.96
Saving in Demand Charges	Lakh Rs/y		5.30
Estimated investment	Lakh Rs		0.13
Payback period	months		0.3
IRR	%	2,946%	
Discounted rate of return	Months	0.12	

4.7 Belt Operated Drives

4.7.1 Specifications

There are 8 drives operated with V Belt of total capacity of 181 kW. Locations include:

- Kiln 1 & 2 have 12 blowers

4.7.2 Field measurement and analysis

During CEA, power consumption of all v belt driven equipment was measured.

4.7.3 Observations and performance assessment

Maximum belts in plant are v belt which are not energy efficient.

4.7.4 Energy conservation measures (ECM)

4.7.4.1 Energy conservation measures (ECM) - ECM #9: V Belt replacement with REC belt

Technology description

Replacing conventional belt (V belt) with energy efficient belt REC (raw edged cogged) belt. REC belts transmit more power as compared to V belts, hence deliver rated RPM and more air supplied.
Benefits of Cogged belts & Pulley over V belts:

- The cogged belts by design, is having 30% power carrying capacity for the same V belt.
- The cogged belts run cooler, 50% more longer hours, and occupy less space in pulley.
- The narrow and cogged belts operate higher speed ratios using smaller diameter pulleys.
- Hence the existing pulley needs Proposed replaced with 20% lighter weight pulley.

Study and investigation

The unit is having about 12 belt driven blowers in plant.

Recommended action

It is recommended to replace the above conventional belt with REC belt for energy savings. Cost benefit is given below:

Table 41: Replacement of conventional belt with REC belt [ECM-9]

Parameters	UOM	Present	Proposed	Present	Proposed
Name of the belt driven blower	#	Glaze Kiln Blowers		Biscuit Kiln Blowers	
Number of Blowers	#	6	6	6	6
Total Rated power of blower	kW	189	189	181	181
Energy Saving	%		3.60%		3.60%
Measured power the blower	kW	24	23	18	17
Operating hours per day	h/d	24	24	24	24
Operating Days per year	d/y	300	300	300	300
Annual energy consumption	kWh/y	175,260	168,951	128,847	124,208
Annual energy saving	kWh/y		6,309		4,638

Parameters	UOM	Present	Proposed	Present	Proposed
Unit cost of electricity	Rs/kWh		7.10		7.10
Annual monetary savings	Lakh Rs/y		0.45		0.33
Estimated Investment	Lakh Rs		0.08		0.08
Payback Period	Months		2.12		2.89
Total Annual monetary savings	Lakh Rs/y		0.78		
Total Estimated Investment	Lakh Rs		0.16		
Payback Period	Months		2.4		
IRR	%		489%		
Discounted rate of return	Months		0.80		

5. Chapter -5 Energy consumption monitoring

5.1 Energy Consumption Monitoring

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

5.1.1 Energy conservation measures (ECM) - ECM #10: Energy monitoring system

Technology description

Installation of energy monitoring system at unit level will monitor the energy consumed by various machines. From this, the benchmark energy consumption can be set with respect to production for 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 system installed in kiln using natural gas.

Recommended action

It is recommended to install online electrical energy monitoring systems (smart energy meters) on the main incomer and on the various electricity distribution panels and fuel monitoring system. This measure will help in reduction in energy consumption by approximately 3% from its present levels. The recommended locations for the energy meter are:

- Kiln
- Dryers

The cost benefit analysis for this project is given below:

Table 42: Cost benefit analysis [ECM-10]

Parameters	Unit	Present	Proposed
Energy monitoring saving for electrical system	%	2.00	
Energy consumption of major machines per year	kWh/y	2,828,868	2,772,291
Annual electricity saving per year	kWh/y	0	56,577
Average Electricity Tariff	Rs/kWh	7.10	7.10
Annual monetary savings	Lakh Rs/y	0	4.01
Number of Electrical equipment	#	30	30
No. of energy meters	#	0	30
Estimate of Investment	Lakh Rs		2.99
Thermal energy monitoring system	%	2.00	
Annual NG consumption	scm/y	3,139,726	3,076,932
Annual fuel saving	scm/y		62,795

Parameters	Unit	Present	Proposed
Average NG cost	Rs/scm	32.6	32.59
Total annual monetary savings	Lakh Rs/y		20.46
Number of equipment or system	#	1	1
Number of NG Meters			4
Estimated investment	Lakh Rs		0.13
Annual monetary savings (Electrical + Thermal)	Lakh Rs/y		24.48
Total Estimated investment (Electrical + Thermal)	Lakh Rs		3.12
Payback period	Months		2
IRR	%	577%	
Discounted rate of return	Months	0.62	

5.2 Best Operating Practices

Unique operating practices which were observed in the unit include the following:

Table 43: Summary of BOP

Sl No	Equipment/System	
1	Transformer	APFC installed to maintain power factor
2	Press	None
3	horizontal dryers	Waste heat from kiln is used in dryer with supplementary firing.
4	Glaze ball mill	Timer control in each ball mill.
5	Glaze line	None
6	Kiln	VFD in each blower, waste heat used in preheating section and dryer. PID control system for controlling chamber temperature in firing zone.
7	Sizing	Fully automatic system. Dust collected system installed.
8	Printing	Automated digital printing with fully auto control system
9	Lighting	LED lights

5.3 New/Emerging Technologies

Evaluation of the techno-economic viability of the following emerging and new technology options, are suggested here:

5.3.1 Dry Clay Grinding Technology: "Magical Grinding System "Technology description

"Magical Grinding System", a technology offered by Boffin - China, is a high-efficiency energy-saving ceramic raw material grinding process, which overcomes the drawbacks of traditional milling process in ceramic production, viz. high energy consumption and high cost of mill materials and consumables[2]. The main technical specifications are as follows:

Table 44 : Specifications of dry clay grinding technology

Parameter	UOM	Scenario-1	Scenario-2	Scenario-3
Moisture content of input material	%	5-7%	7-8%	8-10%

[2] The information in this section has been obtained from : http://www.guangdong-boffin.com/en/

Parameter	UOM	Scenario-1	Scenario-2	Scenario-3
Production output	t/h	≥60	≤50	≤15
Power consumption	kWh/t	≤7.5	≤8.5	≤11
Remarks		Low dust emission, steady output		When the moisture is higher than 8%, the output drops. The cost increases accordingly.

When water content of input materials ≤8% and size of materials <60mm, the overall equipment has a capacity up to 50 t/h, and unit energy consumption is lower than 8.5 kWh/t. Savings include reduction in power consumption by over 25% and reduction in consumables by over 25%.

The working principle is as follows:

- Grinding equipment are used to crush large pieces of different sizes into even, small-size materials (≤10-mesh sieve) – equivalent to rough grinding stage in ball mill. As against the conventional method of grinding by impact, in the dry grinding process, the size reduction is achieved by "squeezing method", where in the squeezing of the two working faces – grinding roller and grinding plate results in the force being fully applied on the materials with lower energy loss (and hence lower power consumption).
- Further, the grinding process optimizes the ball media grading of the ball mill, so as to increase contact of ball media and materials and increase grinding efficiency. Since this process features very small grain sizes of materials, it can directly enter fine grinding stage, without the need of rough grinding of large-size ball media.

Case Study New Pearl Ceramics and Beisite Ceramics Co., Ltd[3]:

After the implementation of dry grinding, the benefits accrued are:

a) Reduction in thermal energy consumption -70%
b) Reduction in water consumption- 75.4%
c) Reduction in power consumption -1%
d) Reduction in use of chemical additives – 100%
e) Overall reduction in manufacturing costs – 44%
f) Reduction in abrasion
g) Reduction in ball milling time
h) Reduction in floor area required

5.3.2 Waste Heat Recovery from Kiln: SACMI Double heat recovery technology description

Heat recovery from roller kiln is most important feature to operate the kiln at optimum efficiency and reduce fuel consumption. The working principle of the heat recovery system with double heat recovery is as follows:

[3] Case Study presented by Mr. Chaitanya Patel – Regional Manager-Guangdong Boffin at the Knowledge Dissemination Workshop for WT & FT units on 8th Feb- 19, under this project

Cooling air may have temperature ranging from 120°C to 250 °C (depending on whether cooling is with a single chimney or with double cooling circuit). Air is drawn from the fan and sent to a filter before being made available to the combustion air fan passing through heat recovery system to raise the combustion air temperature up to 250°C. Final cooling air is also retrieved for use as combustion air, where the air is filtered and sent to combustion air fan before being heated via a heat exchanger in the fast cooling zone reaching temperature up to 250 °C depending upon the product and kiln temperature.

Figure 18 : Heat recovery system for combustion air

The estimated benefits of double heat recovery include[4]:

- Fuel savings upto 10%
- Combustion air temperature up to 250 °C at burner
- Easy installation

A working installation of double heat recovery system is available at a vitrified tile unit in Morbi cluster.

