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

DELIVERABLE 4: COMPREHENSIVE ENERGY AUDIT REPORT

UNIT CODE WT 58: ITALAKE CERAMIC PVT. LTD

Submitted to
GEF-UNIDO-BEE Project Management Unit
BUREAU OF ENERGY EFFICIENCY

Submitted by

DEVELOPMENT ENVIRONERGY SERVICES LTD
819, Antriksh Bhawan, 22 Kasturba Gandhi Marg, New Delhi -110001
Tel.: +91 11 4079 1100 Fax: +91 11 4079 1101; www.deslenergy.com

April-2019

Bureau of Energy Efficiency, 2019

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'.

For more information

GEF-UNIDO-BEE PMU
Bureau of Energy Efficiency
4th Floor, Sewa Bhawan, Sector-1,
R.K. Puram, New Delhi-110066

Email: gubpmu@beenet.in
Website: www.beeindia.gov.in

Disclaimer

ACKNOWLEDGEMENT

DESL places on record its sincere thanks to Bureau of Energy Efficiency (BEE) for vesting confidence in DESL to carry out the assignment “Promoting Energy Efficiency and Renewable Energy in Selected MSME Clusters in India – Morbi Ceramic Cluster”. DESL is grateful to the GEF-UNIDO-BEE Project Management Unit (PMU) for their full-fledged support. Special thanks to UNIDO team for co-coordinating with cluster associations and providing support to DESL team in smooth execution of field activities.

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

DESL is indebted to M/s. Italake 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.

1. Mr. Ashok Savsani, Director
2. Mr. Mahesh Loriya, Electrical Head

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
Team leader and co-coordinator	Mr. M G Dave, Senior Consultant
Team members	Shridhar Manure, Consultant Rajendra Ninganuri, Consultant Sunil Senapati, Senior Analyst Ashok Kumar, Analyst Sandeep Sharma, Assistant Analyst Dhruvkumar Lalitbhai Anavadiya, Project Analyst

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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	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.

Italake Ceramic Pvt. Ltd has been selected as one of the 20 units for detailed energy audit. Italake 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	Italake Ceramic Pvt. Ltd.
Year of Establishment	2014
Address	Jetpar Road, Behind Bahuchar Weigh Bridge, At-Bela, Morbi – 363642, Gujarat
Products Manufactured	Wall Tiles
Name(s) of the Promoters / Directors	Mr. Ashok Savsani

➨ 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 kiln in which the fuel used is natural gas. The temperature maintained in biscuits kiln is approximately 800°C – 1,150°C and glaze kiln is 700°C- 1,085°C (in heating zone).

- **Ball mill:** Here the raw materials like clay, feldspar and quartz are mixed in the ratio of 2:1:1 respectively along with water to form a plastic mass.

- **Glaze mill:** For producing glazing material used on sanitary product.
- **Air Compressor:** Pressurized air is used at several locations in a unit viz. pressing of slurry, air cleaning, glazing etc.
- **Agitator:** The plastic mass after mixing in ball mill is poured into a sump where an agitator is fitted for thorough mixing of materials and preventing it to settle at the bottom.
- **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 dryer for pre drying after it is passed through kiln
- **Kiln:** Biscuits are baked in Roller kiln at 1,100-1,150^oC and again baked after glazing
- **Sizing:** After cutting, sizing and polishing, tiles are packed in boxes and then dispatched

The detailed energy audit covered all equipment which were operational during the field study. The main energy consuming areas are kilns which account for more than 70% of the total energy used.

➨ IDENTIFIED ENERGY CONSERVATION MEASURES

The identified energy conservation measures include the following:

- Preheating combustion air
- Optimize reduction in combustion air pressure at burner tip (Excess air control)
- Close rapid cooling standby blower damper to avoid hot air loss
- Hot surface insulation in firing zone of Kiln-1 to reduce heat loss
- Use timer control in agitator stirrer motor
- Operational pressure optimization in compressors
- Increase compressed air line size to reduce pressure drop in air distribution line
- Install VFD on one of the air compressor(Compressor-3) to avoid unload power
- Replacement of existing cooling tower pumps with EE pumps
- Replacement of existing inefficient light with energy efficient light
- Servo stabilizer in Lighting MDB
- Installation of Solar PV system
- Installation of Energy monitoring system

Table 1: Summary of Energy Conservation Measures

Sl. No.	Energy Conservation Measures	Estimated Annual Savings Electricity kWh/y	NG scm/y	Coal t/y	TOE/y	Monetary Savings Lakh Rs/y	Investment Lakh Rs	Payback Period Months	Emission Reduction tCO_2/y
1	Pre-heating combustion air		222,238		200.0	82.04	Nil	Immediate	427
2	Excess air control system		120,727		108.7	44.57	18.4	5	232
3	Close rapid cooling standby blower damper to avoid hot air outflow		45,954		41.4	16.96	Nil	Immediate	88
4	Hot face Insulation in firing zone of Kiln-1		34,450		31.0	12.72	7.44	7	66
5	Timer control in agitator stirrer motor	11,566			1.0	0.8	0.28	4	9
6	Operational pressure optimization in compressor	35,564			3.1	2.45	Nil	Immediate	29
7	Increase compressed air line size	843			0.1	0.06	0.10	21	1
8	Installation of VFD in Compressor - 3	18,223			1.6	1.25	1.00	10	15
9	Replacement cooling tower pumps	13,320			1.1	0.92	0.78	10	11
10	Energy Efficient Lighting	55,582			4.8	3.82	2.21	7	46
11	Servo Stabilizer in Lighting MDB	16,760			1.4	1.15	1.36	14	14
12	Energy Monitoring System	139,592	3,963	250	182.4	21.05	21.04	12	651
	Total	**291,450**	**427,332**	**250**	**577**	**53**	**188**	**3.4**	**1,589**

* Investment may be revised based on vendor quotation.

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

1 Reduction in energy cost by 6.8%
2 Reduction in electricity consumption by 4.2%
3 Reduction in natural gas consumption by 7.6%
4 Reduction in coal consumption by 2%
5 Reduction in greenhouse gas emissions by 3.4%

➨ 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 Lakh Rs	Internal Rate of Return %	Discounted Payback Period Months
1	Pre-heating combustion air	Nil		-
2	Excess air control system	18.4	184	1.95
3	Close rapid cooling standby blower damper to avoid hot air outflow	Nil		-
4	Hot face Insulation in firing zone of Kiln-1	7.44	128%	2.76
5	Timer control in agitator stirrer motor	0.28	217%	1.66
6	Operational pressure optimization in compressor			-
7	Increase compressed air line size	0.10	36%	7.81
8	Installation of VFD in Compressor -3	1.00	93%	3.73
9	Replacement cooling tower pumps	0.78	90%	3.92
10	Energy Efficient Lighting	2.21	130%	2.72
11	Servo Stabilizer in Lighting MDB	1.36	62%	5.33
12	Energy Monitoring System	21.04	73%	4.63

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	Italake Ceramic Pvt. Ltd.		
Plant Address	Jetpar Road, Behind Bahuchar Weigh Bridge, At -Bela, Morbi - 363642, Gujarat – INDIA		
Constitution	Private Limited		
Name of Promoters	Ashok Savsani		
Contact person	Name	Ashok Savsani	
	Designation	Director	
	Tel	9825222834	
	Fax		
	Email	italakeceramic@gmail.com	
Year of commissioning of plant	2014		
List of products manufactured	Wall tile, 300 x 600 mm Wall tile, 250 x 760 mm Wall tile, 300 x 300 mm		
Installed Plant Capacity	20,000 boxes/day(17,000/day current capacity)		
Financial information (Lakh Rs)	2014-15	2015-16	2016-17
Turnover	Not Provided by Unit		

Description	Details		
Net profit	Not Provided by Unit		
No of operational days in a year	Days/Year	365	
	Hours/Day	24	
	Shifts /Day	2	
Number of employees	Staff	250	
	Worker		
	Casual labour		
Details of Energy Consumption	Source	Yes/No	Areas of Use
	Electricity (kWh)	Yes	Entire Process and Utility
	Coal (kg)	Yes	Spray Dryer through HAG
	Diesel (litres)	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.

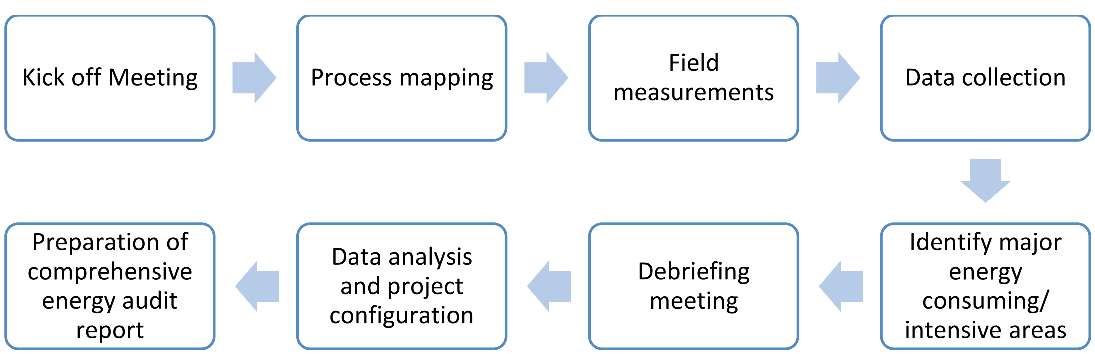


Figure 1: General methodology

The field work was carried out during 13-16th Nov 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 conservation measurements (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 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 upto 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 in the following order:

- 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 cover 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 PRODUCTION AND ENERGY CONSUMPTION

2.1 MANUFACTURING PROCESS WITH MAJOR EQUIPMENT INSTALLED (FLOW DIAGRAM)

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

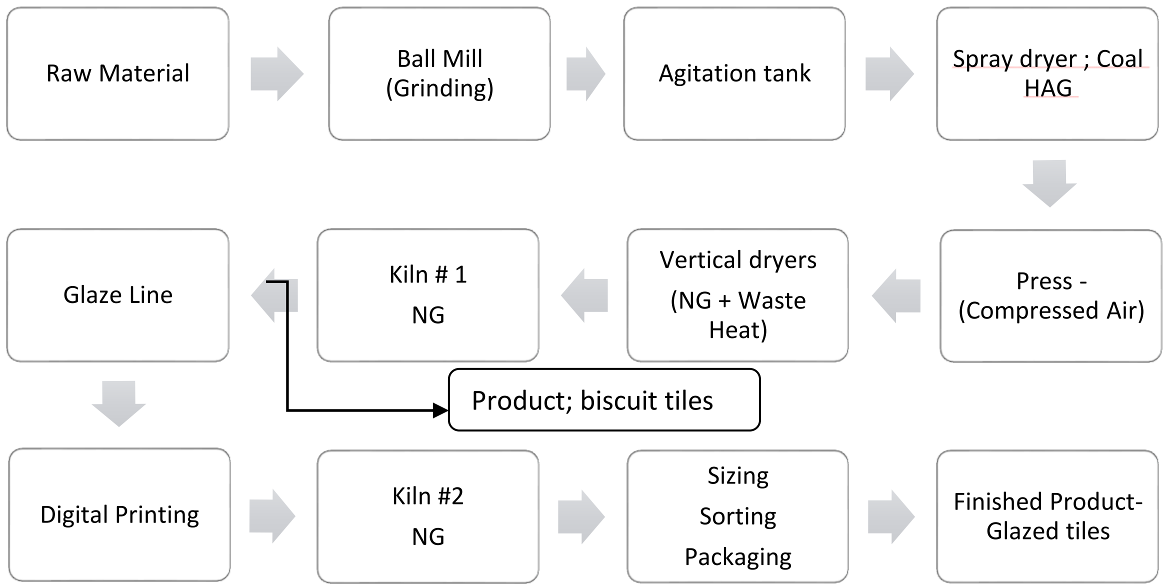


Figure 2: Process Flow Diagram

The process description is as follows:

- The raw materials china clay, talc, calcite, dolomite, silicate, feldspar and scrap are mixed together with water in the ball mill for a period of 55-60 minutes depending upon residue percentage in slurry.
- It is then transferred into the agitator tank for thorough mixing.
- Slurry containing moisture is taken into underground tanks fitted with agitator motor in each tank to maintain uniformity of mixture.
- The slurry containing about 30-40% moisture and required density is then pumped through hydraulic pump at a pressure of 12-13 bar into spray dryer using nozzles. At the top of spray dryer, hot air is passed at a temperature of 550-650°C. This hot air is generated by using hot air generator (HAG) using coal as a fuel. Material is dried in spray dryer, thus the moisture added in grinding process in ball mill gets removed from spray dryer. At the outlet of spray dryer, clay in powdered form is collected having moisture of 5-6%. Final products from spray dryer are collected in silos.
- The product from spray dryer is then sent to hydraulic press where the required sizes of biscuit tiles are formed.
- Biscuit tiles are sent to dryer through conveyor system.
- After drying, the biscuit tiles are sent for kiln#1.
- Some biscuits are considered as final product and remaining biscuits are sent for glazing and digital printing.

- After glazing the biscuit tiles are sent for final firing in the kiln. Glazed tiles are fired at a temperature of 1,050°C-1,100ºC in the kiln (Kiln-2).
- Tiles coming out of kiln are sent for sizing and calibration; the tiles are cut to proper sizes so that all the tiles are of same dimension.

The major energy consuming equipment in the plant are:

- **Ball mill:** Here the raw materials like clay, feldspar and quartz are mixed along with water to form a plastic mass.
- **Agitator:** The plastic mass after mixing in ball mill is poured into a sump where an agitator is fitted for thorough mixing of materials and preventing it to settle at the bottom.
- **Hot Air generator:** Coal is being used as fuel to produce hot air at temperature 540ºC to 712ºC.
- **Spray dryer:** Slip flows from agitator tanks to spray nozzles and sprayed in the upward direction from the nozzles and hot air coming from hot air generator will pass from top of the spray dryer and slip convert into powder. The moisture content is around 5% to 6% (The powder is carried through conveyors and stored in silos.
- **Hydraulic Press:** The required shapes of the final product are made in hydraulic press. Here the product is called biscuit.
- **Vertical Dryer:** Biscuits are sent to dryer for pre drying after it is passed through kiln. Hot air coming from kiln is being used here. If required, additional fuel firing system is also used to meet desired temperature in the dryer.
- **Kiln:** Biscuits are baked in kiln at 1,100-1,150ºC and baked again in the second kiln after glazing.
- **Glaze mill:** For producing glazing material used on tiles.
- **Air Compressor:** Compressed air is used at several locations in a unit viz. Slurry pumping, Sizing, press bed cleaning, glazing, digital printing, etc.

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 wall tiles of the following specifications:

Table 5: Product Specifications

Product	Size /Piece	Weight/box	Area per box	Pieces per box
	mmx mm	Kg	Sq m	#
Wall Tiles	300 x 600	14	0.9	5
Wall Tiles	250 x 760	15.5	0.95	5
Wall Tiles	300 x 300	11	0.81	9

The products are mainly exported to foreign market. The month wise production details of various products is given below:

Table 6: Month wise production

Period	Number of Boxes			Corresponding Area (m^2)			Corresponding Mass (MT)		
	300 x 600	250 x 760	300 x 300	300 x 600	250 x 760	300 x 300	300 x 600	250 x 760	300 x 300
Jun-17	316,738	74,079	84,106	285,064	70,375	68,126	4,434	1,148	925
Jul-17	377,052	102,109	66,406	339,347	97,004	53,789	5,279	1,583	730
Aug-17	147,191	39,729	32,021	132,472	37,743	25,937	2,061	616	352
Sep-17	352,334	60,323	43,602	317,101	57,307	35,318	4,933	935	480
Oct-17	294,798	36,992	20,380	265,318	35,142	16,508	4,127	573	224
Nov-17	179,960	41,843	28,608	161,964	39,751	23,172	2,519	649	315
Dec-17	178,678	35,800	44,662	160,810	34,010	36,176	2,501	555	491
Jan-18	236,685	45,323	58,349	213,017	43,057	47,263	3,314	703	642
Feb-18	364,422	30,527	53,832	327,980	29,001	43,604	5,102	473	592
Mar-18	399,218	20,072	61,850	359,296	19,068	50,099	5,589	311	680
Apr-18	363,348	49,158	78,901	327,013	46,700	63,910	5,087	762	868
May-18	340,702	57,134	64,679	306,632	54,277	52,390	4,770	886	711
Jun-18	188,085	5,580	39,984	169,277	5,301	32,387	2,633	86	440
Average	287,632	46,051	52,106	258,868	43,749	42,206	4,027	714	573
	128,596			114,941			1,771		

2.3 ENERGY SCENARIO

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

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

Total energy consumption pattern for the period Jun-17 to May-18, from different sources are as follows:

Table 7: Energy use and cost distribution

Particular	Energy cost		Energy use	
	Rs Lakhs	% of total	MTOE	% of total
Grid – Electricity	69.8	3	600	4
Thermal-Coal	439.5	19	8,343	60
Thermal – NG	1,856.3	78	5,064	36
Total	2,365.6	100	14,007	100

This is shown graphically in the figures below:

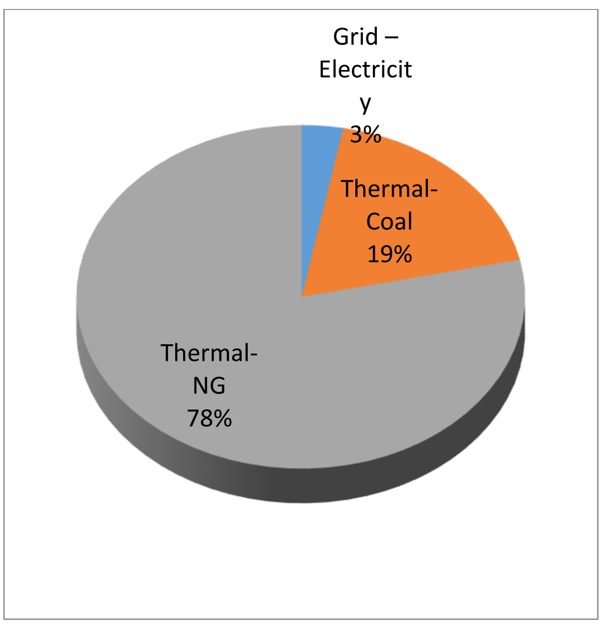


Figure 3: Energy cost share

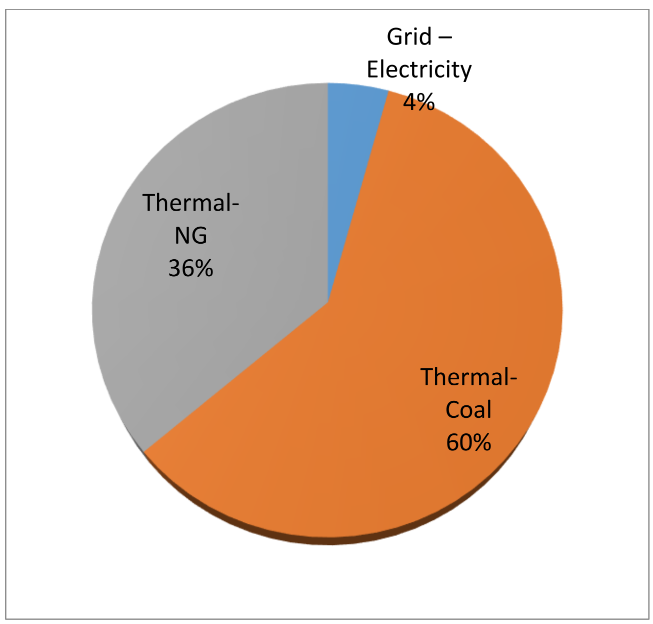


Figure 4: Energy use share

The major observations are as under:

- The unit uses both thermal and electrical energy for the manufacturing operations.
- Electricity is sourced from the grid as well as self-generated in DG sets when the grid power is not available. However, blackouts are infrequent, due to which the diesel consumption is minimal and records are not maintained.
- Electricity used in the utility and process accounts for the 3% of the energy cost and 4% of the overall energy consumption.
- Source of thermal energy is from combustion of NG, which is used for firing in the kilns, and coal for the hot air generator (HAG).
- NG used in kilns account for 78% of the total energy cost and 36% of overall energy consumption.
- Coal used in the HAG accounts for 19% of cost and 60% of overall energy consumption.