5.3.3 Roller Kiln Performance improvement by Total Kiln Revamping

The roller kiln is major energy consuming system in ceramic tile unit. Over a period of time, the losses from kiln increases for various reasons like operating practices, insulation deterioration, poor maintenance, high breakdown level etc. It is beneficial to upgrade the kiln performance by total kiln revamping including following systems[5]:

1. **Upgrading burners** with better technology and higher combustion efficiency with several benefits like:
    a. Broad working range
    b. Most stable flame detection

[4] SACMI Kiln Revamping catalogue for roller kilns

[5] SACMI Kiln Revamping catalogue for roller kilns

c. Better flame speed
d. Compatibility with burner block types
e. Easy head cleaning procedure

2. **Heat recovery systems** – Sin**gle and double heat r**ecovery for combustion air.
3. **NG fuel Consumption monitoring kit** : Real time monitoring of gas consumption on operator panel and on kiln.
    a. Retrofittable and can be installed on dryers and kilns
    b. Real-time gas consumption monitoring on operator panel
    c. Instantaneous pressure and temperature readings
    d. Easy calibration

Figure 19: NG consumption monitoring kit

4. **Combustion air control:** The combustion system is divided in to 3 macro zones, each of which supplies a specific kiln zone namely: Pre-heating, Pre-firing and Firing zone. The operator panel can be used to adjust the air flow to burners in specific zones according to raw material recipe used in body clay, product and kiln conditions. Maximum efficiency is obtained by combining this modification with Oxygen Analyzer to optimize the amount of combustion air under all conditions and consequently, optimize product quality and fuel consumption both.

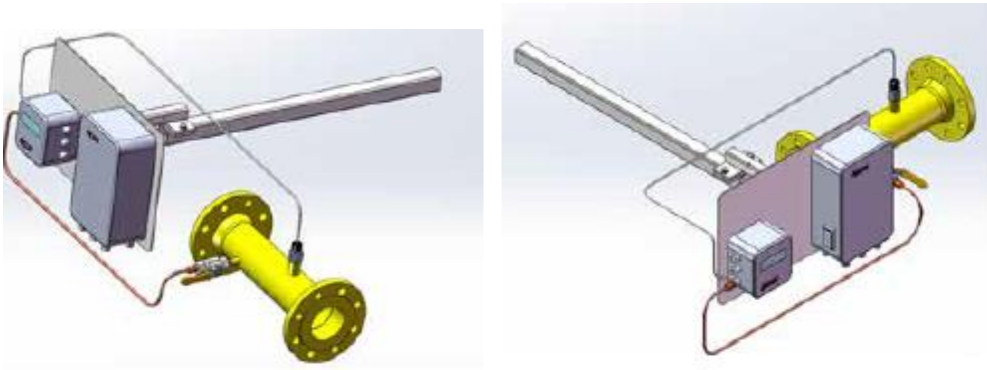


Figure 20: Combustion air control for burner

The combustion air circuit is modified to create three fuel feed macro-zones. Each macro-zone is, in turn, sub-divided into an upper branch and a lower one and each branch has a motorized valve connected to a pressure transducer. The system is completed by installation of an inverter on the fan and a pressure transducer on the main duct to keep circuit pressure stable under all operating conditions. The system is managed via a control panel, ensuring repeatability of settings and letting the user differentiate opening in the different zones according to production requirements. In the event of a gap in production valve aperture can be adjusted to a pre-defined setting. The advantages include:

- Flexibility – Air volume can be set according to the product
- Fuel consumption optimization
- Reduced consumption if there is gap in production
- 3 independent macro zones can be controlled separately

5. **Heat recovery from Kiln to Dryer:** The air is drawn from the final cooling chimney by a fan and sent via an insulated duct to the dryers. The booster fan is equipped with an inverter getting feedback from the pressure transducer mounted on the duct downstream from the fan helps to control the air transfer flow. The control panel is independent and can be installed /retrofitted on any machine. System parameters are constantly monitored by software to maximize the saving without changing the production cycle. The advantages of the system include:
    - Immediate savings
    - Control system to optimize the economic advantages
    - Complete integration with existing plant
    - Suitable for all kilns and dryers – horizontal and vertical
    - Quick return on investment

Figure 21: Heat recovery from kiln to dryer

6. **Fast Cooling Management:** This retrofit intervention involves modification of the fast cooling duct by separating the upper and lower circuit with motorized control valve which can be controlled from operator panel. Further modification to the duct can allow the creation of two separate fast cooling zones. Each zone has a general motorized valve which is controlled by a thermocouple; it also has a motorized valve with position control for both upper and lower channel separately. To complete the system, an inverter is fitted on fan drive motor and a pressure transducer is fitted on the main duct. All regulators and valves are controlled via operator panel. The advantages of the system include:
    - Complete control
    - Parameters can be changed / set as per RM recipe
    - Volume control in case of gap in production
    - Flow control via fan inverter

- Adjustment flexibility in upper and lower roller bed

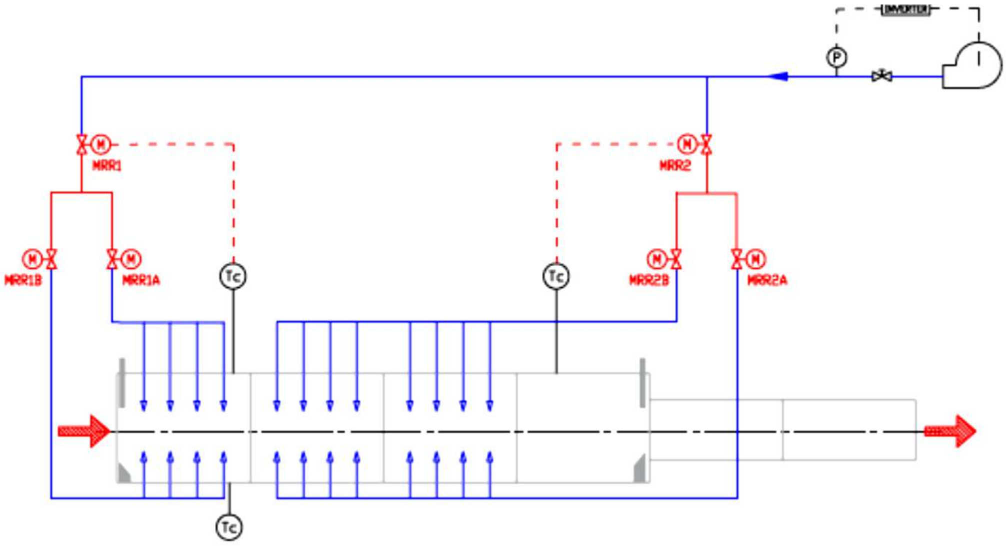


Figure 22: Fast cooling air management

7. **Industry 4.0 system for easiness in operation and real-time information:** Industry 4.0 system provides opportunity to make full use of data control and management system. These systems are modern, compatible with the most widely used data platforms and ensure machines can be used flexibly with excellent usability of collected data. The technical features of such a system includes:
   - Network connected PLC system for automation and operator/machine safety
   - Simple user-friendly man-machine interface that can be used by operators in any situation
   - Continuous monitoring of process parameters and working conditions using suitable sensors
   - Adaptive - behavior system control in the event of any process drift
   - Remote tele-assistance service allows modification of process parameters and updating the software
   - PC/SCADA system allows monitoring, control and supervision of the machine using connection network
   - Compelete consumption and production database available to corporate network and to management software using internet or database SQL protocol

Figure 23: Real time information system 4.0

The advantages of the system are:

- Production and consumption data can be shared with company management system
- Coordinated automation to plan production
- Remote/Tele-assistance system
- Productivity and plant problem analysis

5.3.4 High Alumina Pebbles for Ball Mills:

Ball mills performance is greatly affected by quantity and quality of grinding balls / Pebbles used. There are different qualities of pebbles used in Morbi cluster:

a. Local pebbles from river
b. Imported pebbles from China
c. High Alumina Pebbles from EU

Figure 24: - High Alumina pebbles for Ball mill

The cost and quality of each pebble is different and has major impact on energy consumption of ball mill as described below:

a. Local pebbles: The local river pebbles are used mainly for economic reasons as they are cheap but its sizes vary irregularly and wears out very fast resulting in longer grinding time which increases the energy consumption.
b. Imported Pebbles: Chinese pebbles are available in different quality and variable working life span. These quality is also widely used by ceramic units which gives better performance as compared to local pebbles.
c. High Alumina Pebbles: The third quality is High alumina pebbles from Spain/ EU origin which are having very high Alumina percentage ranging from 80-92 % which gives very long life. As per one feedback from unit during audit, it was learnt from production team that local pebbles are worn out in 8-10 grinding batches where as high alumina pebbles last 8-10 times longer (90-100 batches) which reduces energy consumption and running time of ball mill. The fineness and residue percentage of RM used are also affected with local /poor quality pebbles which is not the case in high alumina pebbles. The cost is relatively high which restricts the use of high alumina pebbles, but if the running cost, productivity and energy consumption is taken in to account, the high alumina pebbles are proven better.
d. Replacement of pebbles is a coniferous process as this is consumable. Only a few units in Morbi cluster are already following this practice, there is a scope for wider adaption of the recommended practice.