2.2.1 Analysis of Electricity Consumption

2.2.1.1 Supply from Utility

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

Table 8: Details of Electricity Connection

Particulars	Description
Consumer Number	32861
Tariff Category	HTP-I
Contract Demand, kVA	1,300
Supply Voltage, kV	11

The tariff structure is as follows:

Table 9: Tariff structure

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

(As per bill for June-18)

2.2.1.2 *Month wise Electricity Consumption and Cost*

Month wise total electrical energy consumption is shown as under:

Table 10 : Electricity consumption & cost

Month	Units Consumed kWh	Total Electricity Cost Rs	Unit Cost Rs/kWh
Jun-17	656,162	4,319,038	6.58
Jul-17	777,176	5,074,025	6.53
Aug-17	652,997	4,264,373	6.53
Sep-17	354,420	2,434,562	6.87
Oct-17	603,120	3,923,829	6.51
Nov-17	548,194	3,535,625	6.45
Dec-17	404,145	2,671,468	6.61
Jan-18	447,660	2,924,836	6.53
Feb-18	644,648	4,060,383	6.30
Mar-18	624,285	3,946,060	6.32
Apr-18	571,281	3,715,420	6.52
May-18	695,490	4,445,182	6.39

Average electricity consumption is 581,631 kWh/month and cost is Rs 37.76 Lakhs per month. The average cost of electricity is Rs. 6.51/kWh.

2.2.1.3 Analysis of month-wise electricity consumption and cost

The figure below shows the month wise variation of electricity purchase and variation of cost of electricity.

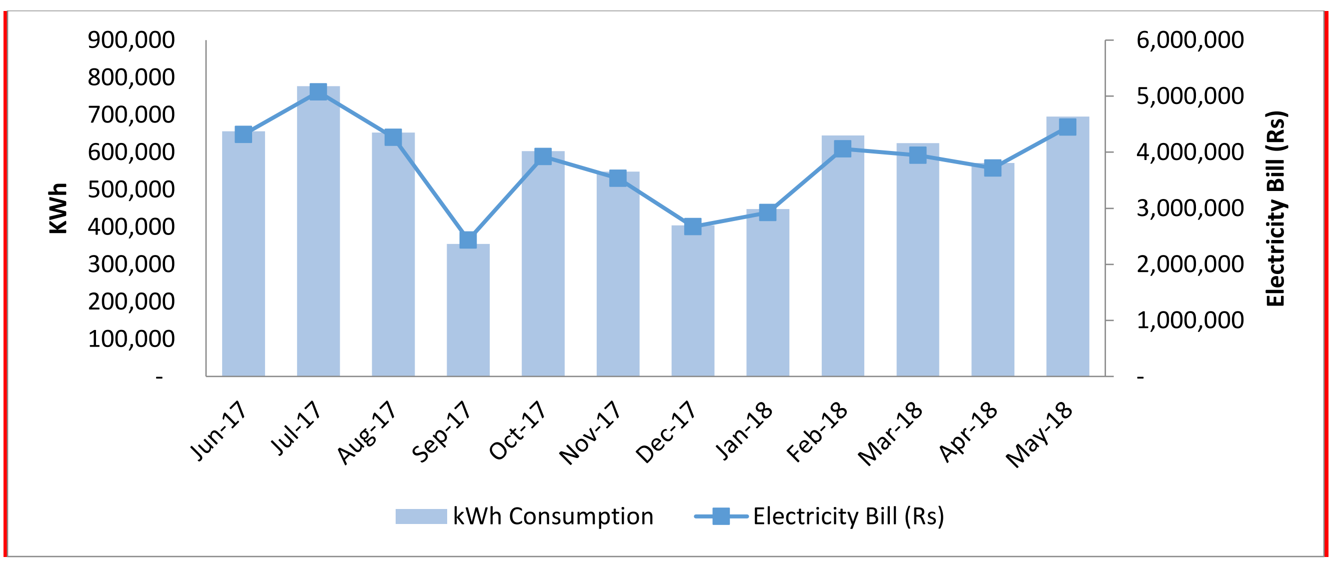


Figure 5: Month wise Variation in Electricity Consumption

Power Factor: Power factor as per electricity bills is shown below:

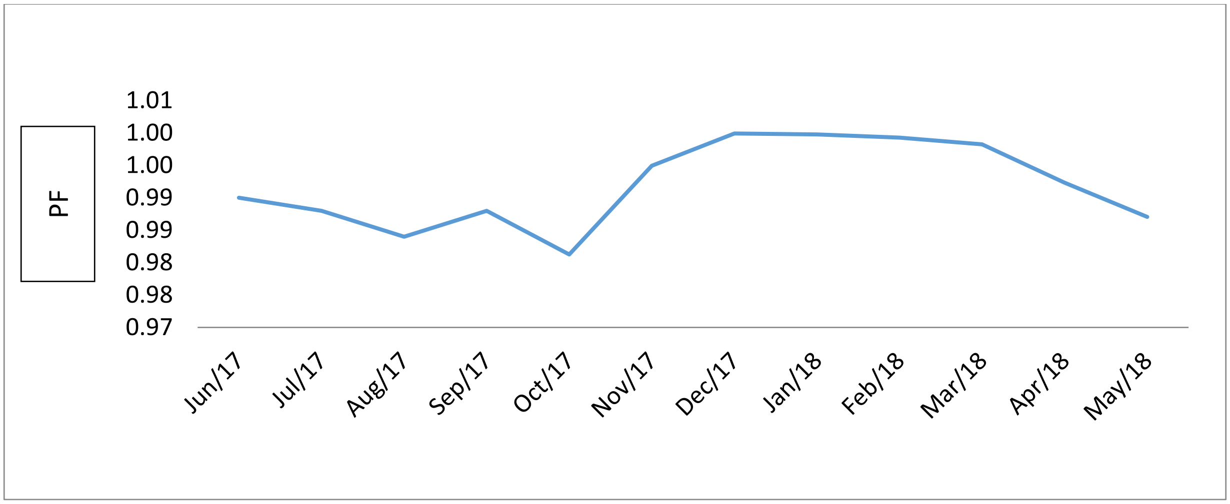


Figure 6 : Month wise variation in Power Factor

The utility bills reflect the power factor. A study was conducted by logging the electrical parameters of the main incomer using a power analyzer. The average power factor was found to be 0.99 with the minimum being 0.99 and the maximum being 1.00.

Maximum Demand: Maximum demand as reflected in the utility bill is 1,297 kVA from the bill analysis.

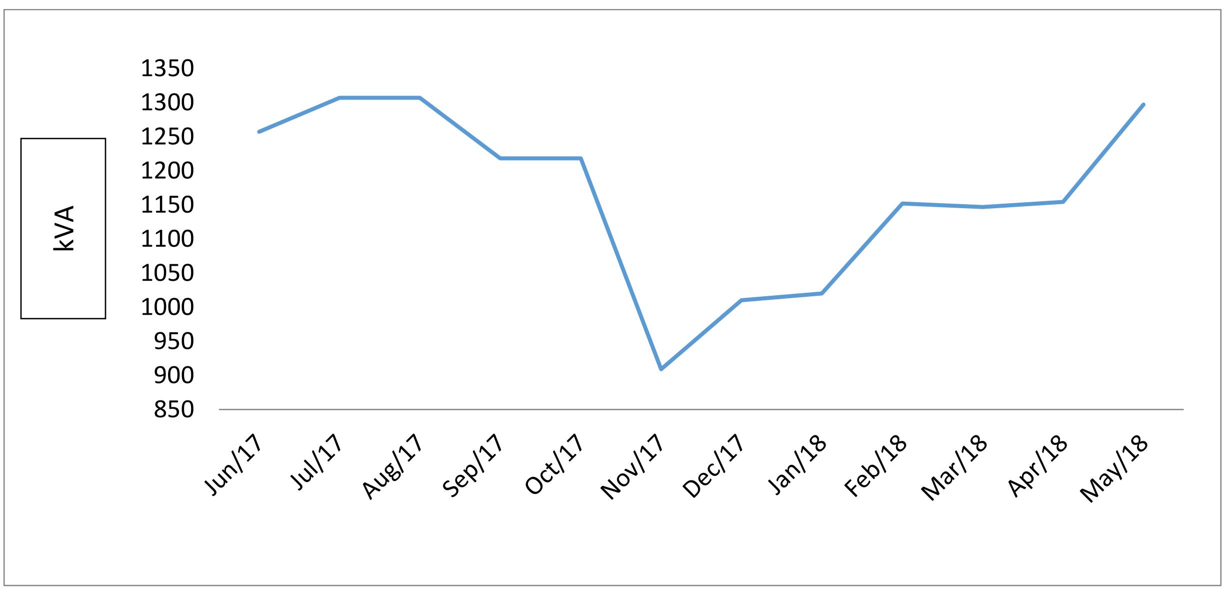


Figure 7 : Month wise variation in Maximum Demand

2.2.1.4 *Single Line Diagram*

Single line diagram of plant is shown in below figure:

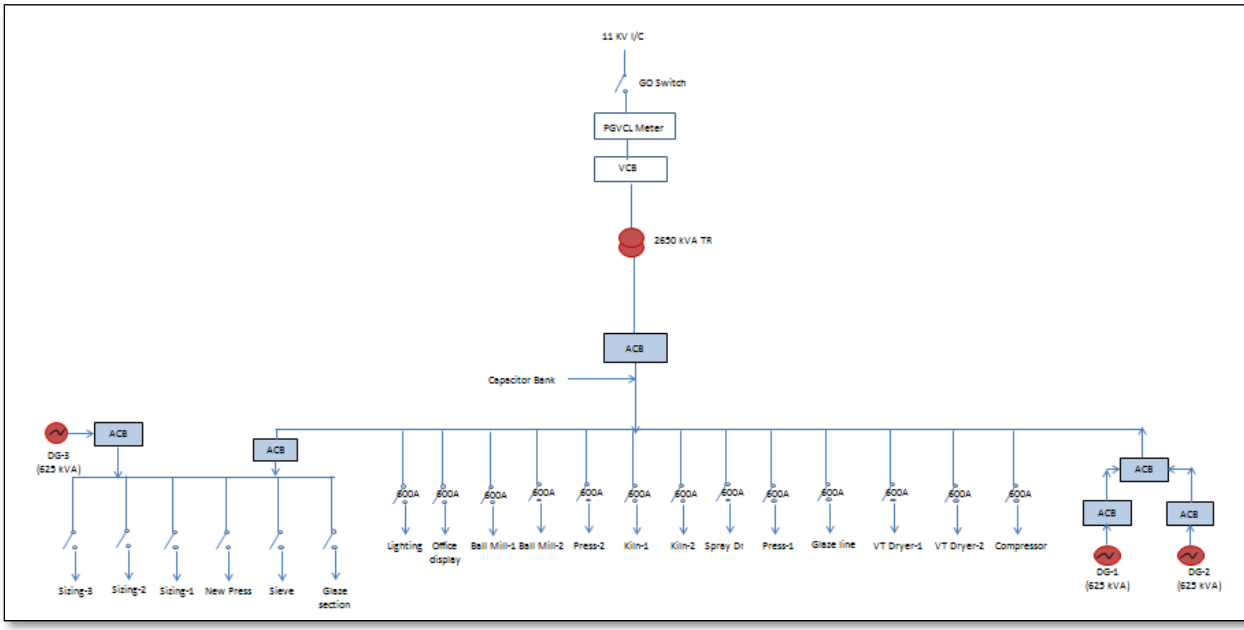


Figure 8: SLD of Electrical Load

2.2.1.5 *Electricity consumption areas*

The plant total connected load is 3,417 kW, which includes:

- The plant and machinery load is 3,237 kW
    - The utility load (fan and lighting) is about 180.0 kW including the single phase load

Table 11: Equipment wise connected load

Sl. No.	Equipment	Numbers	Total capacity (kW)
1	Ball mill motor	2	451.2
2	Agitator Tank	8	93.5
3	Spray Dryer	1	214.8
4	Hot Air Generator	1	63
5	Press	3	333.7
6	Cooling Tower	1	16.7
7	Vertical Dryer	1	196.2
8	Conveyer	2	32.5
9	Printing	18	6.7
10	Kiln	2	735.0
11	Sizing Line	3	737.2
12	Glaze Line	1	149.2
13	Glaze Ball Mill	3	207.4
14	Lighting	1,338	180.0
	Total		3,417.2

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

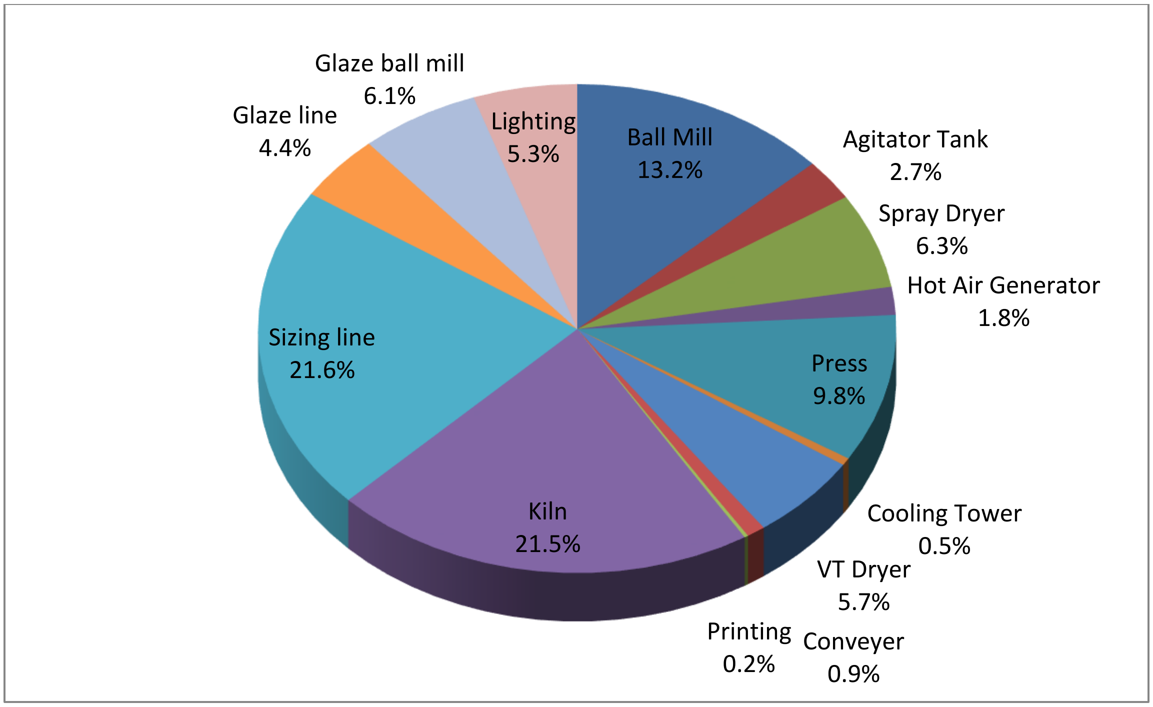


Figure 9 : Details of connected load

As shown in the figure, the maximum share of connected electrical load is for the Kiln & Sizing Line – 22%, followed by Ball Mill – 13%, Press – 10%, Spray Dryer – 6%, Glaze ball Mill – 6%, Glaze Line - 4%, Agitator Tank – 3%, vertical dryer -6%, Compressor-2, Other machinery including Conveyer and Cooling Tower– 1% each and Lighting load of 3%.

2.2.1.6 Specific electricity consumption

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

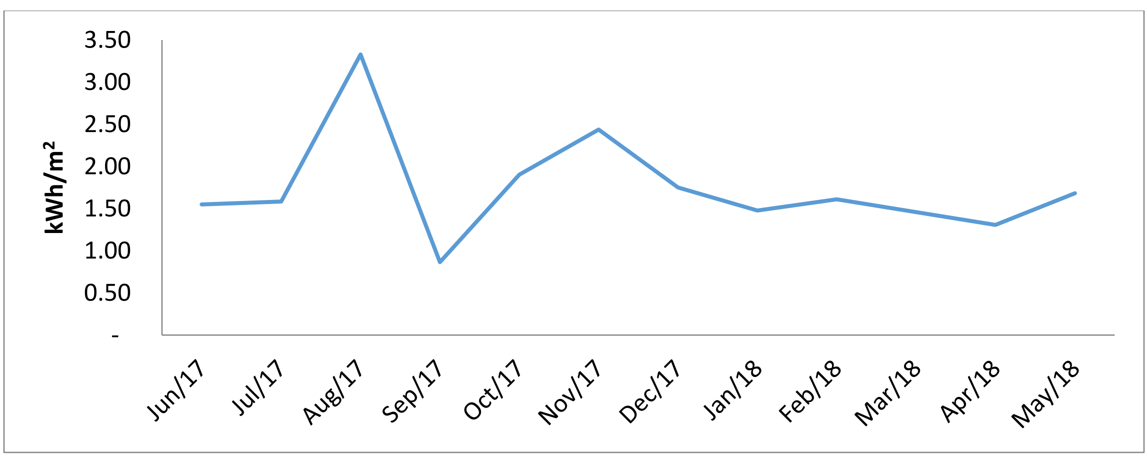


Figure 10: Month wise variation in Specific Electricity Consumption

Three months, Aug-17, Sep-17 and Nov-17 are outliers. Excluding these months, the maximum and minimum values are within ±20% of the average SEC of 1.75kWh/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 ball mill section, spray dryer section, press section, biscuits kiln, glaze kiln, utility like compressor, pumps etc.

2.2.2 Analysis of Thermal Consumption

2.2.2.1 Month wise Fuel Consumption and Cost

The thermal consumption areas are the hot air generator, vertical driers and the kilns. Coal is used as fuel for the hot air generator while NG is used as fuel for the kilns. Main source of heat for secondary dryers is waste heat from the kiln, supplemented by NG . Coal is purchased from local coal suppliers who in turn import coal from Indonesia. NG is purchased from GSPC (Gujarat State Petroleum Company). Annual fuel consumption and cost are summarized below:

Table 12: Month Wise Fuel Consumption and Cost

Month	Kiln-1			Kiln-2			Spray Dryer		
	NG Use	NG Cost	NG Cost	NG Use	NG Cost	NG Cost	Coal Used	Coal Cost	Coal Cost
	scm	Rs	Rs/scm	scm	Rs	Rs/scm	MT	Rs	Rs/MT
Jun-17	338,474	10,298,316	30	275,195	8,376,319	30	1,129.24	4,587,757	4,063
Jul-17	359,451	10,840,816	30	296,591	8,951,174	30	1,051.48	3,605,073	3,429
Aug-17	164,189	5,058,558	31	120,802	4,017,052	33	400.57	1,390,931	3,472
Sep-17	362,804	10,278,294	28	278,043	7,864,200	28	884.84	3,058,192	3,456
Oct-17	358,420	9,876,745	28	108,410	5,311,583	49	939.77	3,062,819	3,259
Nov-17	342,690	9,720,340	28	0	6,213,060		821.69	2,621,620	3,191
Dec-17	354,933	10,201,934	29	0	6,519,828		1,003.73	3,337,584	3,325
Jan-18	358,344	10,775,193	30	135,992	7,347,637	54	1,021.03	3,437,289	3,366
Feb-18	332,127	10,261,564	31	245,943	6,024,231	24	1,423.58	5,174,414	3,635
Mar-18	343,524	10,542,356	31	269,852	8,279,561	31	1,252.34	4,324,871	3,453
Apr-18	-	-		-	-		1,110.71	3,846,385	3,463
May-18	334,210	10,836,222	32	246,516	8,037,216	33	1,449.33	5,503,725	3,797

Observation:

- Kiln-1 is used for baking of biscuit tiles whereas Kiln-2 is used for baking of glazed tiles. Kiln-1 accounts for 65% of total NG used. Average monthly gas consumption in Kiln-1 is about 331,742 scm and average cost is Rs 98.80 Lakhs/month whereas monthly gas consumption in Kiln-2 is about 179,759 scm and average cost is about Rs. 69.94 Lakh/month. Cost of natural gas in Kiln-1 is Rs. 30.0/SCM whereas in Kiln-2 is Rs. 35.0 /scm
- Coal is fired in the hot air generator. Average coal consumption is 1,041 tons and average cost Rs. 36.62 Lakhs/month Cost of coal is Rs. 3,492 /ton
- There are two gas connections to the unit and out of one connection a tapping is given to vertical dryers.