5.3.5 Use of Organic deflocculant in Ball Mill grinding process of Ceramic tiles:

In the tile manufacturing process different raw materials which include one or more clays are mixed in specific Ratio (Clay Body). Clay body is subjected to wet grinding in a ball mill to get required density and viscosity. For efficient grinding, inorganic dispersants like STPP, SHMP or sodium silicate are used. These can be replaced either partially or fully by organic deflocculant (Brand name FLOSPERSE[6]) to save fuel cost during spray drying. Slip is stored in tanks which will be sieved for sending to spray drying.

Purpose of using deflocculants is to avoid increase in the viscosity of the slurry due to thixotropy. Lower viscosity during wet-grinding makes the grinding operation faster, thus reducing power consumption. Lower viscosity also prevents choking of pipelines & spray drier nozzles, thus ensuring proper granulometry of spray dried dust/clay, which is essential for achieving green tile strength. Deflocculants allows for achieving higher slurry density (more solids loading per litre of slurry) without increasing viscosity. For spray drying operation, achieving higher slurry density is important since more solids in slurry, less water to be evaporated in spray drier and less fuel consumption , making the operation viable commercially.

In water, the deflocculant ionizes to cation and anion. The anion absorbs on the particle imparting it a negative surface charge. Thus the electric double layer on the particle surface is expanded (as opposed to coagulation, where the double layer is compressed) leading to increased repulsion and lower viscosity.

Estimated savings from use of deflocculants for **Partial Replacement of STPP/Sodium Silicate include**

- STPP dosage is reduced by more than 50%
- For the same treatment cost as STPP alone, by using FLOSPERSE in combination, a higher density slip can be achieved at the same viscosity thus saving much more in terms of fuel cost in spray dryer

Since this is a new product, a small scale pilot is recommended to ascertain the cost and benefits.

5.3.6 Use of Organic Binder in Porcelain/Granite Tiles Manufacture:

In ceramic bodies where highly plastic clays are used, sufficient green and dry strength is achieved due to the inherent binding ability of the clays hence the use of external binders is not necessary. However, in the manufacturing process of vitrified/granite tiles, almost 75 % of raw materials are non-plastic in nature which contribute very less to green and dry strength. Special white firing clays which are not highly plastic are used in small quantity and do not impart sufficient strength. Organic binders like FLOBIND[7] can be used very effectively to increase the green and dry strength as well as edge strength of the tiles. The working principle of the binder is as follows:

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[6] Product brochure of M/s SNF (India) Pvt. Ltd. Vizag

[7] Source: Product brochure of M/s SNF (India(Pvt. Ltd., Vizag, India

- During wet grinding, the binder gets uniformly mixed through the body and inter-particulate bonds are formed which remain intact even after physically combined water is removed during the drying stage. Thus, green and dry strength is imparted.
- Conversely, during each process stage, if water is absorbed, there is loss of strength. Organic binders ensures that sufficient strength is maintained to withstand all the process stages thus reducing rejections due to cracks, damaged edges and breakages.

Advantages of using Binder for Vitrified tiles include:

- Lower dosage or effective binder cost.
- The product is non-fouling which is not susceptible to bacteriological contamination during slip storage, hence no need to use biocides.
- Minimum or no adverse effect on the rheological properties of slip (The rheological behavior of non-Newtonian fluids such as cement paste, mortar, or concrete is often characterized by two parameters, yield stress, τ0, and plastic viscosity, μ, as defined by the Bingham equation Eq. (1) If observed, can be easily corrected by a small dosage of deflocculant.
- The use of organic binder could reduce the addition of expensive clays in the clay body which impact higher resistance and reduce the cost

Since this is a new product, a small scale pilot is recommended to ascertain the cost and benefits.

5.3.7 Use of Direct blower fans instead of belt drive:

There are a numbers of fans used in tile manufacturing, most of which are using belt drive system. The major application of blower fans in kiln is for combustion heating, cooling, recovery of hot air, exhaust / flue air etc. There are also other applications viz. FD and ID fans on Hot Air Generators. In most of these applications, the air temperature is high and overall system is working in handling high temperature air with whole mechanical structure including fan and shaft are at higher temperature compared to atmospheric air temperature. The fans are working with heavy inertia load of fan impeller and air flow which continuously create stress on V-belts resulting in belt elongation and slippage. In order to avoid energy loss in belt drive slippage, direct mounted fans on motor shaft eliminates the slippage issue and depending upon size and application, @ 3-5 % of energy loss can be reduced using direct motor mounted fans along with Inverter drive for speed control.

A few units in Morbi cluster are using direct drive fans.

Figure 25: Direct driven blower fans

6. Renewable energy applications

The possibility of adopting renewable energy measures was evaluated during the CEA.

6.1 Installation of Solar PV system

The possibility of adopting renewable energy measures was evaluated during the CEA. A roof top area of 200 m^2 is available in the unit. The feasibility of installing solar PV in this area was evaluated. The corresponding solar energy generation potential is shown below.
The cost benefit analysis for solar PV installation is given below:

Table 45: Cost benefit analysis of solar PV installation (ECM 11):

Parameters	UOM	As Is	To Be
Available area on roof	m^2	200	200
Capacity of solar panel	kW		20
Energy generation from solar panel	kWh/d		96
Solar radiation day per year	d/y		300
Average electricity generation per year	kWh/y		28,800
Cost of Electricity	Rs/kWh		7.10
Annual monetary savings	Lakh Rs/y		2.04
Estimated Investment	Lakh Rs		13.73
Payback Period	Months		80.62
IRR	%		-14%
Discounted rate of return	Months		28.35

The project IRR is negative and hence the project is not considered feasible. The reasons are as follows:

a) Increase in capital expenditure on account of
   a. Requirement for strengthening the structure for accommodating the solar panels.
   b. Requirement for construction of walkways for cleaning of solar panels.
b) Degradation of generation considered on account of heavy dust accumulation on the panels.
c) Increase in operating costs on account of
   a. Increased cleaning frequency.
   b. Requirement of DM water for cleaning the panels twice a day.