2.2.2.2 Specific Fuel Consumption

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

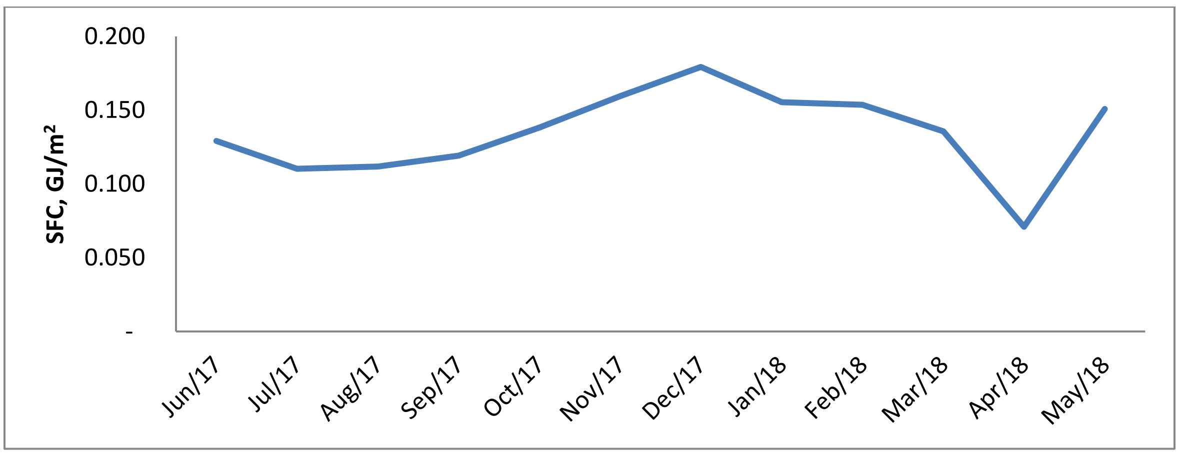


Figure 11 : Month wise variation in Specific Fuel Consumption

The average SFC is 0.135 GJ/m^2, i.e. 0.056 GJ/m^2 for the kilns and 0.084 GJ/m^2 for the hot air generator. Excluding the month of Apr-18, the NG consumption varied between 0.05-0.061 .084 GJ/m^2 and was within ±10% of the average value. The SFC for coal varied between 0.057 and 0.121 GJ/m^2 which is a very wide variation. This is because coal data is based on purchase and actual information on consumption is not being maintained. The SEC therefore does not follow the production.

For better quality information, sub-metering /data logging is required at hot air generator (HAG) and vertical dryers for monitoring thermal energy consumption.

2.2.3 Specific energy consumption

2.2.3.1 Based on data collected during EA

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

Table 13: Specific energy consumption

Particulars	Units	Value
Daily Production	m^2/h	488
Power Consumption	kW	3,417
Coal Consumption	kg/h	1,426
NG Consumption	scm/h	642
Energy Consumption	TOE/h	1.60
SEC of Plant	TOE/m^2	0.0033

2.2.3.2 *Section wise energy consumption*

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

Table 14: Section wise specific energy consumption (per unit production)

Particulars	NG	Coal	Electricity
	scm/t	kg/t	kW/t
Ball Mill			15.16
Agitator			2.0
HAG		111	7.53
Spray Dryer			1.93
Vertical Dryer - 1	28.5		
Hydraulic Press 1			5.8
Hydraulic Press 2			14.3
Kiln-1	34.0		4.71
Glazing Mill			4.61
Kiln-2	44.8		3.53
Sizing unit			9.6

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

2.2.3.3 *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 15: Overall: specific energy consumption

Parameters	UoM	Value
Annual Grid Electricity Consumption	kWh	6,979,578
Self-generation from DG Set	kWh	-
Annual Total Electricity Consumption	kWh	6,979,578
Annual Thermal Energy Consumption (NG)	scm/y	5,626,510
Annual Thermal Energy Consumption (Imported Coal)	t/y	12,488
Annual Energy Consumption	TOE	14,007.5
Annual Energy Cost	Rs Lakh	2,748.98
Production	m^2	4,275,739
	t	69,080
SEC; Electrical	kWh/m^2	1.6324

Parameters	UoM	Value
	kWh/t	101.04
SEC; NG	scm/ m^2	1.32
	scm/t	81.45
SEC; Coal	kg/m^2	2.92
	kg/t	180.78
SEC; Overall	kgOE/ m^2	3.28
	MTOE/t	0.20
	GJ/m^2	0.14
	GJ/t	8.48
SEC; Cost Based	Rs./m^2	64.29
	Rs./t	3,979.44

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
- GCV of Imported Coal : 6,681 kCal/kg
- CO_2 Conversion factor
  - Grid : 0.82 kg/kWh
  - Imported Coal : 2.116 t/t
  - NG : 0.001923 tCO_2/SCM

2.2.3.4 *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 16: Baseline parameters

Parameters	Units	Value
Cost of electricity	Rs/ kWh for (Jun 17 to May 18)	6.88
Cost of NG	Rs./scm	37
Cost of Coal	Rs./MT	3,519
Annual operating days	d/y	365
Operating Hours per day	h/d	24
Annual Production	m^2	4,275,739

2.4 Water Usage & Distribution

Water usage and pumping efficiencies (including water receipt, storage, distribution, utilization etc.) pump specs, breakdown maintenance etc.

Water requirement is met by purchase of water and stored in storage tank. From this storage water tank, water is distributed to various sections as per requirement through different pumps. Water consumption on daily basis is about 150-200 m^3/day as informed by unit.

Water distribution diagram is shown below.

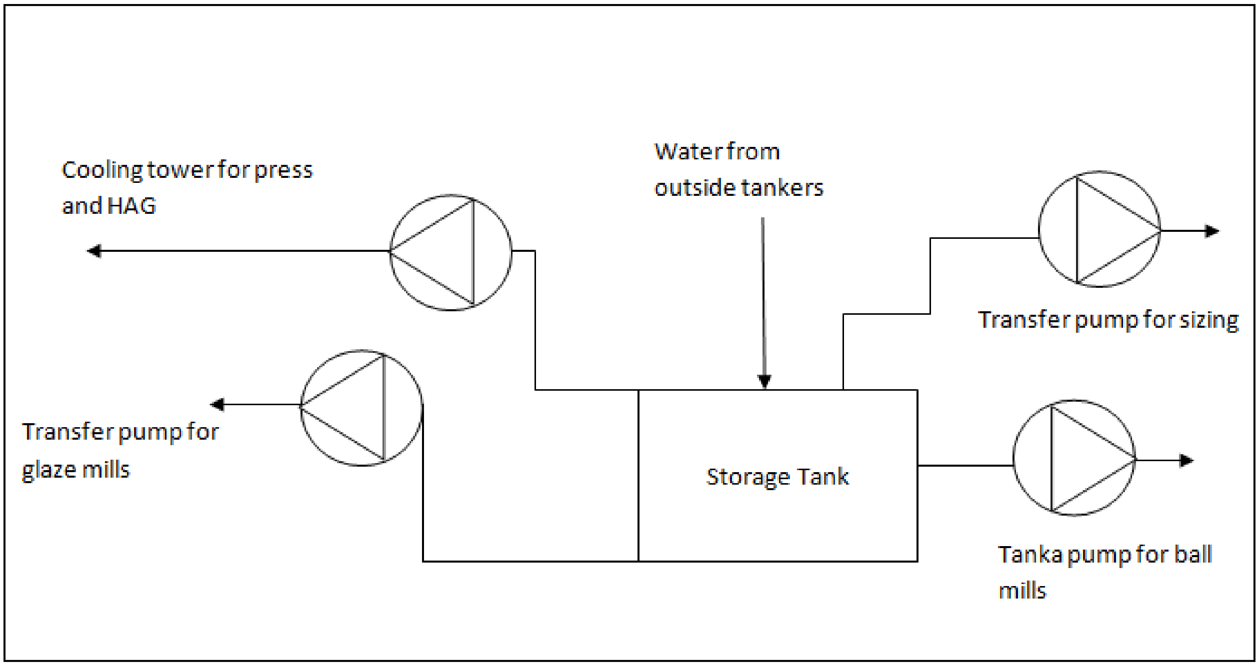


Figure 12: Water Distribution Diagram

Water tankers are procured to meet the water requirements of process, water supplied has TDS of about 450 ppm whereas ground water at the unit has TDS>1,000 ppm; hence unit is not using ground water (cooling water pumps for press, pump for ball mills and domestic use. Flow measurements were done cooling tower pump-1 and cooling water pump-2 circulation pumps which is given below:

Table 17: Press cooling water circulation pump details

Parameters	Unit	Cooling Water Pumps
Make	-	-
Motor rating	kW	5.6
RPM	Rpm	2,900
Quantity	Number	3

Major water consuming areas like Ball Mills and Glaze Ball Mills are monitored.

3 PERFORMANCE EVALUATION OF THERMAL EQUIPMENT

3.1 Kiln

3.1.1 Specifications

Natural gas is used as a fuel in both the kilns to heat the ceramic tiles to the required temperature. The required air for fuel combustion is supplied by a blower (FD fan). 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. Kiln-1 consists of 334 kW electrical loads whereas Kiln-2 has 401 kW of electrical load. Kiln - 1 includes75 HP smoke blower, 55 HP combustion blowers, 37 HP for rapid cooling, 37 HP for Hot air blower, 55 HP for cooling section, 75 HP for final cooling blowers. Kiln - 2 includes75 HP smoke blower, 55 HP combustion blowers, 37 HP for rapid cooling, 37 HP for Hot air blower, 55 HP for cooling section, 75 HP for final cooling blowers & 37 HP final exhaust blower and remaining electrical load of kiln roller motors.

Table 18: Kiln Details

Sl. No.	Parameter	Unit	Kiln-1	Kiln-2
	Make		Local	Local
1	Kiln operating time	h	24	24
2	Fuel Consumption	scm/h	422	409
3	Number of burner to left	-	116	96
4	Number of burner to right	-	116	96
5	Cycle Time	Minutes	49	49
6	Pressure in firing zone	mmWC	60	60
7	Maximum temperature	ºC	1,146	1,083
8	Waste Heat recovery option		Yes	Yes
8	Kiln Dimensions (Length X Width X Height)			
	Preheating Zone	m	67.2 x 0.8 x 3.6	75.6 x 0.8 x 3.6
	Firing Zone	m	71.2 x 1.87 x 3.6	60.9 x 1.87 x 3.6
	Rapid Cooling Zone	m	12.6 x 0.8 x 3.6	12.6x 0.8 x 3.6
	Indirect cooling Zone	m	29.4 x 0.8 x 3.6	29.4 x 0.8 x 3.6
	Final cooling zone	m	48.3x 0.8 x 3.6	37.8x 0.8 x 3.6

3.1.2 Field Measurement and Analysis

During DEA, measurement of power consumption for all blowers, surface temperature of the kiln, flue gas analysis, air flow measurement of blowers and section wise temperature profile of both the kilns were done. Flue gas analysis (FGA) study was conducted and result of same is summarized in the table below:

Table 19: FGA study of kilns

Parameter	Kiln-1	Kiln-2

Oxygen Level measured in Flue Gas	5.88%	13.73%
Ambient Air Temperature	43.4°C	43.4°C
Exhaust Temperature of Flue Gas	117 °C	121 °C

From the above table, it is clear that the oxygen level measured in flue gas was high in Kiln-2. The inlet temperature of raw material in Kiln-1 was in the range of 70°C whereas in Kiln-2 it was in the range of 45°C which was the ambient air temperature.

Surface temperature was high, throughout the surface of the kilns as shown in the table below:

Table 20: Surface temperature of kilns

Kiln Surface Temperatures (°C)	Kiln-1	Kiln-2
Ambient Temperature	43.4	43.4
Pre-heating zone average surface temperature	39.6	45.6
Heating zone average surface temperature	63.5	69.0
Rapid cooling zone average surface temperature	74.5	69.6
Indirect cooling zone average surface temperature	72.5	67.7
Final cooling zone average surface temperature	45.7	51.3

The temperature profiles of the kilns are identical is shown below:

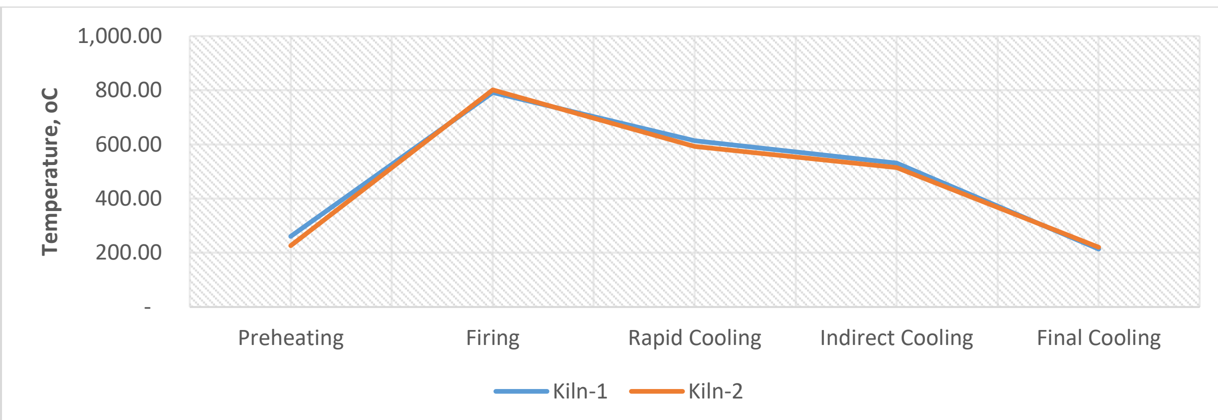


Figure 13: Temperature Profile of Kilns

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

Table 21: Power measurements of all blowers

Equipment	Kiln 1 Average Power (kW)	PF	Kiln 2 Average Power (kW)	PF
Final Cooling Blower	14.4	0.994	3.4	0.991
hot air Blower	11.4	1.000	7.6	0.996
Rapid Cooling Blower	10.0	0.994	4.8	0.977
Smoke Blower	24.4	0.999	14.0	0.999
Combustion Blower	9.7	0.995	11.2	0.997

3.1.3 OBSERVATIONS AND PERFORMANCE ASSESSMENT

Kiln efficiency has been calculated based on the flue gas analysis study conducted during visit. Overall heat mass balance of the kiln-1nd kiln-2 with all losses is shown in below figure:

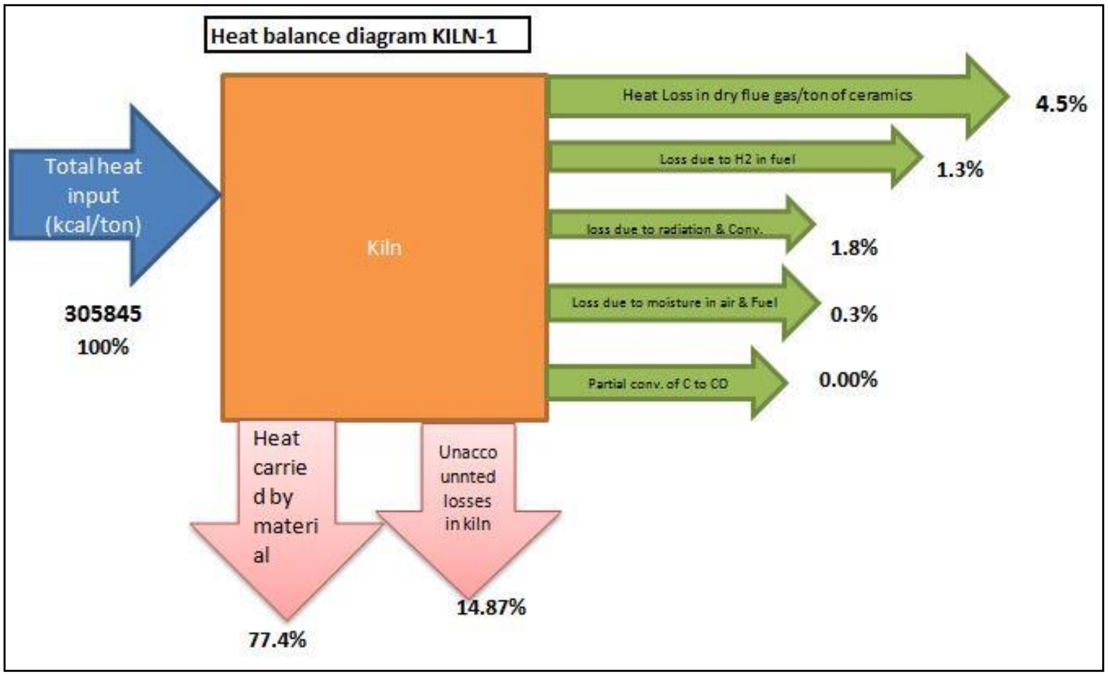


Figure 14: Heat Balance Diagram of Kiln-1

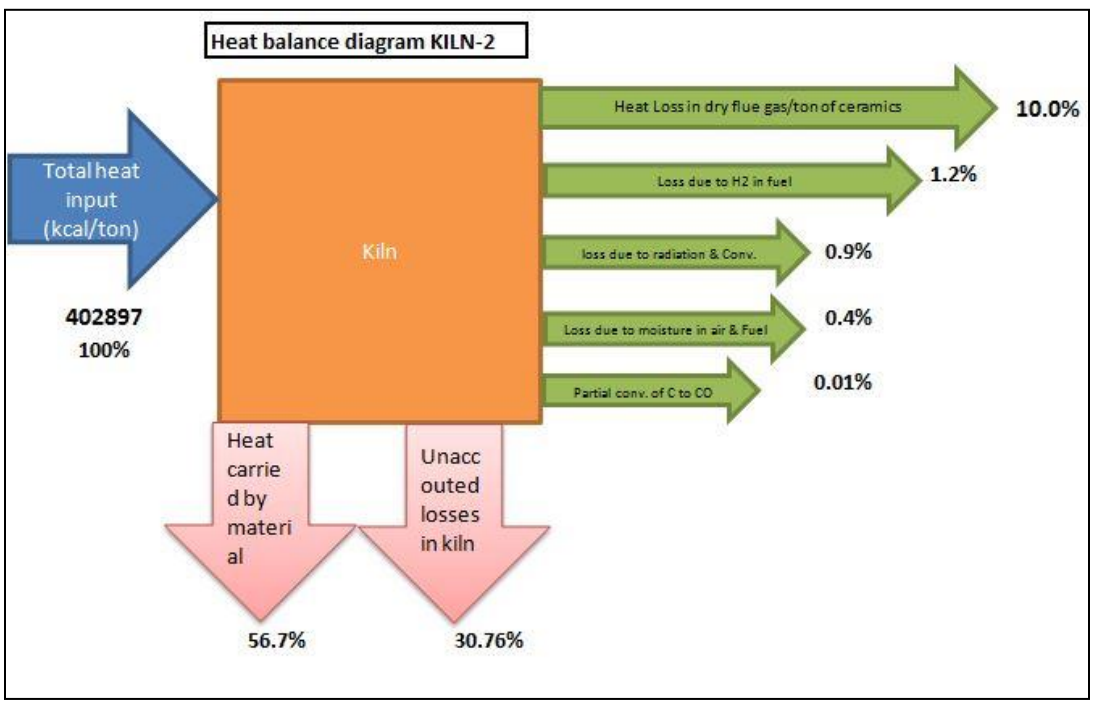


Figure 15: Heat Balance Diagram of Kiln-2

Causes of unaccounted losses arising due to following reasons:

- Kiln leakage observed in kiln 1 & kiln 2
- Rollers are gettinng heated itself by kiln heat
- Inspection holes are closed by aluminnum dart which increases radiation loss
- Hot air fans body are uninsulated
- Atmopsheric air dilution in kiln

Detailed calculation is included in Annexure-5.

3.1.4 Energy Conservation Measures (ECM)

Energy conservation measures are described below:

3.1.4.1 ECM #1: Pre-heating combustion air

Technology description

Hot air path from hot air blower to combustion blower was completely closed and combustion air is coming directly from outside at ambient temperature. Flow path to recuperator also partially closed so ambient air directly going to burner instead of going through recuperator at rapid cooling zone.

Study and investigation

It was observed during energy audit that combustion air temperature was only 80°C to 85°C.

Recommended action

It is recommended to use hot air as combustion air or to circulate air through recuperator to improve combustion air temperature. The cost benefit analysis for the measure is given below:

Table 22: Cost benefit analysis (ECM-1)

Parameters	UOM	Present	Proposed	Present	Proposed
Equipment	#	Kiln-1		Kiln-2	
Blower Capacity	CFM	11,000	11,000	11,000	11,000
Measured air velocity	m/s	11.27	11.27	12.23	12.23
Blower air inlet area	m^2	0.18	0.18	0.18	0.18
Actual volume of supplied air	m^3/s	2.08	2.08	2.26	2.26
Actual air delivered	CFM	4,412	4,412	4,791	47,91
Hot air damper opening % to combustion blower	%	0	50	0	50
Combustion air temperature	°C	85	150	80	150
Ambient air temperature	°C	45	45	45	45
Specific heat of air	kCal/kg °C	0.24	0.24	0.24	0.24
Density of air	kg/m^3	0.90	0.90	0.90	0.90
GCV of NG	kCal/scm	9,000	9,000	9,000	9,000
Efficiency of Kiln	%	77.4		56.7	
Fuel Saving	scm/h	-	12	-	14
Kiln operating hours	h/d	24	24	24	24
Annual operating days	d/y	365	365	365	365
Annual fuel saving	scm/y		102,446		119,792

Parameters	UOM	Present	Proposed	Present	Proposed
NG cost	Rs/scm		37		37
Annual fuel cost saving	Rs Lakh/y		37.90		44.32
Estimated investment	Rs Lakh		Nil		Nil
Payback Period	Months		Immediate		Immediate
IRR	%				
Discounted payback period	Months				

3.1.4.2 ECM #2: Excess air control system

Technology description

It is necessary to maintain optimum excess air levels in combustion air supplied for complete combustion of fuel. The excess air levels are calculated based on oxygen content in the flue gases. The theoretical air required for combustion of any fuel can be known from the ultimate analysis of the fuel. All combustion process requires certain amount of excess air in addition to the theoretical air supplied. Excess air supplied needs to be maintained at optimum levels, as, too much excess air results in excessive heat loss through the flue gases whereas too little excess air results in in-complete 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 excess air. This results in the formation of excess flue gases, taking away the heat produced from the combustion and increasing the fuel consumption. This also results in the formation of excess GHG emissions.

A PID controller, if installed, measures 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) is regulated and subsequently proper temperature and optimum excess air for combustion is attained in the kiln.

Study and investigation

At present, there is no proper automation and control system installed in the kiln to monitor and maintain optimum excess air levels. Fuel was fired from the existing burner system and no air flow control mechanism was in place for maintaining proper combustion of the fuel. The combustion air and cooling air (through air curtains) were being supplied from the same FD fan. The pressures required for combustion and for cooling air were different and supplying both the air from one common FD fan was not a good practice.

Recommended action

Separate blowers for Kiln-1 and Kiln-2 have been recommended for supplying combustion air and cooling air. It is proposed to install control system to regulate the supply of excess air for proper combustion. As a thumb rule, reduction in every 10 percent of excess air will save one percent in specific fuel consumption. For **Kiln 2** oxygen level is 13.73% which is very high. The cost benefit analysis of the energy conservation measure is given below:

Table 23: Cost benefit analysis for Kiln 2(ECM-2)

Parameters	UOM	Present	Proposed
Combustion blower capacity	Cfm	11,000	11,000
Combustion air pressure at burner tip	mm of H_2O	60	50
Reduction in combustion air pressure	mm of H_2O		10
Combustion air flow	m^3/h	8,140	7,431
Excess air quantity	m^3/h		709
Combustion air temperature at burner tip	°C	150	150
Average temperature of firing zone	°C	879	879
Specific heat of air	kCal/kg °C	0.24	0.24
Excess heat required to heat up excess air at firing zone	kCal/h		124,035
GCV of natural gas	kCal/h	9,000	9,000
Natural Gas Saving	scm/h		14
Operating Hours	h/d	24	24
Annual Operating Days	d/y	365	365
Annual Natural Gas Saving	scm/y		120,727
NG cost	Rs/scm	37	37
Annual monetary saving	Rs Lakh/y	45	
Estimated investment	Rs	18.4	
Payback Period	Months	5	
IRR	%	184	
Discounted payback period	Months	1.95	

3.1.4.3 ECM#3 Close rapid cooling standby blower damper to avoid hot air outflow

Technology description

During DEA, it was observed that hot air was coming out from standby rapid air blower damper. Damper must be closed perfectly to avoid heat loss.

Study and investigation

During energy audit, it was found that rapid cooling standby blower damper was open and the hot air was exhausted in the atmosphere was getting bypassed through this open damper. Combustion air temperature to furnace chamber was only 80-85°C.

Recommended action

It is recommended to close the rapid cooling standby blower damper and avoid the hot air outflow. Combustion air temperature will be raised by closing this damper and temperature should reach up to 150-200°C. The cost benefit analysis is given below:

Table 24: Cost Benefit analysis (ECM-3)

Parameters	UOM	Present	Proposed	Present	Proposed
Equipment	#	Kiln-1		Kiln-2	
Blower Capacity	cfm	10,200	10,200	10,200	10,200
Measured air velocity flowing out from blower	m/s	2.80	2.80	4.50	4.50
Area of the blower	m^2	0.18	0.18	0.18	0.18

Parameters	UOM	Present	Proposed	Present	Proposed
Actual air bypassed through open damper	m^3/s	0.52	0.00	0.83	0.00
Hot air temperature	°C	90	0	90	0
Ambient air temperature	°C	45	45	45	45
Specific heat of air	kCal/kg °C	0.24	0.24	0.24	0.24
Density of air	kg/m^3	0.90	0.90	0.90	0.90
GCV of NG	kCal/scm	9,000	9,000	9,000	9,000
Heat lost to atmosphere	kCal/h	18,109	-	29,104	-
Heat Loss in term of fuel	scm/h		2		3
Kiln operating hours	h/d	24	24	24	24
Annual operating days	d/y	365	365	365	365
Annual fuel saving	scm/y		17,626		28,328
NG cost	Rs/scm		37		37
Annual fuel cost saving	Rs Lakh/y		6.52		10.48
Estimated investment	Rs Lakh		Nil		Nil
Payback Period	Months		Immediate		**Simple**
IRR	%				
Discounted payback period	Months				

3.1.4.4 ECM #4 Hot face insulation in firing zone of Kiln-1

Technology description

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

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

A kiln wall is designed as a combination of refractory and insulation layers, with the objective of retaining maximum heat inside the kiln and avoids losses from kiln walls.

Study and investigation

There are three different zones in kiln, i.e. pre- heating, firing and cooling zones. The surface temperature of each zones were measured. The average surface temperature of kiln body in the firing zone must be in the range of 45-50°C and it was measured as 90°C, hence the kiln surface has to be properly insulated to keep the surface temperature within the specified range.

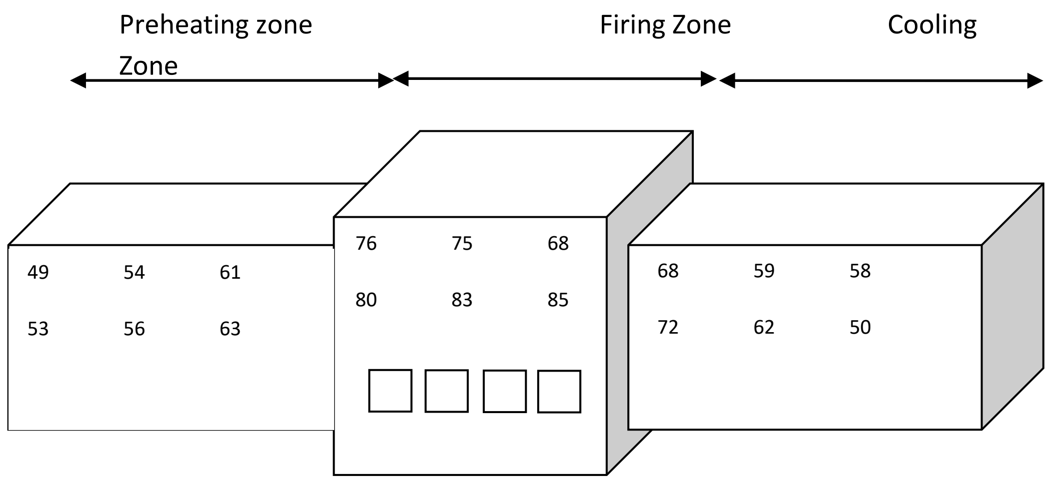


Figure 16: Surface temperature – Kiln-1

Recommended action

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

Table 25: Cost benefit analysis (ECM-4)

Parameters	UOM	Present	Proposed
Location of kiln	#	Firing Zone (Module 56 to 67)& Rapid cooling (Module 68 to 74)	
Surface area of kiln wall (firing zone and rapid cooling)	m2	96.0	96.0
Average surface temperature	°C	93	70
Average fuel loss due to high skin temperature	scm/h	5.0	2.3
Average fuel saving	scm/h		2.7
Annual operating hour	h/y	8,760	8,760
Annual fuel saving	scm/y		23,805
NG cost	Rs/scm	37	37
Annual fuel cost saving	Rs Lakh/y		8.81
Estimated investment	Rs Lakhs		4.8
Payback period	months		7
IRR	%		128
Discounted payback period	Months		1.7

3.2 Dryers

3.2.1 Specifications

There are three vertical dryers out of which two were operating and third dryer was not in operation. Vertical dryer 2 is being run with hot air (waste heat from kiln) only and vertical dryer 1 has NG consumption along with hot air (waste heat from kiln) supply. Preheating of biscuit is done in dryers before entering into kilns. The specifications of dryers are given below table:

Table 26: Specifications of vertical dryer

Particular	Units	Vertical dryer 1	Vertical dryer 2
Capacity	No of tiles/h	2,040	1,920
Fuel type		NG + Waste heat	Waste Heat
Exit temperature of tiles	°C	135	135
FD Blower	kW	22.4	24.6
Hot Air Circulation blower	kW	7.5	7.5

3.2.2 Field Measurement and Analysis

During DEA, the following measurements were done:

a) Mass flow study (table below)
b) Temperature of each tile at exit (table below)
c) Gas consumption data

Data measured during study is tabulated below:

Table 27: Field measurement at site

Particular	Units	Vertical dryer 1	Vertical dryer 2
Tiles passed though dryer		2,040	1,920
Mass of each tile	g	3,400	3,500
Average surface temperature	° C	57	52
Gas consumption	scm/h	198	Nil (hot air only)

Hot air from both kilns is collected in an accumulator from where air is distributed to both the dryers. Maximum hot air is consumed in vertical dryer 2 only. All blowers are operating with VFDs.

3.2.3 Observation and Performance Assessment

Mass and energy balance of vertical dryers could not be done since it was not feasible to measure volume of hot air being supplied to vertical dryers. Design data of vertical dryers was also not available with unit.

Based on observations during DEA, Specific thermal energy is 28.5scm/ton of tile for vertical dryer -1. This is based on input of tiles from pressto Vertical Dryer-1 and gas consumption data (scm/h) is provided by unit.

For vertical dryer-2 only waste heat is utilized.

Since all blowers are VFD controlled, hot air is utilized and operation is optimized. No energy conservation measure is proposed.

3.3 Hot Air Generator& Spray Dryer

3.3.1 Specifications

Bubbling bed type hot air generator is used for evaporating water from slurry which is coming from ball mill. Spray dryer is the heat exchanging unit for power generation from slurry by taking heat from hot air of HAG. Specifications of HAG are given below:

Table 28: Specifications of Hot air generator (HAG)

Particular	Units	Bubbling bed
Fuel type		Coal
Air handling capacity	m^3/h	13,067
Fuel consumption	kg/h	1445.0
Flue gas temperature	°C	740.0
FD Blower	kW	1 x 45
Combustion blower	kW	1 x 132

The specifications of spray dryers are given below:

Table 29: Specifications of spray dryer

Particular	Units	Value
Powder generation capacity	MT	450.0
Inlet slurry moisture	%	40
Outlet powder moisture	%	6
Slip house pump	kW	2x30

3.3.2 Field measurement and analysis

During DEA, the following measurements were done:

- Hot air generators
    - Power consumption of FD and ID fan
    - Air flow measurement of FD fan
    - Exhaust air temperature
    - Surface temperature
- Spray dryer
    - Inlet and outlet moisture data
    - Power consumption of slip house pump

Details of measurements on HAG are given below:

Table 30: Field measurement at site

Particular	Units	Bubbling bed
Air velocity at FD fan suction	m/s	21.8
Suction area	M^2	0.17
Exit temperature of air	° C	750
Surface temperature	° C	70

Particular	Units	Bubbling bed
Average power consumption-FD Blower	kW	9.9 (PF=0.91)
Average power consumption-ID Fan	kW	88.2 (PF=0.94)
Average power consumption-spray pump	kW	36.3 (PF=0.94)

All blowers are operating with VFDs.

Energy and mass balance is done on the basis of log book data maintained for HAG and spray dryer.

3.3.3 Observations and performance assessment

Mass and energy balance of HAG and spray dryer determined based on data collected is as follows:

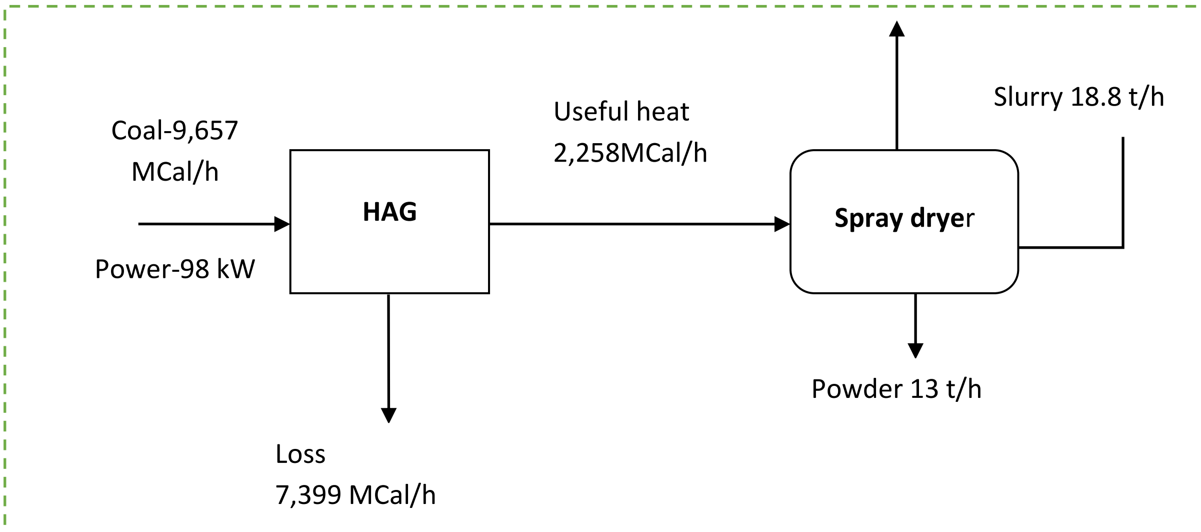


Figure 17: Energy and mass balance of Chain Stoker HAG and New spray dryer

Performance of HAG is measured in terms of specific electricity consumption (electrical energy used for evaporating one kg water from slurry) and specific thermal energy measure (fuel used for evaporating 1 kg of water in slurry). Based on observations during DEA, the bubbling bed HAG corresponding values are 7.53 kW/ton and 111.0 kg of coal/kg.

Performance of spray dryer measures in terms of specific electricity consumption (electrical energy used for delivering one kg of powder). Based on observations during DEA, the specific electricity consumption of new spray dryer was 1.93kW/ton. Since blowers are VFD controlled and operation is optimized, no energy conservation measure is proposed.

4 PERFORMANCE EVALUATION OF ELECTRICAL EQUIPMENT

4.1 Ball mills

4.1.1 *Specifications*

Ball mills produce slurry by mixing clay, water and chemicals SMS and STPP. Ball mills take 5 to 6 hours for slurry preparation. The specifications of ball mills and its accessories are given below:

Table 31: Specifications of ball mills

Particular	Units	Value
Numbers of ball mills	#	2
Capacity of each ball mill	t/batch	40
Water consumption in each ball mill	t/batch	18
SMS (chemical consumption)	kg/batch	150
STPP (chemical consumption)	kg/batch	25
Water TDS	ppm	500
Nos. of batch per day		7
Power consumption	kW	215

4.1.2 Field Measurement and Analysis

During DEA, the following measurements were done:

- Power consumption of all ball mills

All power profile is included in Annexure-4. Average power consumption and power factor are given in below table:

Table 32: Average power consumption and PF of ball mills

Equipment	Average Power (kW)	PF
Ball Mill#1	136.4	0.94
Ball Mill#2	148.4	0.94

4.1.3 Observations and Performance Assessment

Mass balance of Ball mills based on measurements for Ball Mill#1 and Ball Mill#2 is given below:

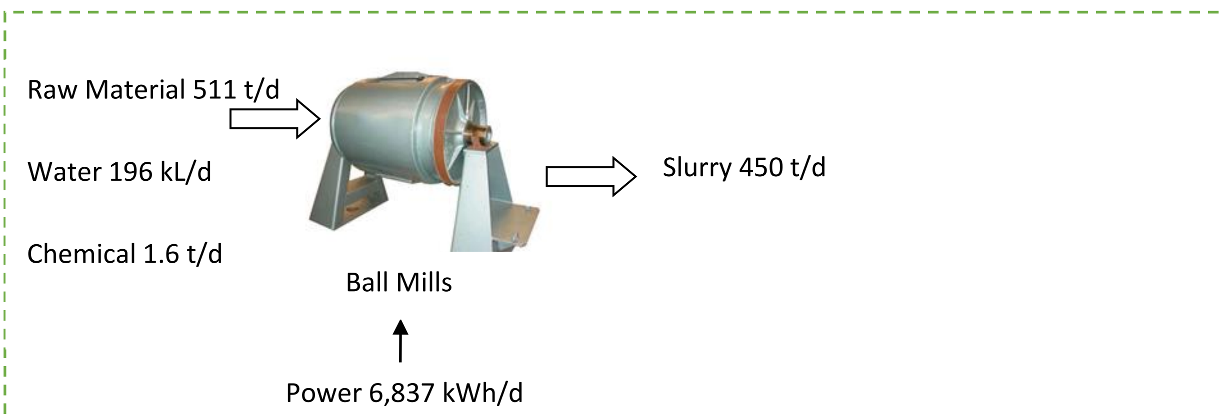


Figure 18: Energy and mass balance of Ball Mills

Performance of ball mills measure in terms of specific energy consumption (power consumed for preparation of 1 ton of slurry). Based on observations during DEA, the specific energy consumption of coal was 15.2kW/ton. Plant purchase tankers from outside parties with good quality water (having TDS in range 0f 400 – 500ppm only), due to which operation time of ball mill is optimized.