7. ANNEXES

Annex-1: Process Flow Diagram

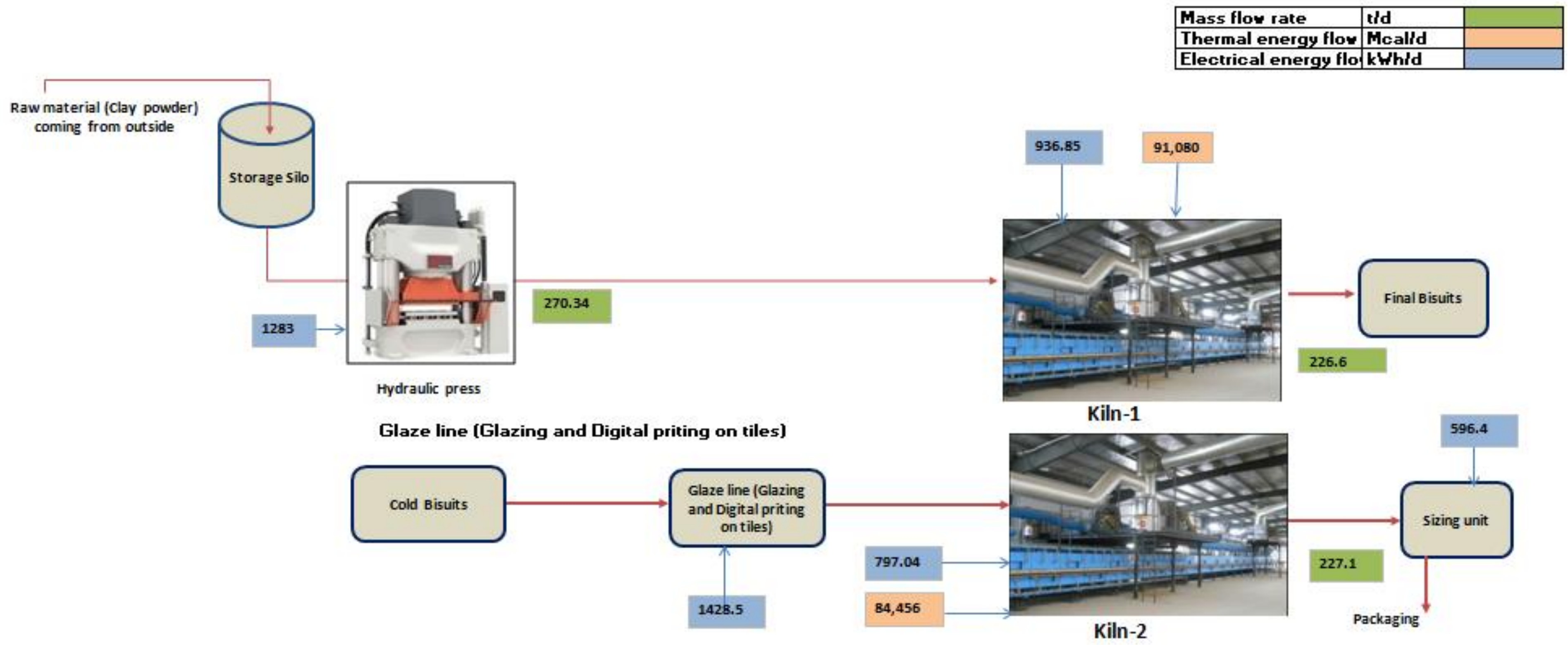

Figure 26: Process Flow Diagram of Plant

Annex-2: Detailed Inventory

Table 46: Detailed Inventory list

Equipment Name	Electrical Load (kW)
Press	353.102
Kilns	796.45
Glaze Ball Mills	106.245
Glaze Line	99.744
Cooling Tower	22.26064
Sizing Machine	283.35
Compressors	53
Single Phase Load	30.8
Total	1,391.8

Annex-3: Single Line Diagram

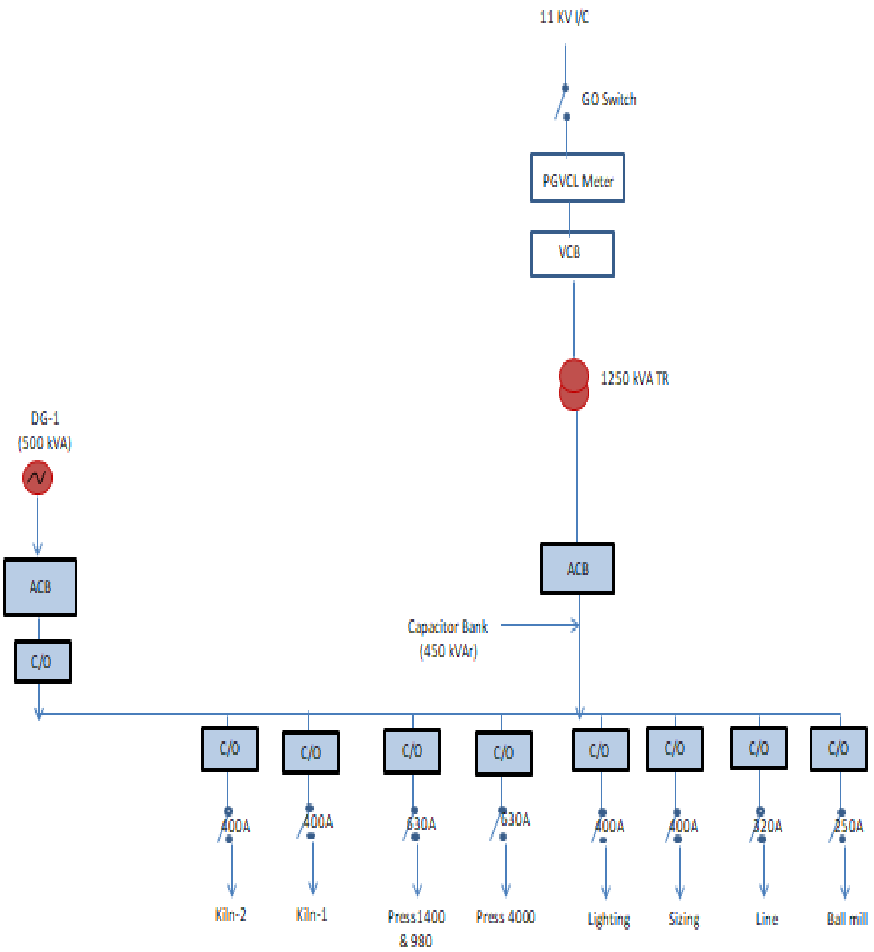

Figure 27: Single Line Diagram (SLD)

Annex-4: Electrical Measurements

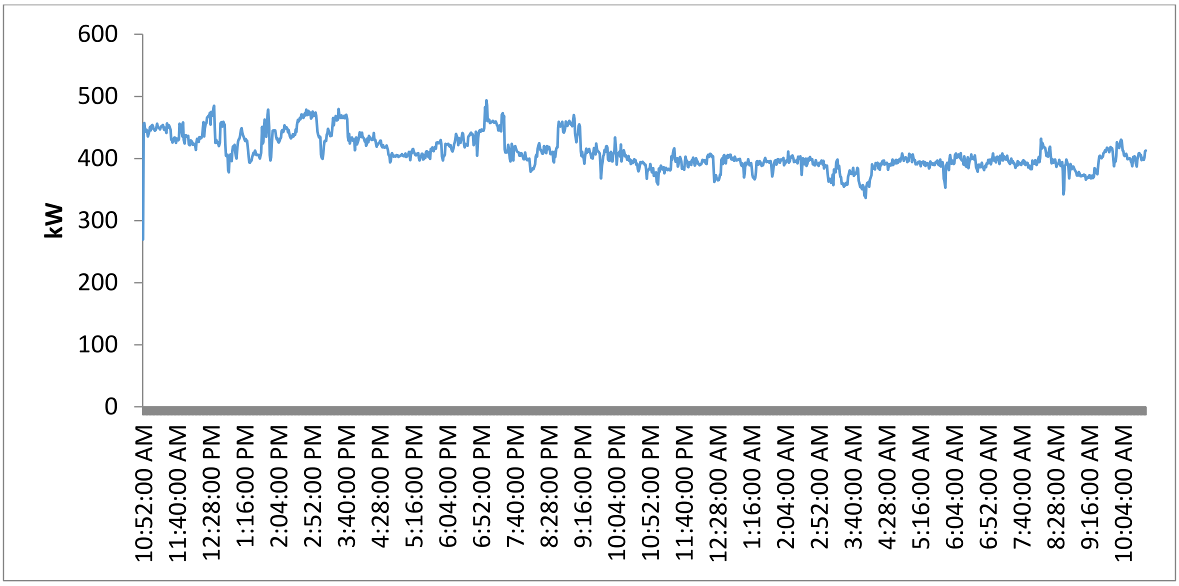

Figure 28: Power profile (kW) of Main Incomer

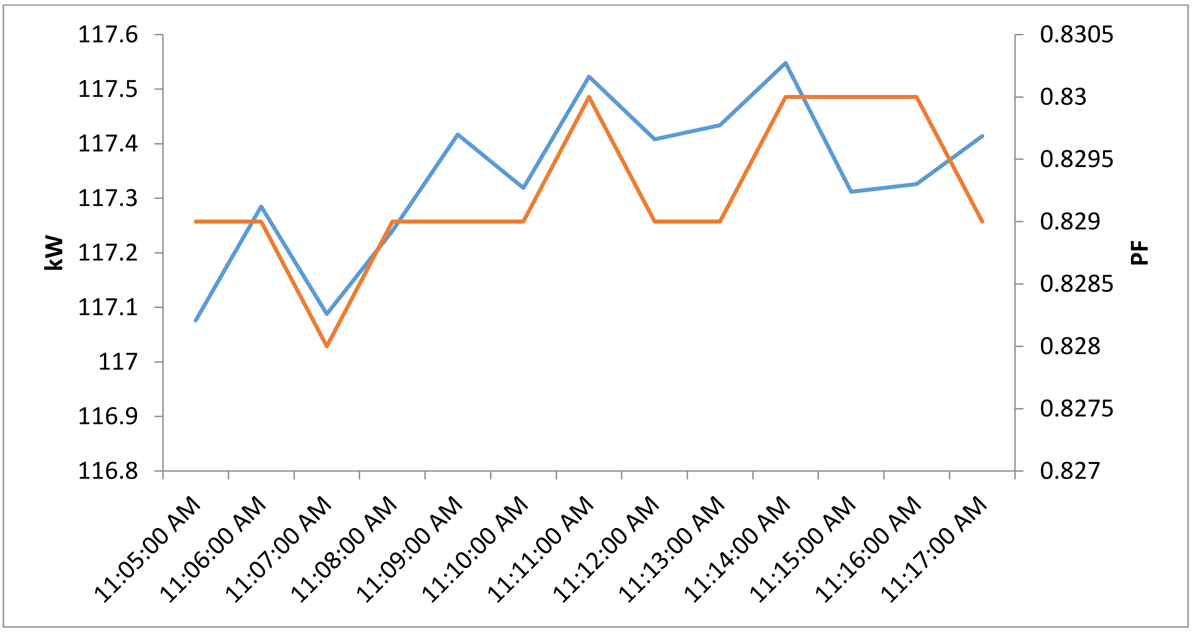

Figure 29: Power and PF profile of old press MBD

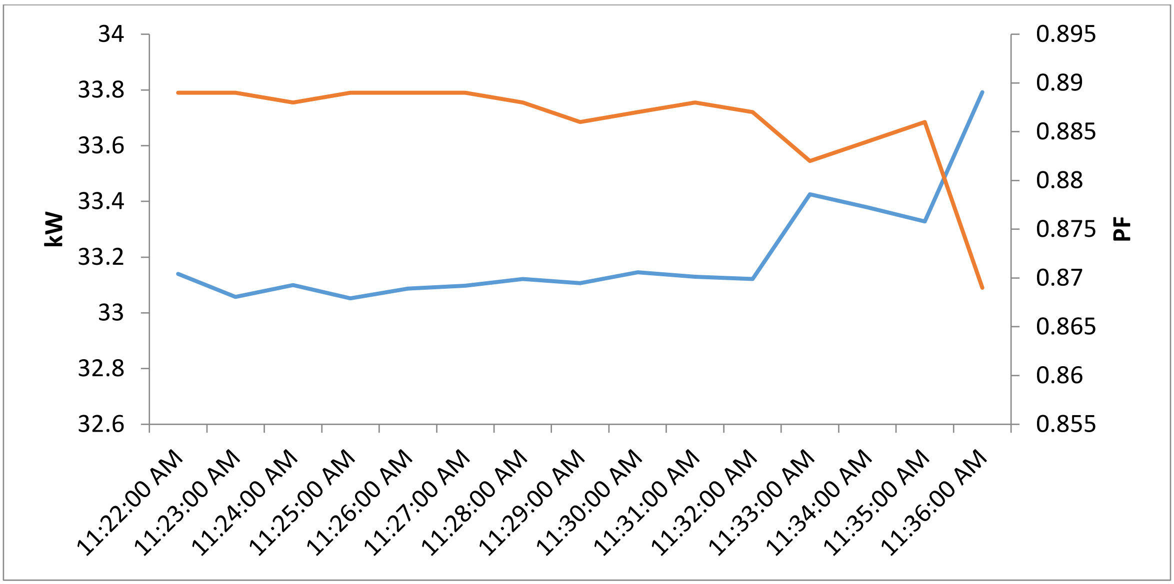

Figure 30: Power and PF profile of Kiln-2 MDB

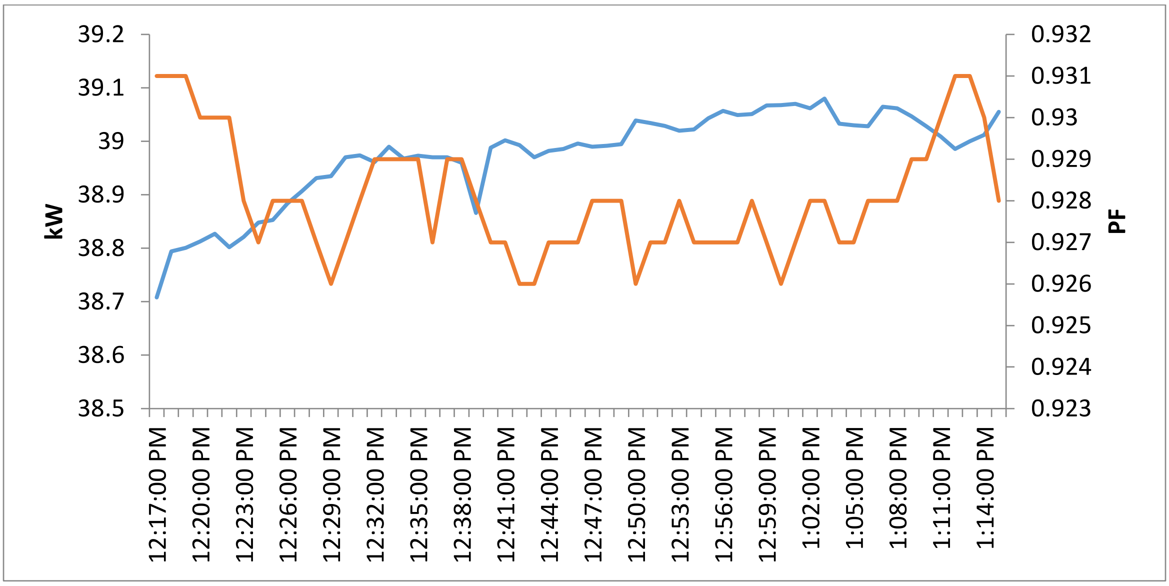

Figure 31: Power and PF profile of Kiln-1 MCB

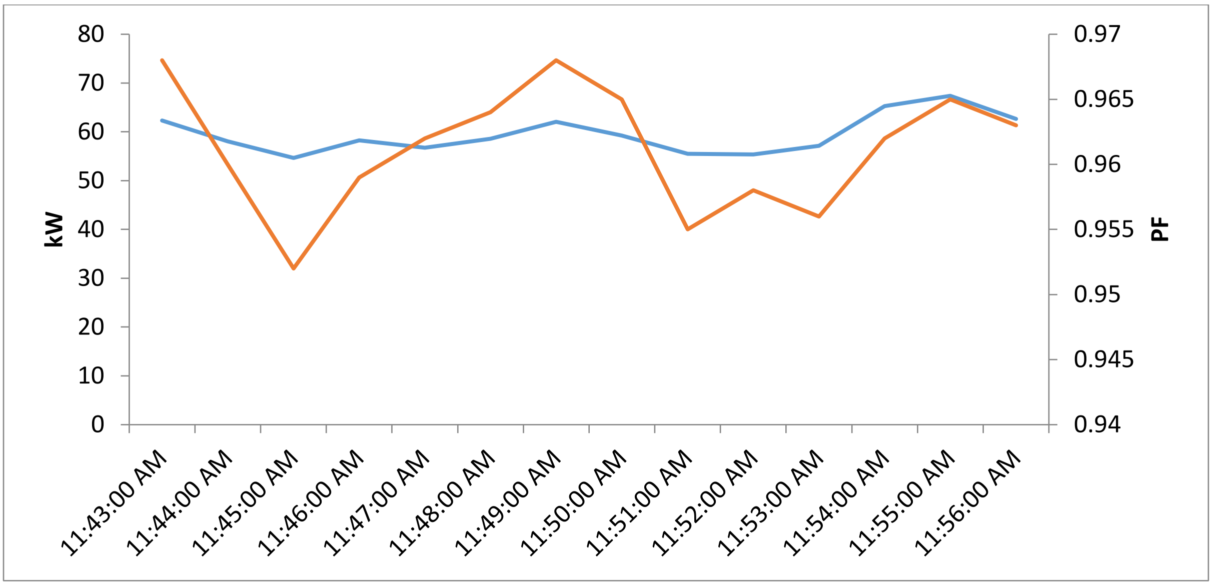

Figure 32: Power and PF profile of Glaze Line MDB

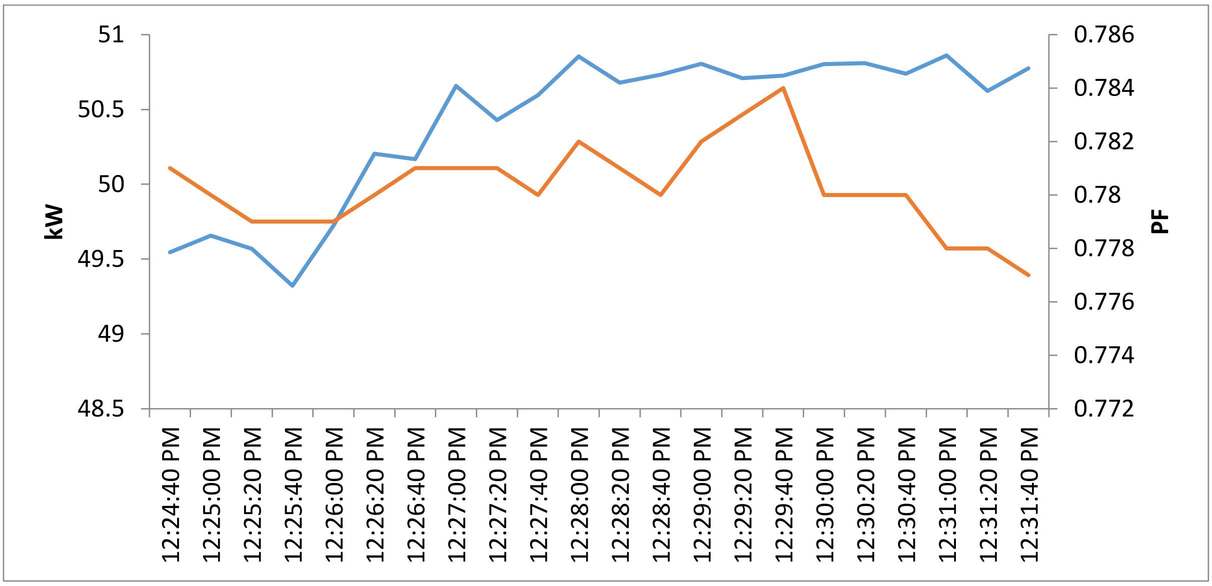

Figure 33: Power and PF profile of Kiln entry table MDB

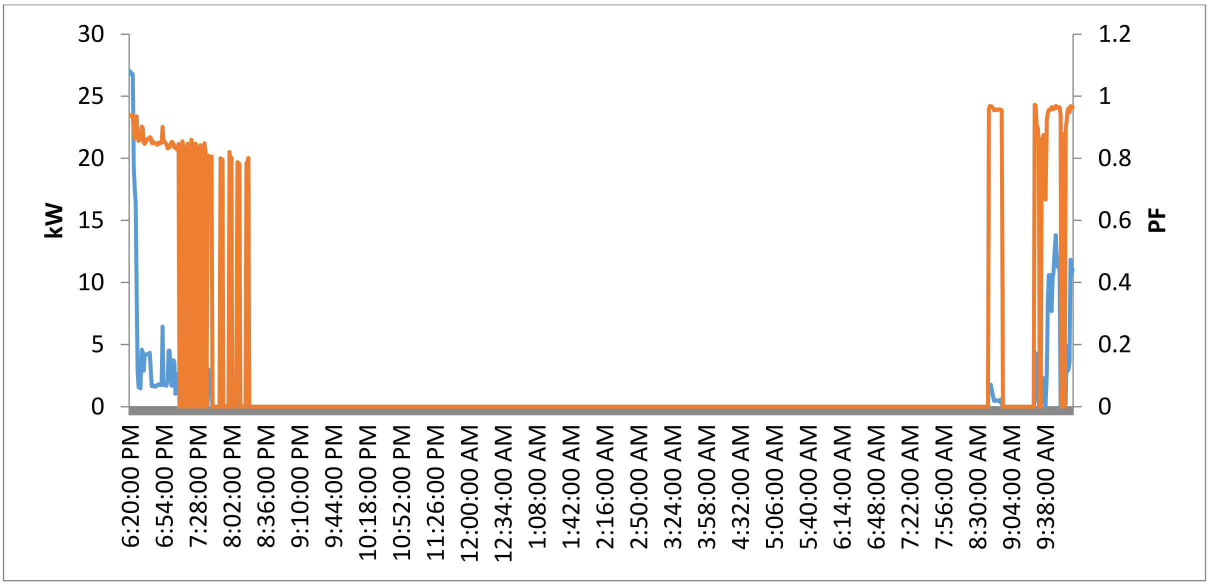

Figure 34: Power and PF profile of OFC load MDB

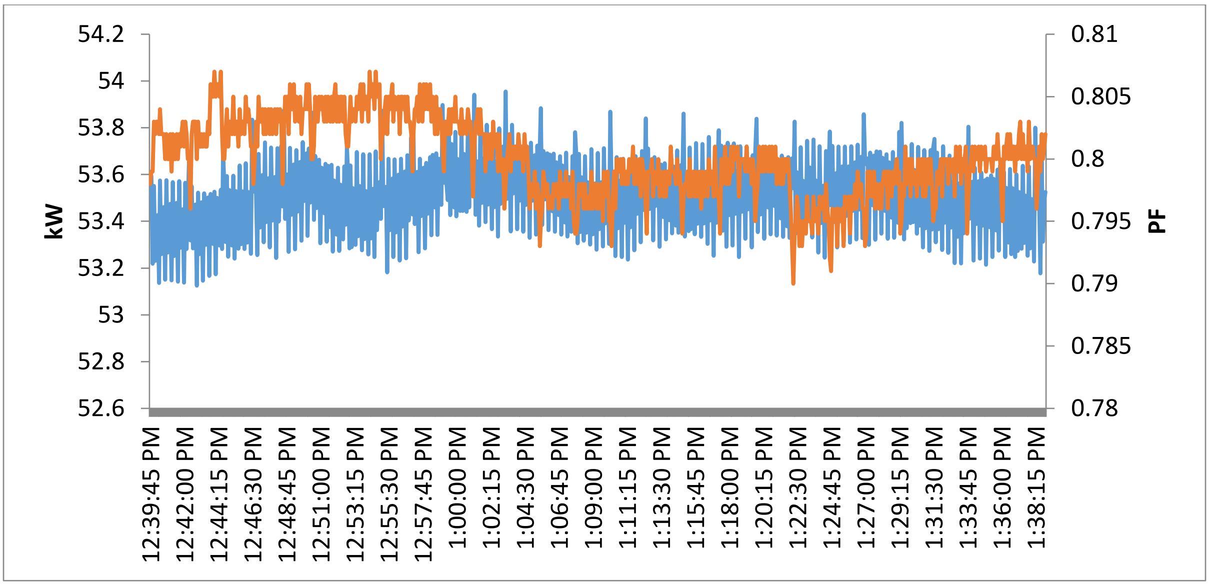

Figure 35: Power and PF profile of Press 980

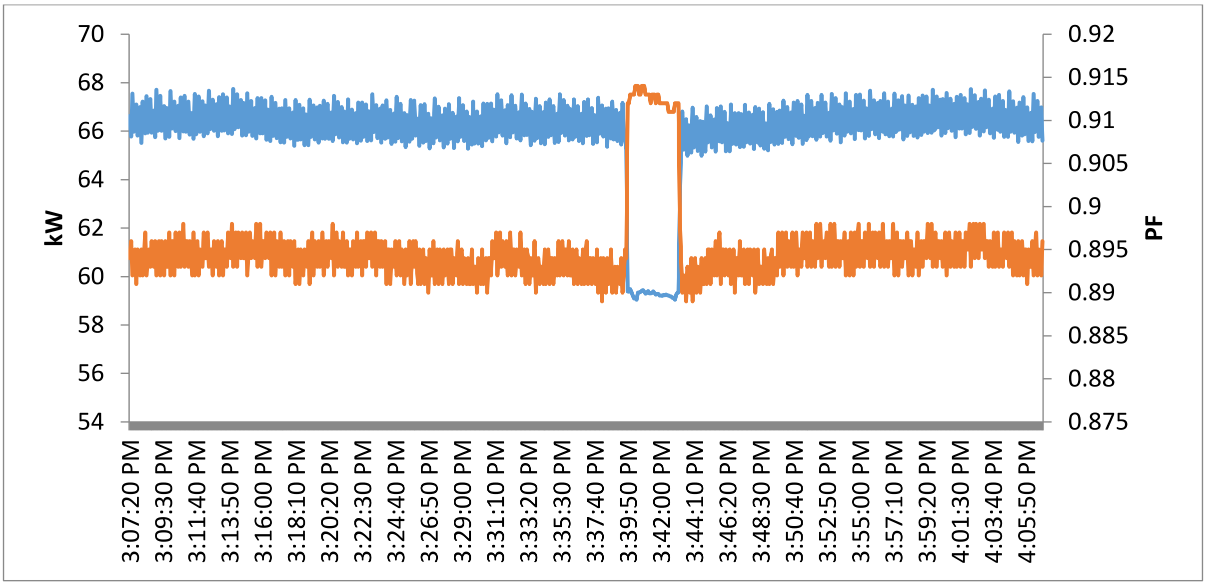

Figure 36: Power and PF profile of Press 1400

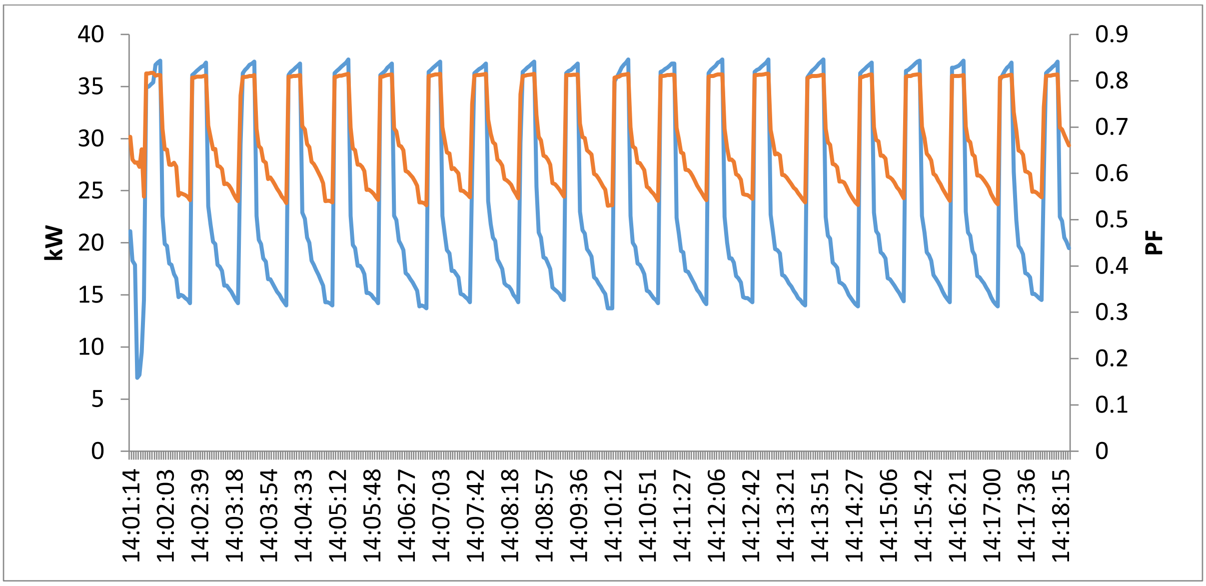

Figure 37: Power and PF profile of Compressor

Annex-5: Thermal Measurements, Kiln Efficiency

1. *Kiln efficiency calculations*

Input parameters

Input Data Sheet			
Type of Fuel		**NG**	
Source of fuel		**Gujarat gas**	
	Biscuit Kiln	Glaze Kiln	Unit
Particulars	**Value**	**Value**	
Kiln Operating temperature (Heating Zone)	1,082	1,019.3	*°C*
Initial temperature of kiln tiles	65	60	*°C*
Avg. fuel Consumption	421.7	391.0	*scm/h*
Flue Gas Details			
Flue gas temp at smog blower	169	169	*°C*
O2 in flue gas	5.8	8.40	*%*
CO2 in flue gas	8.65	7	*%*
CO in flue gas	9	23	*ppm*
Atmospheric Air			
Ambient Temp.	38	38	*°C*