4.2 Hydraulic presses

4.2.1 Specifications

There are 3 hydraulic presses. Hydraulic presses give shape for powder that is coming from spray dryer in tiles form by pressing powder with high pressure (15.5MPa). Hydraulic oil gets heated when pressed so that it is required to be cooled in heat exchanger where water circulates as cold media. The specifications of presses and its accessories are given below:

Table 33: Specifications of hydraulic press

Particular	Units	Press 1	Press 2
Cycle (stock) per mins	N/m	8.5	8
Nos. of tiles per stock		4	4
Tile size	mm × mm	300 × 600	300 × 600
Tile thickness	Mm	14.2	12.9
Tiles weight	kg	3.4	3.5
Power rating	kW	126	126
Water Circulation Pump	#	1	1

Press -3 was not in operating during DEA.

4.2.2 Field measurement and analysis

During DEA, the following measurements were done:

- Power consumption of presses and water circulation pumps
- Count of tiles processed

Average power consumption of press 1 was 40.3 kW (PF 0.0.5) and press 2 was consuming 96 kW (P.F. 0.82). Two water circulation pumps were consuming power as 4.9 kW and 5.0 kW.

4.2.3 Observation and performance assessment

Both circulation pumps operates 24 hours in a day while press has frequent shut down, however it is not advisable to regulate pump based on oil temperature as the temperature will suddenly rise if circulation pump is stopped

Performances of hydraulic presses can be measured in terms of specific energy consumption (power consumed for preparation of 1 ton of tile). Based on observations during DEA, the specific energy consumption of press was 19.8kW/ton and that off the old press was 49.9kW/ton.

4.3 Agitator

4.3.1 Specifications

Slurry is stored in the agitation tank after preparation in ball mils where agitator motors (stirrer) were rotating continuously. Stirrer prevents the settling of slurry. The specifications of agitator motors are given below:

Table 34: Specifications of agitators

Particular	Units	Value
Numbers of agitators in tank	#	17
Capacity of each agitator motor	kW	5.5
Number of motors	#	16

4.3.2 Field measurement and analysis

During DEA, the following measurements were done:

- Power consumption of all agitator motors

Power consumption and P.F. of all agitator motors (stirrer) are given in below table:

Table 35: Power consumption and P.F. of agitator motors

Equipment	kW	PF
Agitator Stirrer motor-1	3.08	0.63
Agitator Stirrer motor-2	2.95	0.6
Agitator Stirrer motor-3	3.04	0.6
Agitator Stirrer motor-4	2.73	0.56
Agitator Stirrer motor-5	2.37	0.56
Agitator Stirrer motor-6	2.53	0.57
Agitator Stirrer motor-7	2.42	0.59
Agitator Stirrer motor-8	2.2	0.48
Agitator Stirrer motor-9	2.23	0.52
Agitator Stirrer motor-10	2.41	0.58
Agitator Stirrer motor-11	2.29	0.51
Agitator Stirrer motor-12	2.32	0.52
Agitator Stirrer motor-13	Not in operation	
Agitator Stirrer motor-14		
Agitator Stirrer motor-15	2.9	0.60
Agitator Stirrer motor-16	3.5	0.75

4.3.3 Observations and performance assessment

Based on measurement it can be seen that power factor of agitator motor is in the range of 0.48-0.75. During DEA, it was observed that all motors operate at the same time. It is suggested that all motors should operate by timer control.

Performance of agitator motors can measure in terms of specific energy consumption (power consumed for holding 1 ton of slurry). Based on observations during DEA, the specific energy consumption of agitator motors were 2.0kW/ton.

4.3.4 Energy conservation measures (ECM) – ECM# 5 Timer Control in Agitator Stirrer Motor

Technology description `

In agitation section, agitators are provided in underground tanks to maintain the uniformity of the slurry. These motors operate for about 24 hours in a day. Installation of automatically time controller ON-OFF system on the agitator motors do not affect the uniformity (quality) of slurry but gives saving in electricity consumption in agitator motors. This system automatically switches ON agitator motors for about 10 minutes and then switches OFF for about 5 minutes. This means that in one hour agitator motors operate for about 40 minutes and remain switch off for about 20 minutes.

Study and investigation

It was observed during energy audit that agitator's motors are operated continuously for 24 hours in a day.

Recommended action

It is recommended installing time controls on agitator motors. This could result in 20-30% saving in the electricity consumption.

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

Table 36: Cost benefit analysis (ECM-5)

Parameters	UOM	Present	Proposed
No of agitator stirrer	#	16	16
No of agitator stirrer running	#	14	14
Rated power of agitator stirrer motor	kW	5.5	5.5
Running of each stirrer motor	h/d	24	12
Average power of stirrer motor	kW	2.6	2.6
Annual operating days	d/y	365	365
Annual power consumption	kWh/y	23,133	11,566
Annual energy saving	kWh/y		11,566
Electricity cost	Rs/kWh	6.88	6.88
Annual energy cost saving	Rs Lakh		0.80
Estimated investment	Rs Lakh		0.28
Payback Period	months		4
IRR	%		217
Discounted payback period	Months		1.7

4.4 Glazing

4.4.1 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 37: Specifications of glazing machine

Particular	Units	Glaze mill
Numbers of glazing mills	Nos.	4
Capacity of glaze mill 1	Ton/batch	1
Capacity of glaze mill 2	Ton/batch	2
Capacity of glaze mill 3	Ton/batch	3
Capacity of glaze mill 4	Ton/batch	0.1
Power consumption of mill 1	kW	149
Power consumption of mill 2	kW	22
Power consumption of mill 3	kW	15
Power consumption of mill 4	kW	2.2

4.4.2 Field measurement and analysis

During DEA, the following measurements were done:

- Power consumption of three glaze mills which were in operation.

Power consumption and P.F. of all glaze mills are given in below table:

Table 38: Power consumption and P.F. of glaze mills

Equipment	kW	PF
Glaze mill 2	6.7	0.76
Glaze mill 3	7.2	0.8
Glaze mill 4	1.25	0.6

4.4.3 Observations and performance assessment

Performance of glaze mill can measure in terms of specific energy consumption (power consumed for glazing 1 ton of tiles). Based on observations during DEA, the specific energy consumption of glaze mills were 4.6 kW/ton.

4.5 Sizing

4.5.1 *Specifications*

There were 3 sizing lines; each holding two sizing machines each comprising many grinders along with dust collector blower. The specifications of sizing machines are given below:

Table 39: Specifications of sizing machine

Particular	Units	New sizing
Numbers of sizing machines	Nos.	6

Particular	Units	New sizing
Capacity of grinders	kW	121
Capacity of dust collector blower	kW	3.7

4.5.2 FIELD MEASUREMENT AND ANALYSIS

During DEA, the following measurements were done:

- Power consumption of new sizing and old sizing machines
- Daily tiles production of each sizing machine

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

Table 40: Measured Parameters of sizing machine

Equipment	Unit	Value
Average Power (M/c#1)	kW	41.4
Average Power (M/c#2)	kW	41.9
Average Power (M/c#3)	kW	37.3
Average boxes production	Boxes/d	15,500

4.5.3 OBSERVATION AND PERFORMANCE ASSESSMENT

Based on observations during DEA, the specific energy consumption were 9.6 kW/t for sizing unit.

4.6 AIR COMPRESSORS

4.6.1 *Specifications*

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

Table 41: Specifications of compressors

Particular	Units	Air compressor 1	Air compressor 2	Air compressor 3
Power rating	kW	22	22	22
Maximum pressure	Bar (a)	8	8	8
Rated Capacity	m^3/min	3.56	3.56	3.56

All three compressors have a common receiver.

4.6.2 FIELD MEASUREMENT AND ANALYSIS

During DEA, the following measurements were done:

- Power consumption of all compressor
- Loading and unloading time

Average power consumption and loading/unloading of the compressors is given below:

Table 42: Measured parameters of Compressors

Equipment	Average Power (kW)	PF	% of time on load	Air flow rate (m^3/min)
Compressor-1	25.2	0.89	100	Not possible to measure
Compressor-2	25.8	0.90	100	

Compressor-3	16.6	0.66	79	

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

4.6.3 Observation and Performance Assessment

Based on observations during DEA, it was observed that operating pressure was higher in all three compressors which can be reduced as per requirement. Another observation was that pressure drop in line was higher which can also be reduced by changing line size. VFD installation is recommended for compressor 3 to avoid power consumption during unloading.

4.6.4 Energy Conservation Measures (ECM)

The energy conservation measures recommended are:

4.6.4.1 ECM #6: Operational pressure optimization in compressor

Technology description

Compressed air is one of the most costly utilities for any production process. In ceramic industry, compressors are used for press, sizing, and digital printing. For the purpose of cleaning, very high pressure compressed air is not necessary. Compressed air is also used for operation of pneumatic valves to different equipment's used in ceramic process like press, kiln, spray dryer etc.

Study and investigation

It was observed during the energy audit that the cut-in pressure was 7.0 kg/cm^2 and cut-out pressure was 8.0kg/cm^2. All three compressors were running and only one out of three compressors was running in unload/load condition (Compressor-3).

Recommended action

As very high pressure compressed air is not necessary in the process area. it is recommended that the existing cut-out pressure setting of 8.0 kg/cm^2 be lowered to 7.0kg/cm2 which will reduce the energy consumption by 6% (approx). The cost benefit analysis is given in the table below:

Table 43: Cost benefit analysis (ECM-6)

Parameter	UOM	Present	Proposed
Production Pressure Requirement	kg/cm²	6	6
Compressor operating pressure	kg/cm²	8	7
Reduction in pressure	kg/cm²	-	1
% of energy saving	%	-	6%
Average operating power	kW	68	63.6
Average compressor operating hour per day	h/d	24	24
Annual operating days	d/y	365	365
Annual energy consumption	kWh/y	592,733	557,169
Energy Savings	kWh/y	-	35,564
Electricity Cost	Rs/kWh	6.88	6.88
Monetary saving	Rs lakh/y	-	2.45
Investment	Rs Lakh	Nil	

Parameter	UOM	Present	Proposed
Payback Period	Months	Immediate	
IRR	%		
Discounted payback period	Months		

4.6.4.2 ECM #7: Increase compressed air line size

Technology description

Pressure drop is caused due to inadequate or poorly designed compressed air distribution system. This can lead to low productivity, poor air tool performance and more importantly high energy bills. In order for a compressed air system to operate properly and cost effectively, it should be carefully designed to meet the needs of the applications.

Study and investigation

During energy audit and by inspection of pressure at various locations in the plant, it was observed that pressure drop is higher than the acceptable limits.

Recommended action

It is recommended to increase the compressed air line size to reduce pressure drop in the distribution line. The cost benefit analysis is given below:

Table 44: Cost Benefit analysis (ECM-7)

Parameters	UOM	Present	Proposed
Existing Compressed Air Line Size	mm	50	100
Existing line length	m	150	150
Air Flow	cfm	372	372
Initial Pressure	kg/cm^2	8.5	8.5
Air Flow	m^3/min	10.5	10.5
Pressure Drop	kg/cm^2	0.33	0.01
Reduction in pressure drop	kg/cm^2	0.32	
Saving Potential	%	3.5	
Existing Power Consumption	kW	66	
Proposed Power Consumption	kW	64	
Saving Potential	kW	2	
Saving Potential	kWh/y	843	
Electricity Cost	Rs./kWh	6.88	
Saving Potential	Lakh Rs/y	0.06	
Investment	Lakh Rs	0.10	
Payback Period	months	21	
IRR	%	36	
Discounted payback period	Months	7.8	

4.6.4.3 ECM #8: Install VFD on Compressor-3

Technology description

For fluctuating loads, it is always recommended to install a variable frequency drive (VFD) to control the speed of the motor. A VFD will reduce the power consumption accordingly to the load variation in the compressor. During loading periods, the current drawn by the compressor will be high but during no load / unloading periods, the motor of compressor will draw some current which is 1/3rd or 1/4th of the total current. Hence, this unload power of the compressor can be totally avoided by installing VFD, compressor motor RPM will be raised when compressed air demand is high and when compressed air demand is reduced the RPM of the motor will be lowered based on the pressure feedback given to VFD.

Study and investigation

During measurements, it was found that the compressor#3 is operating in unload/load condition. From the power cycle, it was concluded that about 21% of the time the compressor is running in unload condition.

Recommended action

It is recommended to install VFD with the compressor# 3. This will ensure that the compressor does not get unloaded and only the RPM of the compressor motor is varied based on air demand. The cost benefit analysis of the energy conservation measure is given below:

Table 45: Cost benefit analysis (ECM-8)

Parameters	UOM	As Is	To Be
Compressor Motor Rating	kW	22	22
Average Power Consumption during loading	kW	24.9	-
Average Power Consumption during unloading	kW	12.0	-
On Load time in percentage	%	79.27%	-
Off Load time in percentage	%	20.73%	-
Average power consumption	kW	22.19	18.86
Operating hours per day	h/d	15	15
Operating says per year	d/y	365	365
Electricity consumption per year	kWh/y	121,484	103,261
Electricity saving per year	kWh/y	18,223	
Electricity Cost	Rs/kWh	6.88	
Annual monetary savings	Rs Lakh/y	1.25	
Estimate of Investment	Rs Lakh	1.00	
Payback Period	Months	10	
IRR	%	93	
Discounted payback period	Months	3.7	

4.7 Water Pumping System

4.7.1 Specifications

Pumping system comprises four transfer pumps as shown in Figure 12.

4.7.2 FIELD MEASUREMENT AND ANALYSIS

During DEA, the following measurements were done for the following pumps:

- Power consumption of press heat exchanger circulating water pumps
- Flow measurements for same pump
- Other pumps are having smaller size and internal corrosion problems

Total head, flow and power for pump is given in below table:

Table 46: Operating details of pump

Particulars	Unit	Pump 1	Pump 2
Measured flow	m^3/h	35.4	34.1
Total head	M	20	20
Actual power consumption	kW	4.9	5

4.7.3 OBSERVATION AND PERFORMANCE ASSESSMENT

Based on observations during DEA, the pump efficiencies were calculated as 46% and 44%.

4.7.4 ENERGY CONSERVATION MEASURES

4.7.4.1 ECM#9: Replacement cooling tower pump

Technology description

Replacing inefficient cooling tower pump with energy efficient pump to reduce the power consumption.

Study and investigation

The unit is having two cooling tower pumps. Efficiency of existing pumps is 46% and 44% respectively.

Recommended action

It is recommended to replace inefficient pumps with energy efficient pumps. New pumps shall have efficiency up to 65%. The cost benefit analysis is given below:

Table 47: Cost benefit analysis (ECM-9)

Parameter	UOM	Present	Proposed	Present	Proposed
Design Parameters		Cooling Tower pump-1		Cooling Tower Pump-2	
Pump Efficiency			65		65
Motor I/P Power	kW	5.595	5.595	5.595	5.595
Motor Efficiency	%	85.00	85.00	85.00	85.00
Measured Parameters	**Unit**	**AS IS**	**TO BE**	**AS IS**	**TO BE**
Flow rate Q	m3/h	35.4	35.4	34.1	34.1
Suction Pressure	kg/cm^2	0.0	0.0	0.00	0.0
Discharge Pressure	kg/cm^2	2.00	2.0	2.0	2.0
Motor Input Power	kW	4.9	3.49	5.0	3.37
Saving Assessment	**Unit**	**AS IS**	**TO BE**	**AS IS**	**TO BE**
Flow rate Q	m^3/s	0.00984	0.00984	0.00948	0.00948

Parameter	UOM	Present	Proposed	Present	Proposed
Delta P		2.0	2.0	2.0	2.0
Total Head	m	20.0	20.0	20.0	20.0
Liquid Horse Power	kW	1.9	1.9	1.9	1.9
Motor Input Power	kW	4.9	3.49	5.0	3.37
Motor Loading	%	87.6	62.4	89.4	60.2
Overall System Efficiency	%	39.4	55.3	37.2	55.3
Pump Efficiency	%	46.3	65.0	43.8	65.0
Daily working hours	h/d	12.0	12.0	12.0	12.0
Annual working days	d/y	365.0	365.0	365.0	365.0
Annual working hours	h/y	4380.0	4380.0	4380.0	4380.0
Power Saving	kW	-	1.4	-	1.6
Energy Consumption per Year	kWh/y	21462.0	15299.0	21900.0	14742.8
Energy Saving	kWh/y	-	6163.0	-	7157.2
Electricity cost	Rs/kWh	6.88	6.88	6.88	6.88
Monetary Saving	Rs Lakh/y	-	0.42	-	0.49
Percentage of Energy Saving on Pump Consumption	%	-	28.7	-	32.7
Investment of New Pump	Rs Lakh	-	0.39	-	0.39
Total annual energy saving	kWh/y	13,320			
Total annual monetary saving	Lakh Rs	0.92			
Total investment	Lakh Rs	0.78			
Simple Payback Period	Month	10			
IRR	%	90			
Discounted payback period	Months	3.9			

4.8 Lighting System

4.8.1 Specifications

The plant's lighting system includes:

Table 48: Specifications of lighting load

Particular	Units	T-8	T-12	CFL	CFL	MH
Power consumption per fixture	W	36	40	65	85	400
Numbers of fixtures	#	146	20	93	69	28

4.8.2 Field Measurement and Analysis

During DEA, the following measurements were done by :

- Recording Inventory
- Recording Lux Levels

Measured values are summarized below:

Table 49: Lux measurement at site

Particular	Measured Value Lumen/m^2	Particular	Measured Value Lumen/m^2
Office	160	Ball mill and agitators	70
Kiln control room	110	HAG and spray dryer new	75
Kiln area	60	HAG and spray dryer old	70
New Press	70	Vertical dryer	65
Old press	65	Horizontal dryer	65

4.8.3 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.

4.8.4 Energy conservation measures (ECM) - ECM #10: Energy Efficient Lighting

Technology description

Replacing conventional lamps with LED lights helps in reducing the power consumption and also results in higher illumination (lux) levels for the same power consumption.

Study and investigation

Most of the installed luminaries are of conventional type.