Relative Humidity	45	45	*%*
Humidity in ambient air	0.03	0.03	*kg/kgdry air*
Fuel Analysis			
C	*73.80*	*73.80*	%
H	*24.90*	*24.90*	%
N	*1.30*	*1.30*	%
O	*0.00*	*0.00*	%
S	*0.00*	*0.00*	%
Moisture	*0.00*	*0.00*	%
Ash	*0.00*	*0.00*	%
GCV of fuel	9,000	9,000	*kCal/scm*
Ash Analysis			
Unburnt in bottom ash	*0.00*	*0.00*	%
Unburnt in fly ash	*0.00*	*0.00*	%
GCV of bottom ash	*0*	*0*	kCal/kg
GCV of fly ash	*0*	*0*	kCal/kg
Material and flue gas data			
Weight of Kiln roller material	0	0	*kg/h*
Weight of ceramics material being heated in Kiln	9,443	9,463	*kg/h*
Weight of Stock	9,443	9,463	*kg/h*
Specific heat of clay material	0.22	0.22	*kCal/kg-°C*
Avg. specific heat of fuel			*kCal/kg-°C*
fuel temp	38	38	*°C*
Specific heat of flue gas	0.24	0.24	*kCal/kg-°C*
Specific heat of superheated vapour	0.45	0.45	*kCal/kg-°C*
Heat loss from surfaces of various zone			
Radiation and convection from preheating zone surface	1,918	3,222	*kCal/h*

Input Data Sheet			
Radiation and convection from heating zone surface	10,631	13,590	*kCal/h*
Heat loss from all zones	12,549	16,811	*kCal/h*
For radiation loss in furnace			
Time duration for which the tiles enters through preheating zone and exits through cooling zone of kiln	0.83	0.83	*h*
Area of entry opening	1.2	1.2	*m2*
Coefficient based on profile of kiln opening	0.7	0.7	
Average operating temp. of kiln	343	343	*deg K*

Efficiency calculations

Calculations	Biscuit Kiln	Glaze Kiln	Unit
Theoretical Air Required	17.23	17.23	*kg/kg of fuel*
Excess Air supplied	37.80	66.67	*%*
Actual Mass of Supplied Air	23.74	28.71	*kg/kg of fuel*
Mass of dry flue gas	22.49	27.47	*kg/kg of fuel*
Amount of Wet flue gas	24.74	29.71	*Kg of flue gas/kg of fuel*
Amount of water vapour in flue gas	2.24	2.24	*Kg of H2O/kg of fuel*
Amount of dry flue gas	22.50	27.47	*kg/kg of fuel*
Specific Fuel consumption	44.65	41.32	*scm of fuel/ton of tile*
Heat Input Calculations			
Combustion heat of fuel	401,871	371,886	*kCal/ton of tiles*
Total heat input	401,871	371,886	*kCal/ton of tile*
Heat Output Calculation			
Heat carried away by 1 ton of tile	223,784	211,053	*kCal/ton of tile*
Heat loss in dry flue gas	31,580.93	35,685.62	*kCal/ton of tile*
Loss due to H2 in fuel	628	556	*kCal/ton of tile*
Loss due to moisture in combustion air	1399.27	1692.45	*kCal/ton of tile*
Loss due to partial conversion of C to CO	29.11	47.20	*kCal/ton of tile*
Loss due to convection and radiation (openings in kiln - inlet & outlet of kiln)	16.23	16.20	*kCal/ton of tile*
Loss Due to Evaporation of Moisture Present in Fuel	-	-	*kCal/ton of tile*
Total heat loss from kiln (surface) body	12,549	30,458	*kCal/ton of tile*
Heat loss due to unburnt in Fly ash	-	-	*kCal/ton of tile*
Heat loss due to unburnt in bottom ash	-	-	*kCal/ton of tile*
Heat loss due to kiln car	-	-	*kCal/ton of tile*
Unaccounted heat losses	131,884.51	92,377.92	*kCal/ton of tile*
Heat loss from kiln body and other sections			
Total heat loss from kiln	12,549	30,458	*Kcal/ton*
Kiln Efficiency	55.69	56.75	*%*