Recommended action

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

Table 50: Cost Benefit analysis (ECM-10)

Particulars	UOM	Present	Proposed	Present	Proposed	Present	Proposed	Present	Proposed	Present	Proposed
Fixture		**T-8**	**LED TL**	**T-12**	**20W LED**	**CFL 65 W**	**30W LED**	**CFL 85 W**	**40W LED**	**MH 400W**	**200W LED**
Rated power	W	36	20	40	20	65	30	85	40	400	200
Choke power	W	2	0	12	0	0	0	0	0	0	0
Total power	W	38	20	52	20	65	30	85	40	400	200
Operating Hours/day	h/d	10	10	10	10	10	10	10	10	10	10
Annual days of operation	d/y	365	365	365	365	365	365	365	365	365	365
Electricity usage/ fixture	kWh	139	73	190	73	237	110	310	146	1460	730
Electricity Cost	Rs/kWh	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88
No. of Fixture	Unit	146	146	20	20	93	93	69	69	28	28
Power consumption	kWh/y	20,250	10,658	3,796	1,460	22,064	10,184	21,407	10,074	40,880	20,440
Operating cost	Rs Lakh/y	1.39	0.73	0.26	0.10	1.52	0.70	1.47	0.69	2.81	1.41
Electricity Savings	kWh/y		9,592		2,336		11,881		11,333		20,440
Savings in terms of cost	Rs Lakh/y		0.66		0.16		0.82		0.78		1.41
Investment per fixture	Rs Lakh		0.004		0.004		0.006		0.006		0.006
Estimated investment	Rs Lakh		0.584		0.08		0.558		0.414		0.168
Payback period	Months		11		6		8		6		1
IRR	%	130									
Discounted payback period	Months	2.7									

*200W LED Flood Light

4.9 Electrical Distribution System

4.9.1 Specifications

Unit demand is catered by a HT supply (11kV) which is converted into LT supply (433V) by step down transformer (2.65 MVA). Automatic power factor correction system is installed in parallel to main supply. There were two DGs (capacity of 0.625 MVA) installed in main LT room for emergency purpose which are connected by means of change over. Power is distributed in plant by feeders which are shown in single line diagram in Figure 20.

4.9.2 Field measurement and analysis

During DEA, the following measurements were done:

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

4.9.3 Observations and performance assessment

After analyzing both feeders power profiling, it was observed that the maximum kVA recorded during study period was **1,277 kVA** at main incomer.

The voltage profile of the unit was satisfactory and average voltage measured was **407 V.** Maximum voltage was **421.9 V** and minimum was **394.5 V**.

Average total voltage and current harmonics distortion found **7.8%** & **9.6%** respectively during power profile recording.

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

It was observed that some of the outgoing feeders to sizing and press section has low poor power factor. Poor power factor leads to cable losses (I^2R) in the electrical distribution system. However since cable length is very less no recommendation is given.

4.9.4 Energy conservation measures (ECM) - ECM #11: Servo stabilizer for lighting MDB

Technology description

Single phase loads such as lighting and fan loads require only 220 V instead of 230 V. A separate servo stabilizer in lighting MDB with reduced voltage can serve the purpose.

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.

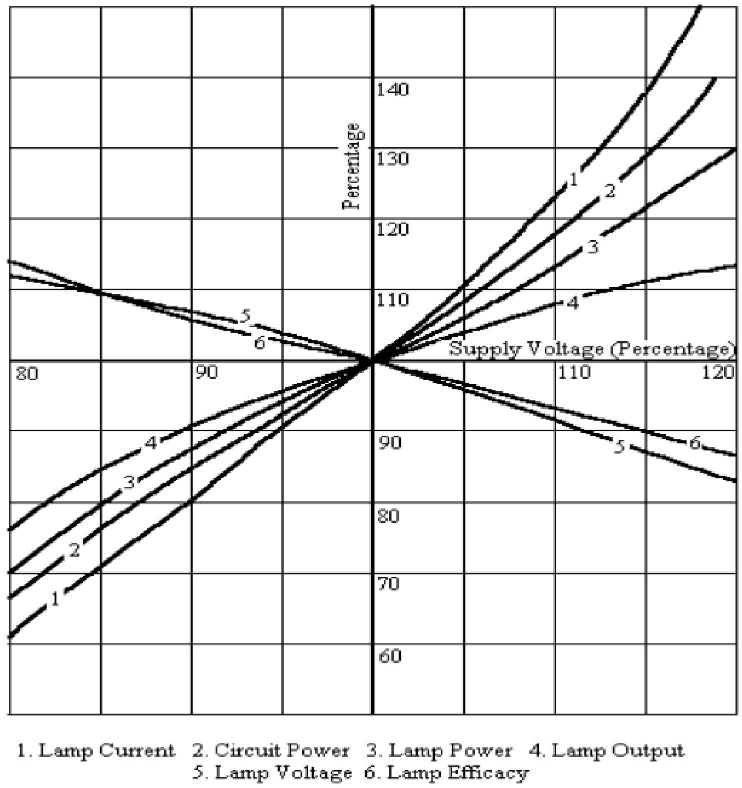


Figure 19: Effect of supply voltage on lamp parameters

Study and investigation

Currently, the single phase loads are operating at 239 V and there is no separate stabilizer for lighting loads. Maximum operating load in lighting circuit is about 25 kW.

Recommended action

Reduction of voltage from 239 V to 220 V for lighting and fan loads. The cost benefit analysis of energy conservation measure is given below:

Table 51: Cost benefit analysis (ECM-11)

Parameter	UOM	As Is	To Be
Maximum Load	kW	25	25
Maximum Load	kVA	26.84	26.84
Maximum voltage	V	250	220
Average Voltage	V	239	220
% reduction In voltage	%		7.9%
% reduction in Energy consumption	%		15.19%
Average Power Factor of System	PF	0.97	0.97
Annual lighting energy consumption	kWh/y	171,752	171752
Savings Estimate	kWh/y		55582
Actual Energy Considered for Voltage Regulation	kWh/year		116,170
Actual Energy Consumption after Voltage Regulation	kWh/year		98,528
Efficiency of Servo Stabilizer	%		95%

Parameter	UOM	As Is	To Be
Assumption : Period for Which Voltage Regulation is required	Months/year		12
Net Saving from Voltage Regulation	kWh/year		16,760
Electricity tariff	Rs /kWh	6.88	6.88
Annual Monetary Saving	Lakh Rs/y	1.2	
Sizing of Servo Stabilizer	kVA	27	
Rating Of Servo Stabilizer	kVA		30
Investment Estimate	Lakh Rs		1.36
Payback Period	Months	14	
IRR	%	62	
Discounted payback period	Months	5.33	

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.

5.1.1 ECM#12: Energy Monitoring System

Technology description

Installation of energy monitoring system on a unit will monitor the energy consumed by various machines. From this, the energy consumption benchmark 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 being done on various electrical panels for the energy consumption. It was also noticed that there were no proper fuel monitoring system installed in kilns like on-line flow-meters.

Recommended action

It is recommended to install online electrical energy monitoring systems (smart energy meters) on the main incomer and on the various electricity distribution panels. This measure will help in reduction in energy consumption by approximately 2% from its present levels. The cost benefit analysis for this project is given below:

Table 52: Cost benefit analysis (ECM-12)

Parameters	UOM	Present	Proposed
Energy monitoring saving for electrical system	%	2.00	
Energy consumption of major machines per year	kWh/y	6,979,578	6,839,986
Annual electricity saving per year	kWh/y		139,592
Cost of electricity	Rs/kWh		6.88
Annual monetary savings	lakh Rs/y		9.60
Number of equipments/system	Nos.	14	14
No. of energy meter	Nos.		42
Estimate of Investment	Lakh Rs		11.04
Simple Payback Period	Months		14
Energy monitoring saving	%		2.00
Current coal consumption in HAG	kg/y	12,488,310	12,238,544
Annual fuel saving per year	kg/y		249,766
Unit Cost	Rs/kg	4.00	4.00
Average annual NG consumption in dryer	SCM/y	198,155	194192
Annual fuel saving per year	SCM/y		3963
NG cost	Rs/SCM	36.9	37
Total annual monetary savings	Rs Lakh/y		11.45
Number of equipments/system	Nos.		3

Parameters	UOM	Present	Proposed
Estimate of Investment for two NG meter and coal weighing machine	Lakhs Rs		10
Payback Period	Months		10
IRR	%		73
Discounted payback period	Months		4.63

5.2 Best Operating Practices

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

Table 53: Unique Operating practices

Sl. No.	Equipment/System	Unique operating practices
1	Transformer	APFC installed to maintain power factor
2	Ball mill	VFD for energy saving. Timer control system. Alumina balls are used in ball mills Low TDS water is used in ball mill process
3	Spray Dryer and HAG	Cyclone separator and Wet scrubber for reducing pollution
3	Press	PRV installed for usage of compressed air
5	VT Dryer	Waste heat from kiln is used in VT dryer. Out of three VT dryer, one VT dryer runs without supplementary fuel.
6	Glaze ball mill	Timer control in each ball mill. Alumina balls are used in glaze ball mills Low TDS water is used in glaze ball mill process
7	Kiln	VFD in each blower, waste heat used in preheating section and VT dryer. PID control system for controlling chamber temperature in firing zone.
8	Sizing	Fully automatic system. Dust collected system installed.
9	Printing	Automated digital printing with fully auto control system
10	Lighting	LED lights in a few locations

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[1]. The main technical specifications are as follows:

Table 54 : Specifications of dry clay grinding technology

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

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

Parameter	UOM	Scenario-1	Scenario-2	Scenario-3
input material				
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[2]:

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

[2] 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

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:

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 20 : Heat recovery system for combustion air

The estimated benefits of double heat recovery include[3]:

- 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

[3] SACMI Kiln Revamping catalogue for roller kilns

maintenance, high breakdown level etc. It is beneficial to upgrade the kiln performance by total kiln revamping including following systems[4]:

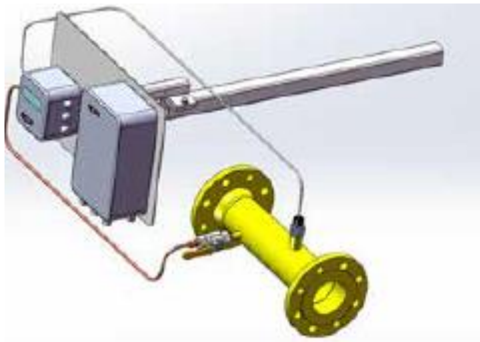
1. **Upgrading burners** with better technology and higher combustion efficiency with several benefits like:
    a. Broad working range
    b. Most stable flame detection
    c. Better flame speed
    d. Compatibility with burner block types
    e. Easy head cleaning procedure

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 21: 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.

[4] SACMI Kiln Revamping catalogue for roller kilns



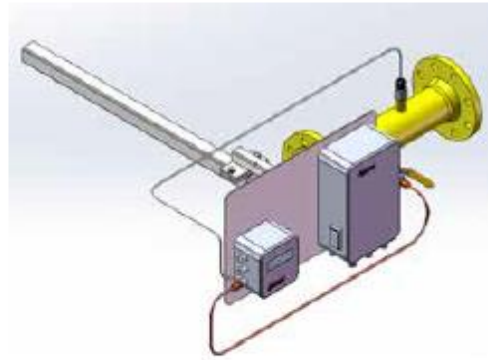


Figure 22: Combustion air control for burner

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 optimisation
- 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 23: 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

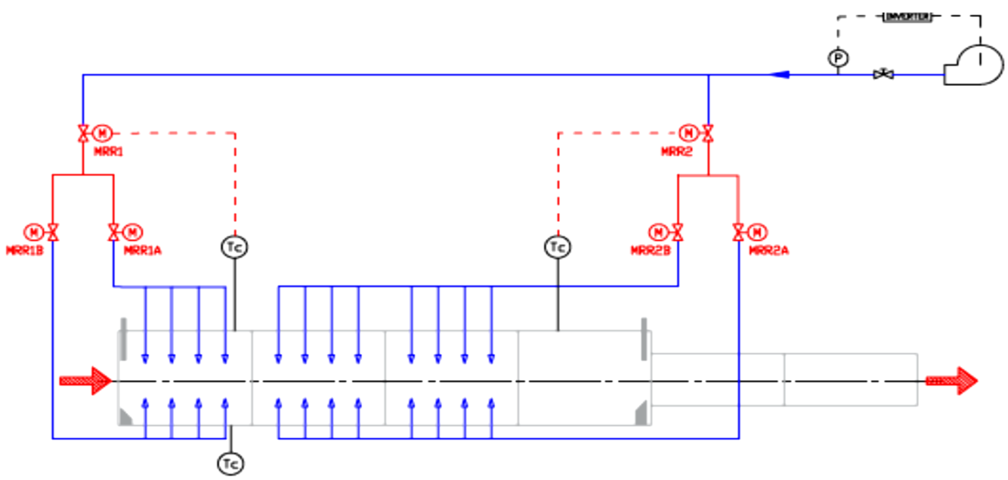


Figure 24: Fast cooling air management

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
    - Compete consumption and production database available to corporate network and to management software using internet or database SQL protocols.

Figure 25: 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

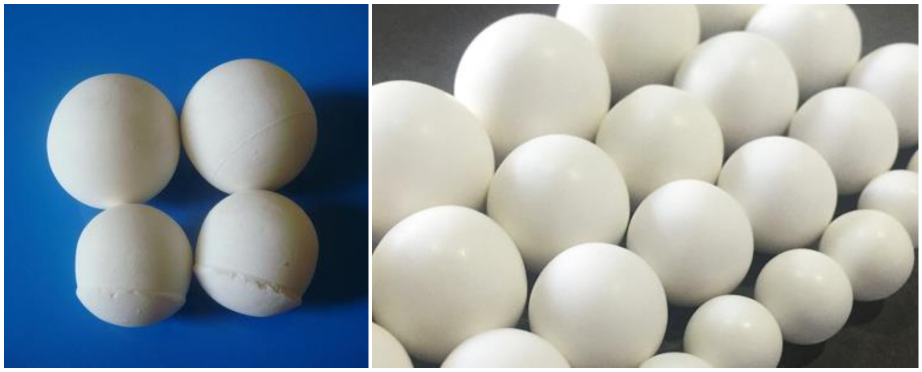


Figure 26: - High Alumina pebbles for Ball mill

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. This 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 are 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[5]) to save fuel cost during spray drying. Slip is stored in tanks which will be sieved for sending to spray drying.

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

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[6] 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:

- 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.

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

- 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, $\tau 0$, 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 27: -Direct drive blower fan

6 RENEWABLE ENERGY APPLICATIONS

The roof top PV potential is estimated as 80 kW. Cost benefit analysis is given below:

6.1 ECM#13 Installation of Solar PV system

Technology description

Solar Photovoltaic system is one of the renewable energy sources which uses PV modules to convert sunlight into electricity. The electricity generated can be stored or used directly, fed back into grid line or combined with one or more other electricity generators or more renewable energy sources.

Study and investigation

It was observed during energy audit that 800 m^2 of area is available on the roof top for installation of solar PV panels.

Recommended action

It is possible to install 80 kW solar panel in available space. The average electricity generation is estimated at 140,000kWh/y. The cost benefit analysis is given below:

Table 55: Cost benefit analysis (ECM 13)

Parameters	UOM	Present	Proposed
Available area on roof	m^2	800	
Capacity of solar panel	kW		80
Energy generation from solar panel	kWh/day		384
Solar radiation day per year	d/y		365
Average electricity generation per year	kWh/y		140,072
Electricity Cost	Rs/kWh		6.88
Annual monetary savings	lakh Rs/Y		9.6
Estimate of Investment	Lakh Rs		41.6
Payback Period	Months		52
IRR	%		-1
Discounted payback period	Months		18.1

The project IRR is negative and the payback period is also very long hence the project is not 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

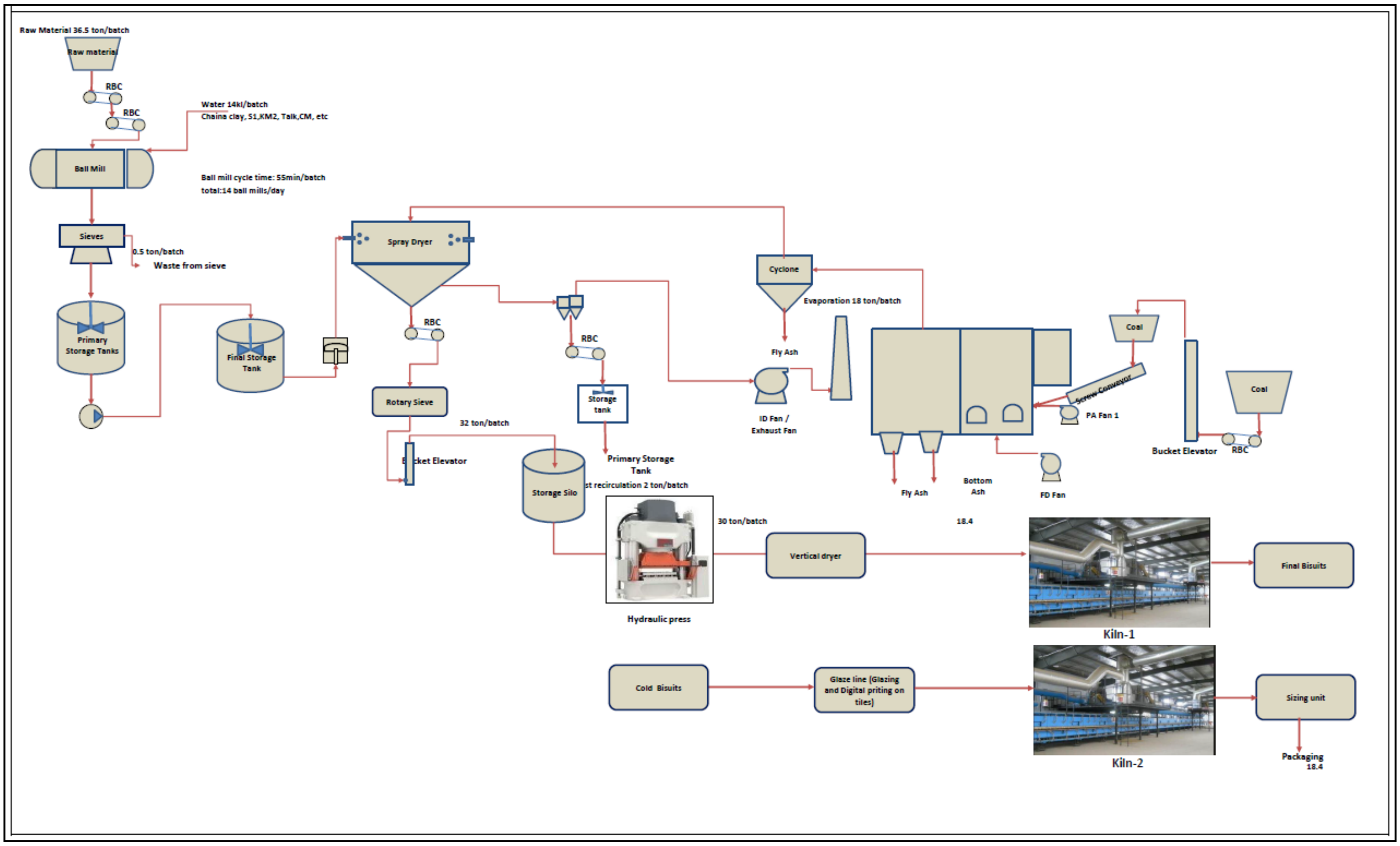


Figure 28: Process Flow Diagram of Plant

Annex-2: Detailed Inventory

Equipment	Connected Load	Rating (kW)
Ball Mill	Ball mill-1	215
	Ball mill-2	215
	weighting M/c	5.5
	Conveyer	8.206
	Mud Pump	7.46
Agitator Tank	Stirrer-1	5.5
	Stirrer-2	5.5
	Stirrer-3	5.5
	Stirrer-4	5.5
	Stirrer-5	5.5
	Stirrer-6	5.5
	Stirrer-7	5.5
	Stirrer-8	5.5
	Stirrer-9	5.5
	Stirrer-10	5.5
	Stirrer-11	5.5
	Stirrer-12	5.5
	Stirrer-13	5.5
	Stirrer-14	5.5
	Stirrer-15	5.5
	Stirrer-16	5.5
Final Tank	Stirrer-1	5.5
Spray Dryer	Hydraulic pump-1	30
	Hydraulic pump-1 (S/B)	30
	ID fan	132
	Cyclone	0.746
	Stirrer	17.6
	Converyer	4.5
Hot Air Generator	SFD fan	11
	Varam	5.5
	FD Fan	45
	Coal Conveyer	0.75
	Coal eliverator	0.75
Press	Press-1	125.97
	Press-2	125.97
	Press-3	81.8
Cooling Tower	Pump	16.785
VT Dryer/HZ dryer	Induction Motor	149.2
	Blower-1	22.38
	Blower-2	24.618
Conveyer	Conveyer	32.451
Printing	Printing	6.66
Kiln	Kiln-1	334
	Kiln-2	401
Sizing line	Sizing M/c-1	121
	Sizing M/c-2	121
	Sizing M/c-3	121
	Sizing M/c-4	121

Equipment	Connected Load	Rating (kW)
	Sizing M/c-5	121
	Sizing M/c-6	121
	Sizing Line-1	3.74
	Sizing Line-2	3.74
	Sizing Line-3	3.74
Glaze line	Line	117.495
	Stirrer	22.753
	Vibrator	8.952
Glaze ball mill	Ball mill 3 ton	149.2
	Ball mill 2 ton	22.38
	Ball mill 1 ton	14.92
	Ball mill 100kg	2.238
	china clay tank	7.46
	Storage Tanks	11.19
	Lighting	180.0011

ANNEX-3: SINGLE LINE DIAGRAM

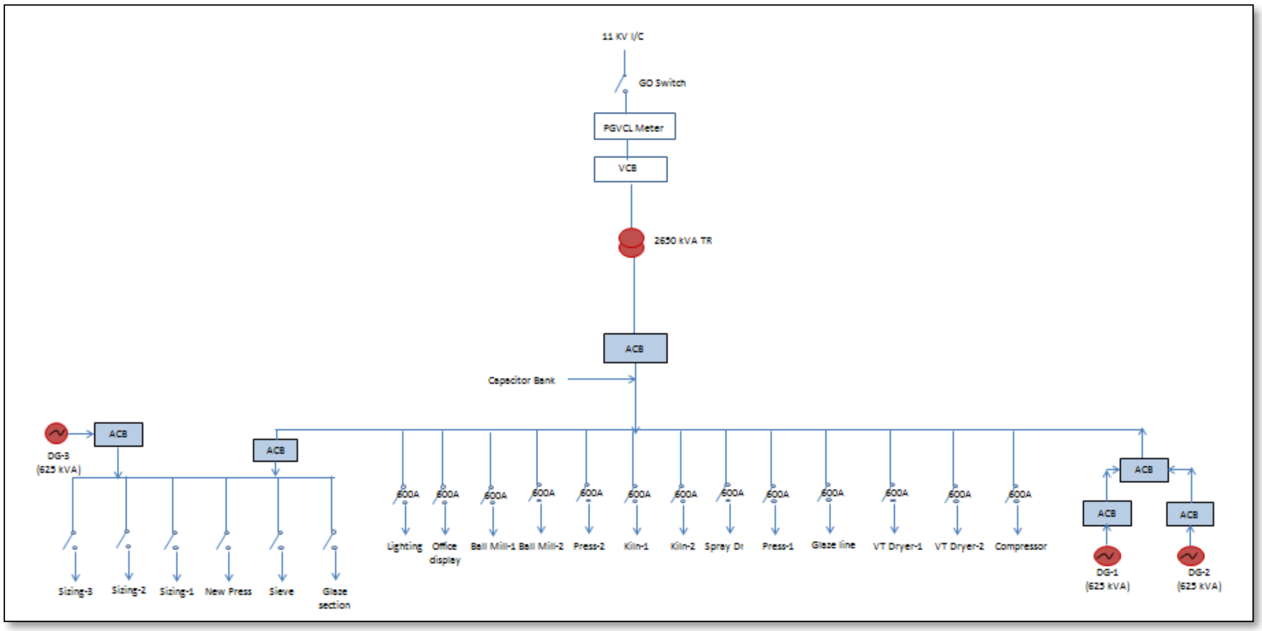
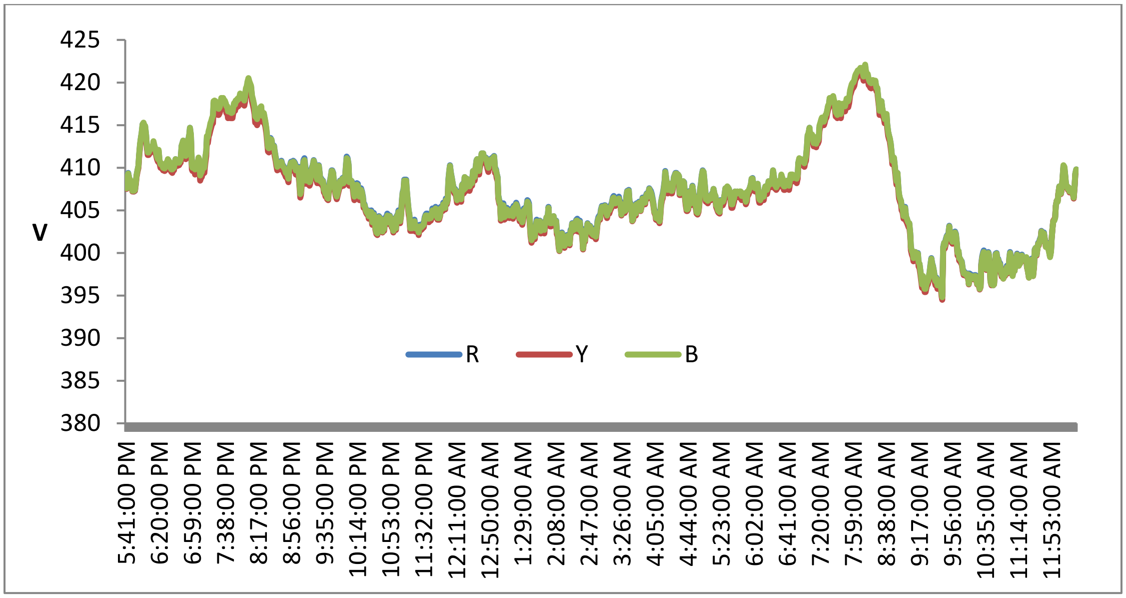


Figure 29: Single Line Diagram (SLD)

Annex-4: Electrical Measurements



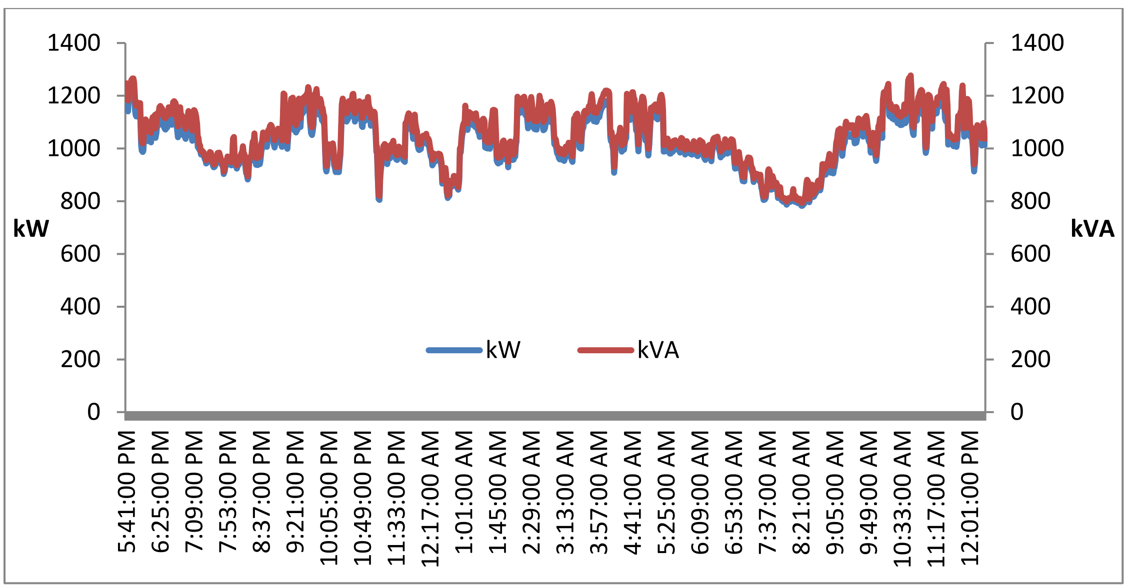
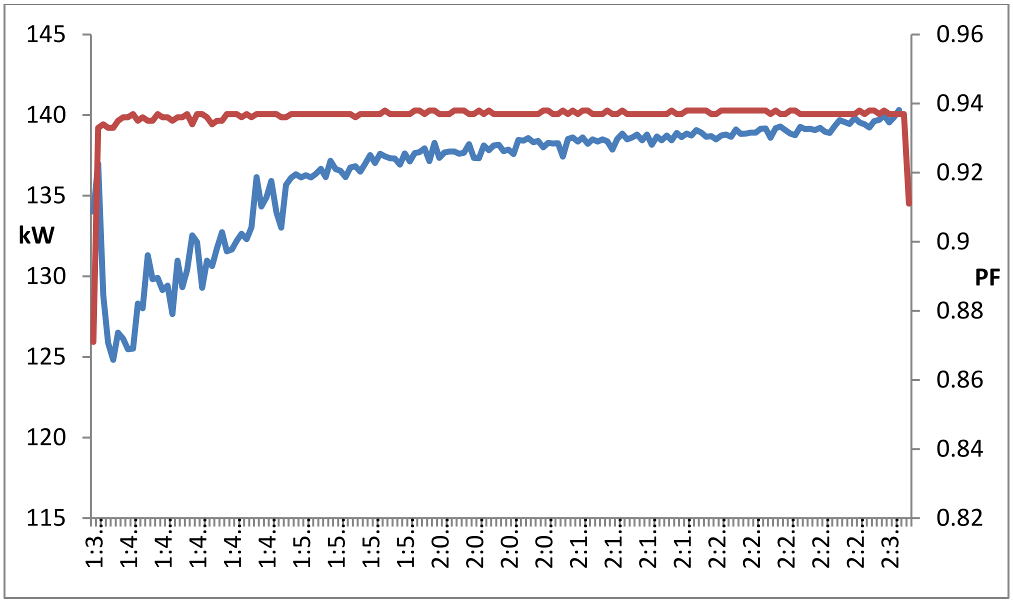


Figure 30: Power and voltage profile of Main Income



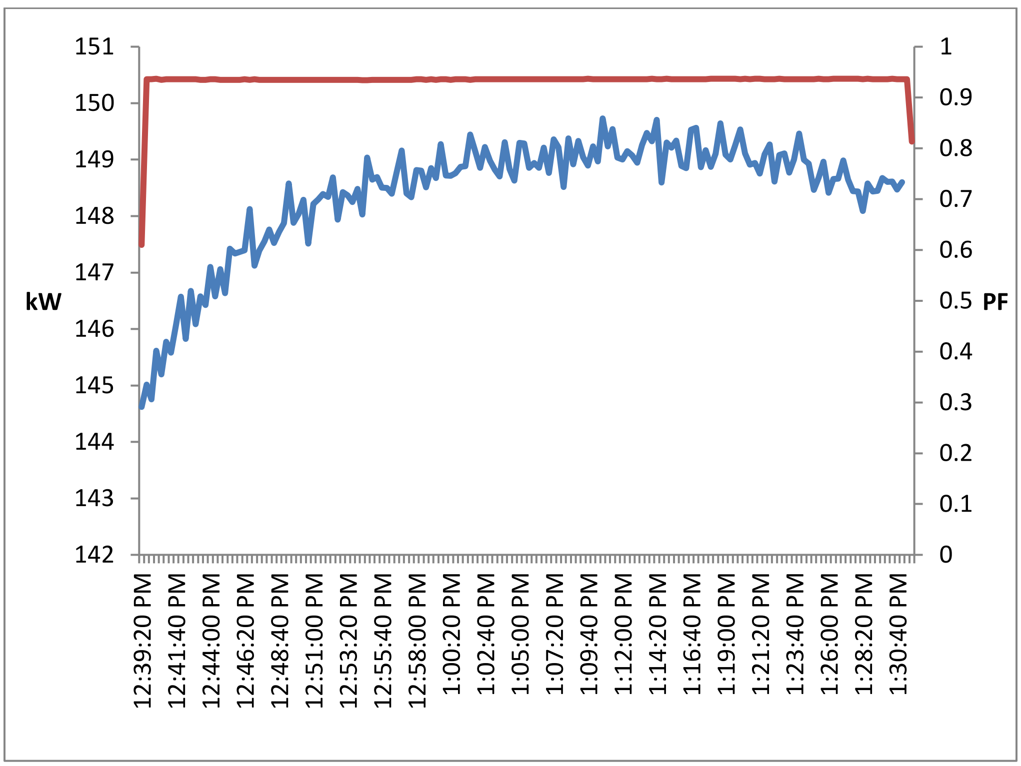
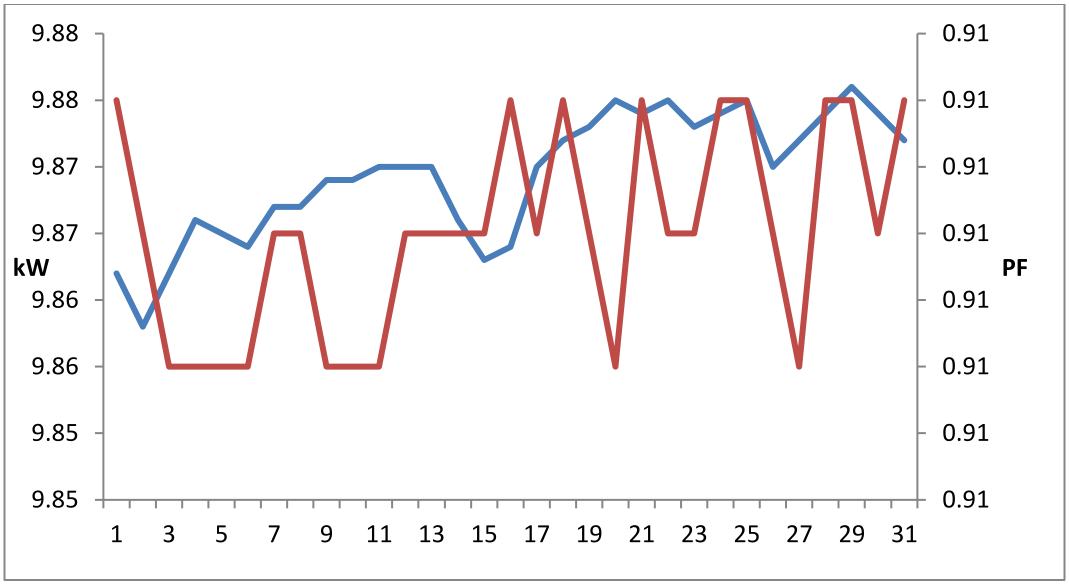


Figure 31: Power and PF profile of Ball Mill 1 and 2



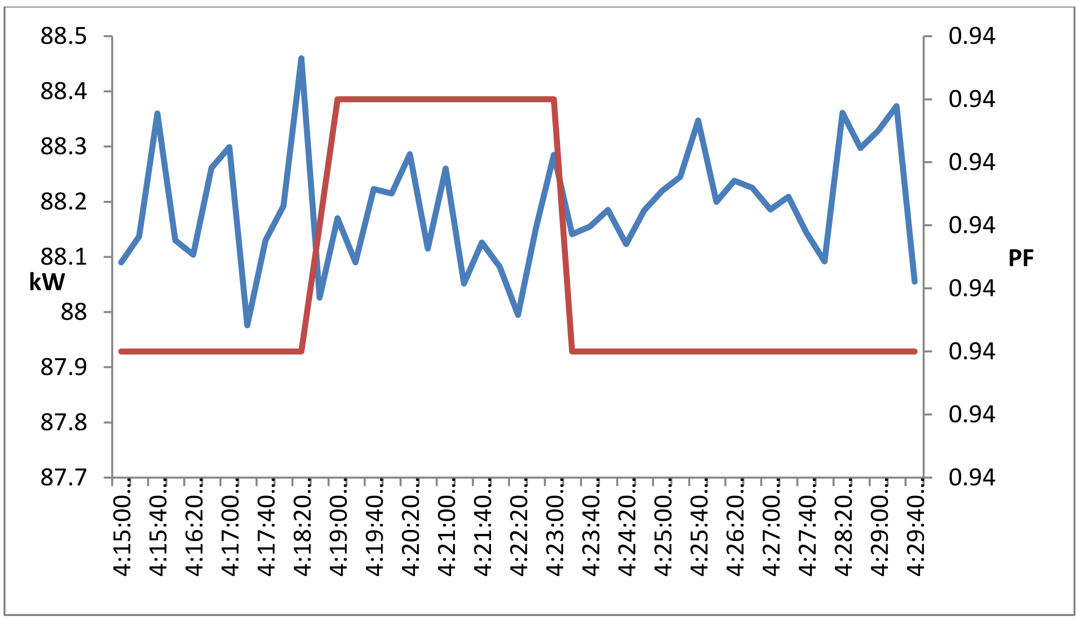
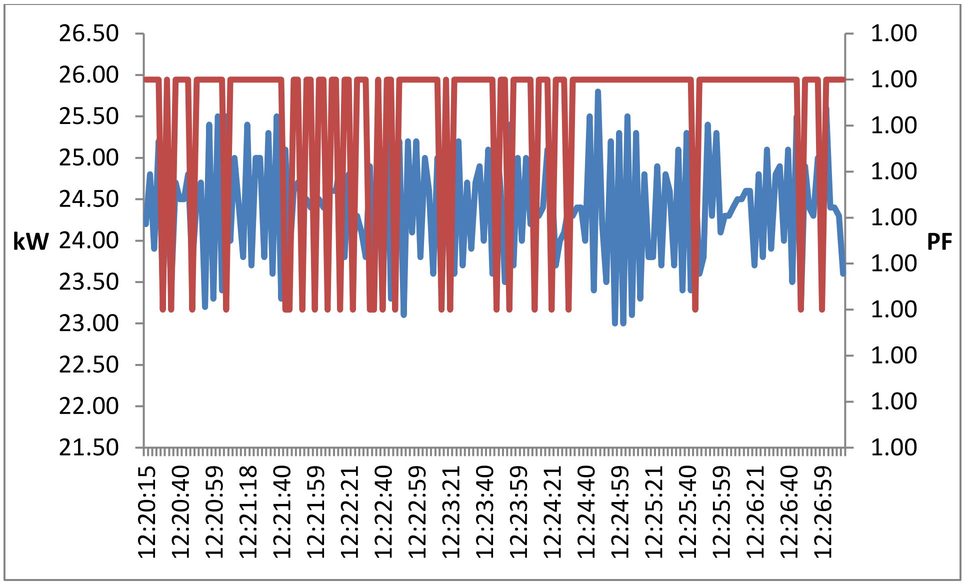
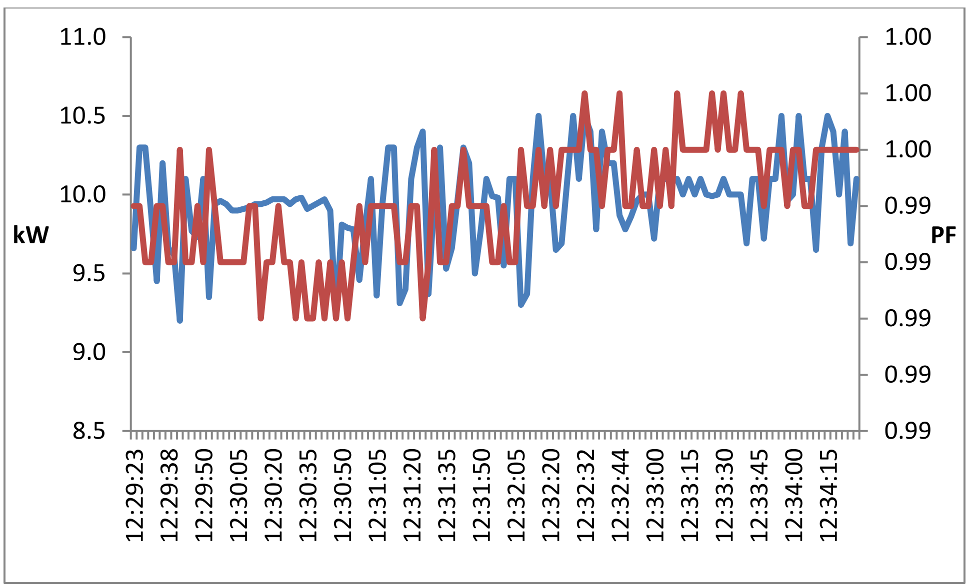
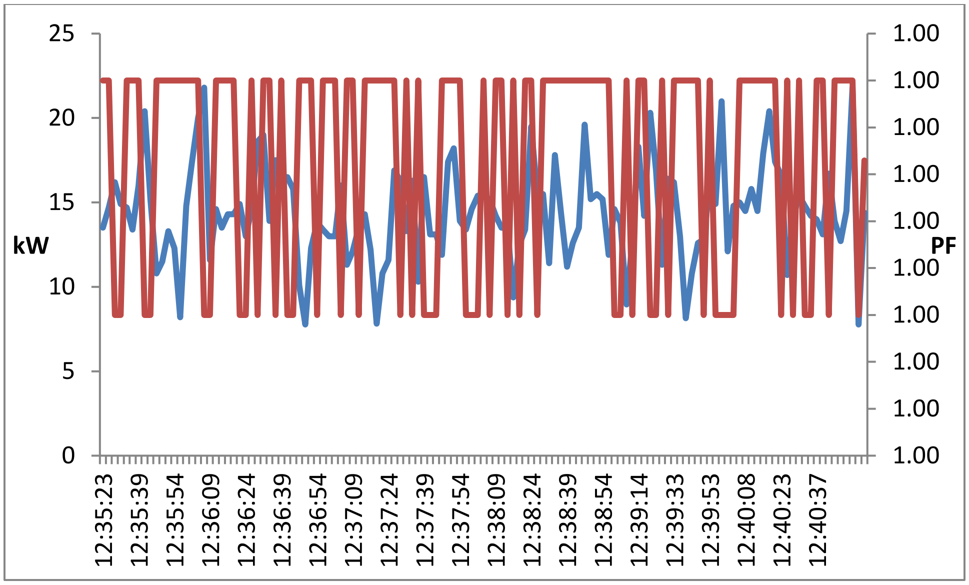
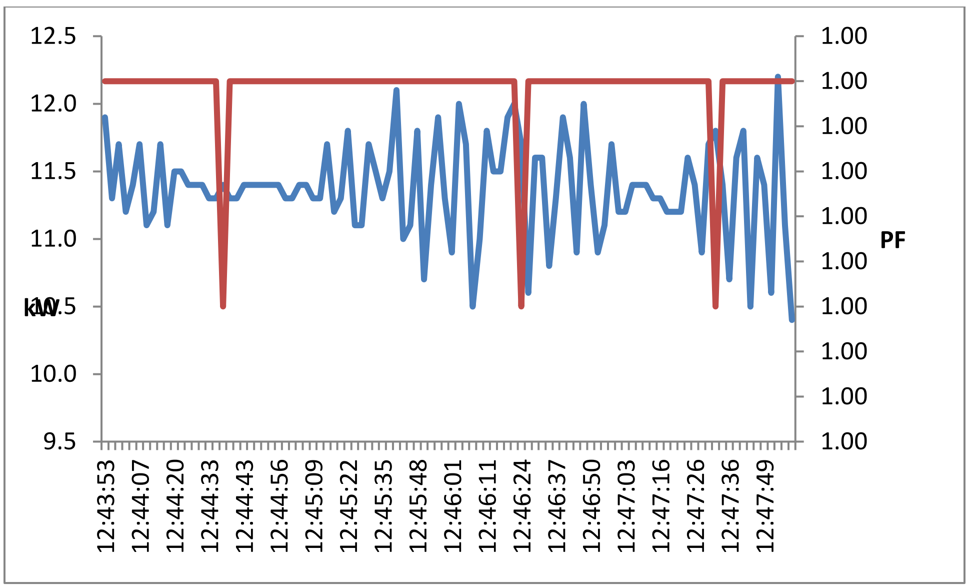