2. Heat Balance Diagram

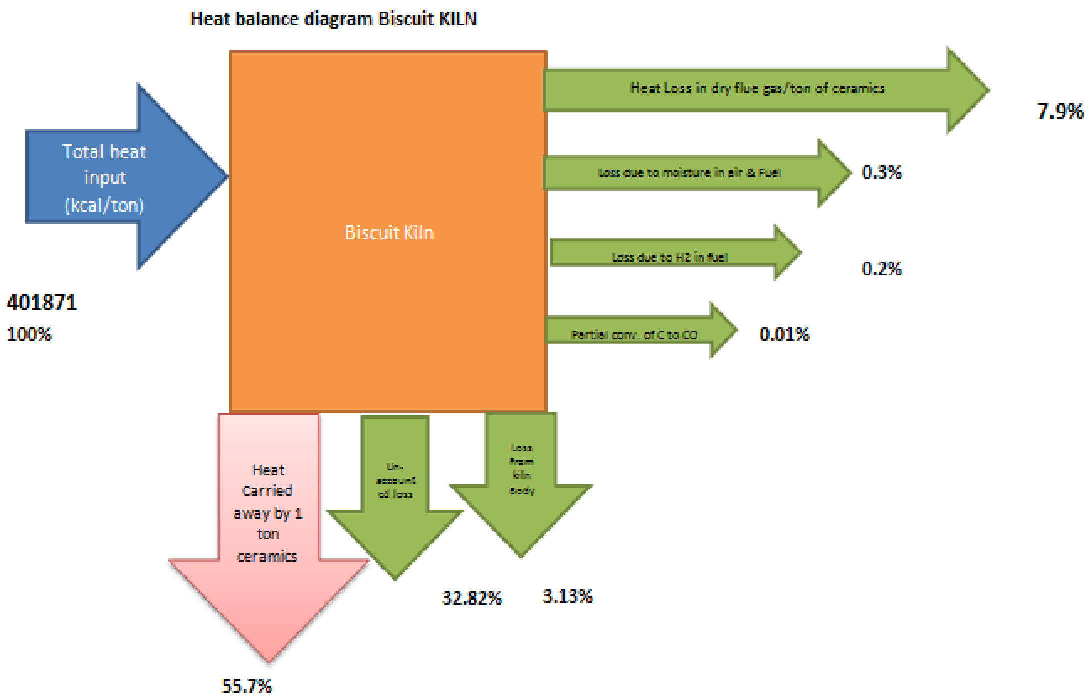

Figure 38 : Heat balance of kiln 1

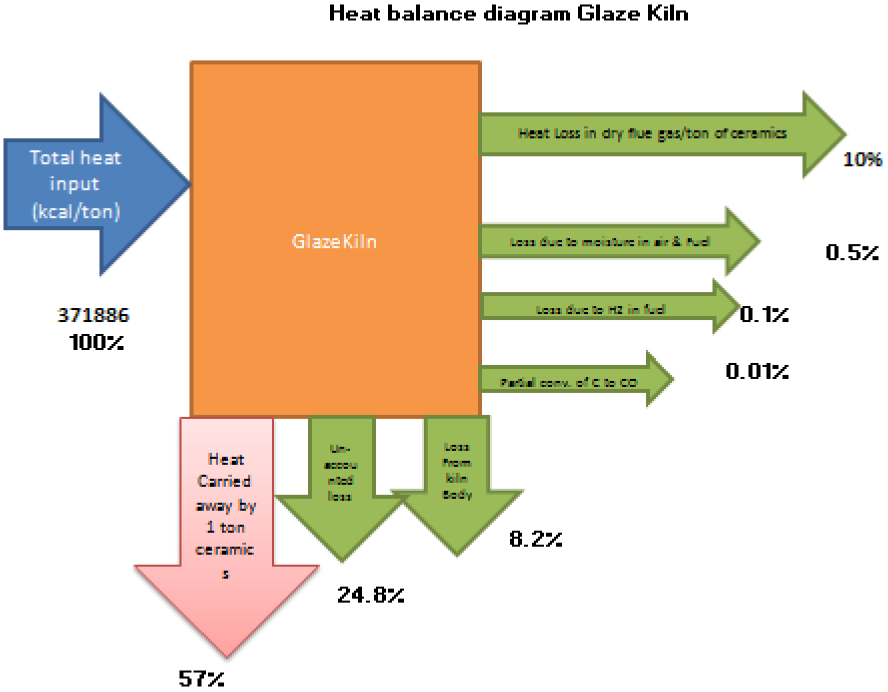

Figure 39 : Heat Balance of kiln 2

Annex-6: List of Vendors

ECM 1: Excess Air control

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Nevco Engineers	90-A (2nd floor), Amrit Puri B, Main Road, East of Kailash, New Delhi – 110065	Tel : 011 – 26285196/197 Fax: 011 – 26285202	Nevco_delhi@yahoo.co.in
2	High-tech controls for ABB Oxygen Analysers	A 5, Vrindavan Tenament, Gorwa Behind SBI Bank, Near Sahyog Garden, Vadodara - 390016, Gujarat,	Mr. Bhavik Parikh M: 8071640984	NA
3	Knack well Engineers	C/2, Akshardham Industrial Estate, Near Ramol Over Bridge, Vatva, GIDC, Phase IV , Ahmedabad - 382445, Gujarat, India	Darshan Thanawala, Ravi Thanawala (Proprietor) 8079452278, 9428597582, 9327013773	www.knackwellengineers.com darshan@kanckwell.com, ravi@kanckwell.com

ECM 3: Temperature controller in CT pump

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Cogent Controls	205, Vinay Industrial Estate, Chincholi Bunder Link Road, Malad – West, Mumbai - 400064	022-28750421 9820032946	COGENT CONTROLS [enquiry@cogentcontrols.com]
2	SHIWKON controls	33-34-35, First Floor, Shakti Chamber - 1, N. H. 8A, Opposite Adarsh Hotel, Morbi-363642	93750 50704	morbi@shiwkon.com
3	Shivson Instruments & Sensors	No-27, Shakti Chamber, 1st Floor, 8-A N.H., Morbi- 363642	Mr. Pragnesh Bhai Ramavat	https://www.tradeindia.com/Seller-2748902-Shivson-Instrument-Sensor/

ECM 4: Screw compressor with VFD

Sl.No.	Name of Company	Address	Phone No.	E-mail
1	Samhita Technologies Pvt. Ltd	309, Vardhman Grand Plaza, Distt Center, Mangalam Place, Plot No. 7, Outer ring road, Sec 3, Rohini, Delhi – 110085	Mob: +91 9711320759 Tel: +91 11 45565088	sales@samhitatech.com
2	Amtech Electronics (India) Ltd	E-6 GIDC Electronics Zone, Gandhinagar	Mr. Sachin Patel 079-23289101/102	mktg2@amtechelectronics.com
3	Hitachi Hi-Rel Power Electronics Pvt. Ltd	B-117 & 118 GIDC Electronics Zone, Sector 25, Gandhinagar- 382044	Mr. V.Jaikumar 079 2328 7180 - 81	v_jaikumar@hitachi-hirel.com

ECM-5: Replacement of inefficient lighting systems

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),	kushagra.kishore@bajajelectricals.com, kushagrakishore@gmail.com; sanjay.adlakha@bajajelectricals.com

ECM 6: Cable loss minimization

Sl. No.	Name of Company	Address	Phone No.	E-mail / Website
1	Cummins Power Generation Contact Person: Rishi Gulati Senior Manager-Power Electronics	Cummins India Limited Power Generation Business Unit 35/A/1/2, Erandawana, Pune 411 038, India	Phone: (91) 020-3024 8600 , +91 124 3910908	cpgindia@cummins.com rishi.s.gulati@cummins.com
2	Krishna Automation System Contact Person: Vikram Singh Bhati	ESTERN CHAWLA COLONY, NEAR KAUSHIK VATIKA, GURGAON CANAL BALLBGARH FARIDABAD 121004	Mob: 9015877030, 9582325232	krishnaautomationsystems@gmail.com
3	Next Gen Power controls	8, Rashmi Growth Hub Estate, Near Shree Sai Palace Hotel Odhav, Ahmedabad- 382415, Gujarat, India	08048110759	

ECM7 : voltage optimization of lighting circuit

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Dynamic Energy Solutions	Plot Number 6, Nangla Industrial Area, Nangla Gazipur Road, Faridabad-121004	9873565940	dynamicenergysolutions@gmail.com
2	Recons Power Equipment Pvt. Ltd	Plot Number 38, Sector-25, Faridabad-121004	0129-4062114-116 9811095526	mail@reconsindia.com

Sl. No.	Name of Company	Address	Phone No.	E-mail
3	SERVOMAX INDUSTRIES LIMITED	Plot No:118A, 2nd Floor, Road Number 70, Journalist Colony,Jubilee Hills, Hyderabad, Telangana - 500033	+91 9111234567	customercare@servomax.in www.wervomax.in

ECM-9 : Conversion of V belt to REC belt

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Reitz India Limited	New Alipore Market Complex, Block - M; Phase - I, Room No. 414 (Fourth Floor), Kolkata - 700 053, India.	Mr. Tarun Roy Mob: +91 94330 32474	tr@reitzindia.com
2.	Mangal singh Bros. Pvt Ltd	24-B, Raju Gardens, Near Krishnasamy nagar, Sowripalayamp Post, Coimbatore-641028	Ramiz Parker +91 77381 86851	mangalsinghcbe@gmail.com
3	Shreeji Traders	Mahavir Cloth Market, B/H, Kapasiya Bazar, Old Railway Station,, Kalupur, Ahmedabad, Gujarat 380001	+91 94281 01565	NA

ECM 10 : Energy Management 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

ECM 11 : Solar PV system

Sl. No.	Name of Company	Address	Phone No.	E-mail / Website
1	GREEN EARTH INFRACON & SOLAR	348, Avadh Viceroy, Sarthana Jakatnaka, Varachha Road, Surat, Gujarat, 395006, India	Mr. Dhaval Patel 7210113608	NA
2	CITIZEN Solar Pvt. Ltd	711, Sakar-2 Ellisbridge corner, Ahmedabad-380006	Girishsinh Rav Jadeja 9376760033	www.citizensolar.com sales@citizensolar.com
3	Sun gold Enterprise	D-134, Udhna Sangh Commercial Complex, Near Divya Bhaskar press, Central Road, Udhna Udhyog nagar, Surat-394010	Mr. Pravin Patel 98251 94488	sungoldindia@gmail.com

Annex-7: Financial analysis of project

Table 47 Assumptions for Financial Analysis

Particulars	Units	Value
Debt Equity Ratio for Bank Loan		2.00: : 1.00
Interest Rate on Bank Loan	%	13.50%
Project Implementation Period	Y	0.50
Moratorium Period	Y	0.50
Loan Repayment Period	Y	5.00
Depreciation Rate (IT Act)	%	80.00%
Depreciation Rate (Co's Act)	%	15.00%
Effective Income Tax Rate	%	26.750%
Effective MAT Rate	%	21.644%
Discount factor	%	15.000%