Figure 32: Power and PF profile of FD and ID fan of HAG


kW
PF
26.50
26.00
25.50
25.00
24.50
24.00
23.50
23.00
22.50
22.00
21.50
1.00
12:20:15
12:20:40
12:20:59
12:21:18
12:21:40
12:21:59
12:22:21
12:22:40
12:22:59
12:23:21
12:23:40
12:23:59
12:24:21
12:24:40
12:24:59
12:25:21
12:25:40
12:25:59
12:26:21
12:26:40
12:26:59


kW
PF
11.0
10.5
10.0
9.5
9.0
8.5
1.00
0.99
12:29:23
12:29:38
12:29:50
12:30:05
12:30:20
12:30:35
12:30:50
12:31:05
12:31:20
12:31:35
12:31:50
12:32:05
12:32:20
12:32:32
12:32:44
12:33:00
12:33:15
12:33:30
12:33:45
12:34:00
12:34:15


kW
PF
25
20
15
10
5
0
1.00
12:35:23
12:35:39
12:35:54
12:36:09
12:36:24
12:36:39
12:36:54
12:37:09
12:37:24
12:37:39
12:37:54
12:38:09
12:38:24
12:38:39
12:38:54
12:39:14
12:39:33
12:39:53
12:40:08
12:40:23
12:40:37


kW
PF
12.5
12.0
11.5
11.0
10.5
10.0
9.5
1.00
12:43:53
12:44:07
12:44:20
12:44:33
12:44:43
12:44:56
12:45:09
12:45:22
12:45:35
12:45:48
12:46:01
12:46:11
12:46:24
12:46:37
12:46:50
12:47:03
12:47:16
12:47:26
12:47:36
12:47:49

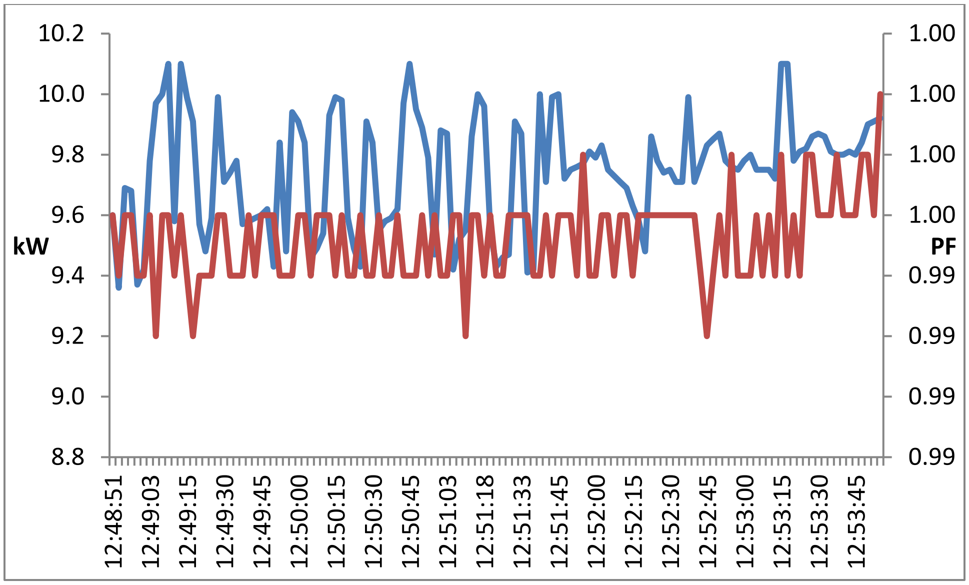
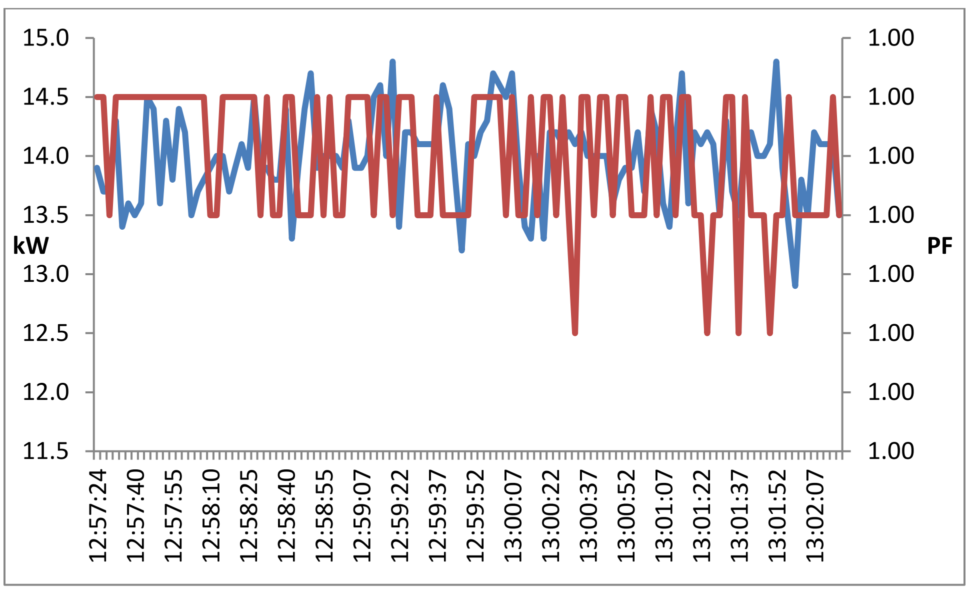
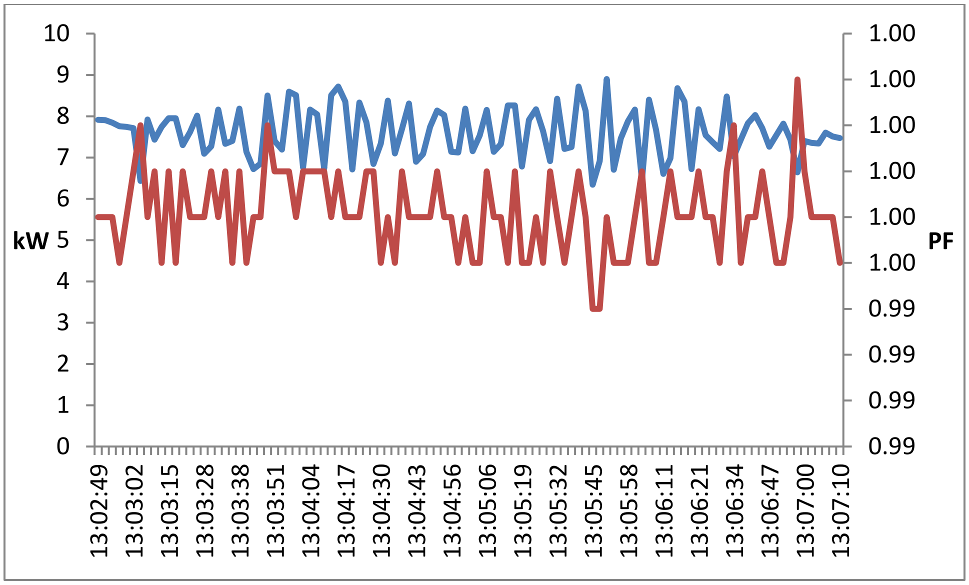
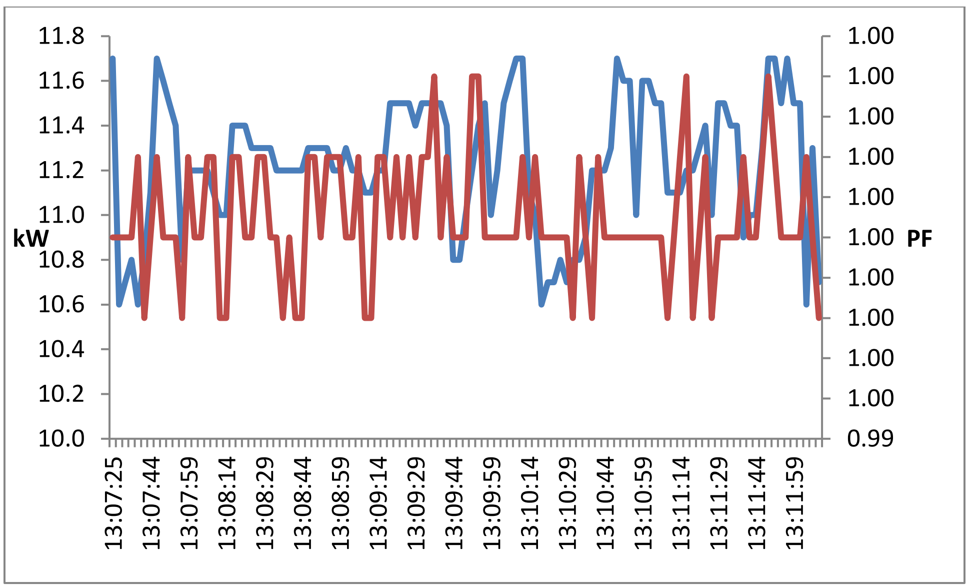
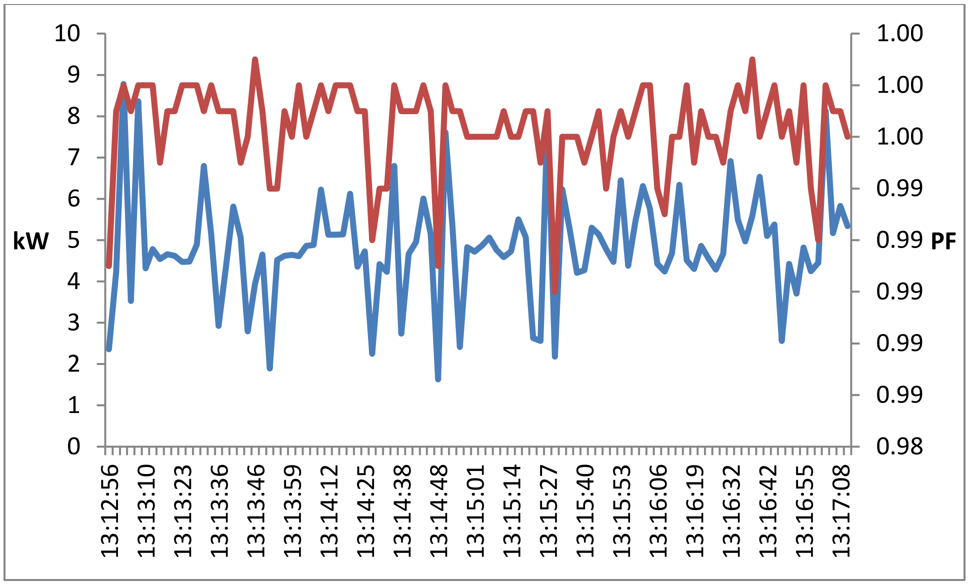


Figure 33: Power and PF profile of blowers of Kiln 1




kW
PF
10
9
8
7
6
5
4
3
2
1
0
1.00
0.99
13:02:49
13:03:02
13:03:15
13:03:28
13:03:38
13:03:51
13:04:04
13:04:17
13:04:30
13:04:43
13:04:56
13:05:06
13:05:19
13:05:32
13:05:45
13:05:58
13:06:11
13:06:21
13:06:34
13:06:47
13:07:00
13:07:10


kW
PF
11.8
11.6
11.4
11.2
11.0
10.8
10.6
10.4
10.2
10.0
1.00
0.99
13:07:25
13:07:44
13:07:59
13:08:14
13:08:29
13:08:44
13:08:59
13:09:14
13:09:29
13:09:44
13:09:59
13:10:14
13:10:29
13:10:44
13:10:59
13:11:14
13:11:29
13:11:44
13:11:59



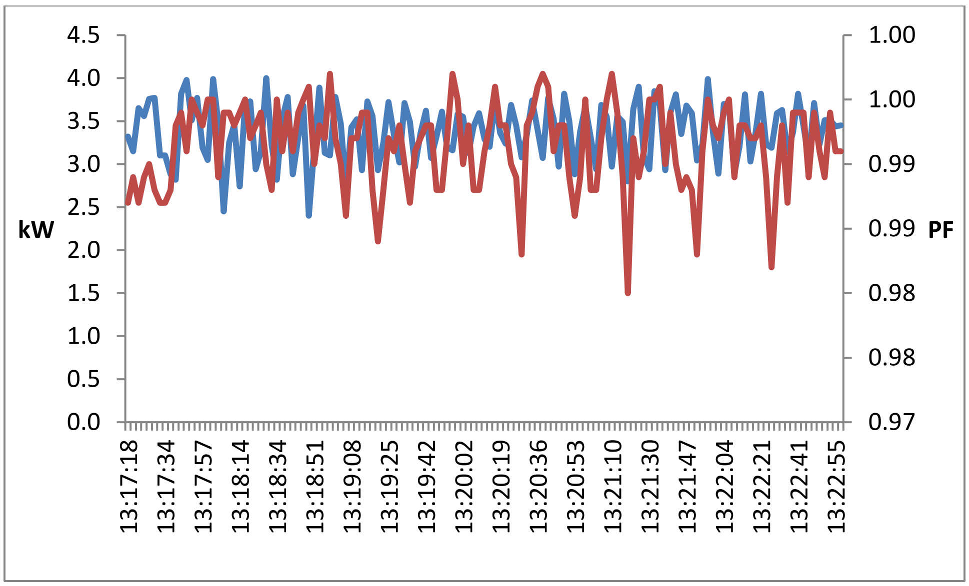


Figure 34: Power and PF profile of blowers of Kiln 2

ANNEX-5: THERMAL MEASUREMENTS, KILN EFFICIENCY, HAG EFFICIENCY, GASIFIER PERFORMANCE

1. Kiln-1 efficiency calculations

Input parameters

Input Data Sheet		
Type of Fuel	PNG	
Source of fuel	Gujrat Gas	
Particulars	**Value**	**Units**
Kiln firing zone maximum perating temperature	1146	*°C*
Initial temperature of material (Biscuits)	70	*°C*
Avg. fuel Consumption	422.1	*scm/h*
Flue Gas Details		
Flue gas temp at smog blower	117	*°C*
Preheated air temp./Ambient	85	*°C*
O_2 in flue gas	5.88	*%*
CO_2 in flue gas	8.41	*%*
CO in flue gas	8.8	*ppm*
Atmospheric Air		
Ambient Temp.	43.4	*Deg C*
Relative Humidity	45	*%*
Humidity in ambient air	0.03	*kg/kg dry air*
Fuel Analysis		
C	*73.80*	%
H	*24.90*	%
N	*1.30*	%
O	*0.00*	%
S	*0.00*	%
Moisture	*0.00*	%
Ash	*0.00*	%
GCV of fuel	9000	kcal/scm
Ash Analysis		
Unburnt in bottom ash	*0.00*	%
Un burnt in fly ash	*0.00*	%
GCV of bottom ash	*0*	kcal/kg
GCV of fly ash	*0*	kcal/kg
Material and flue gas data		
Weight of Kiln car material	0	*Kg/h*
Weight of ceramic material being heated in Kiln	12421	*Kg/h*
Weight of Stock	12421	*kg/h*
Specific heat of clay material	0.22	*kcal/kg°C*
Specific heat of kiln car material		*kcal/kg°C*
Avg. specific heat of fuel	0.51	*kcal/kg°C*
fuel temp		*°C*
Specific heat of flue gas	0.24	*kcal/kg°C*
Specific heat of superheated vapor	0.45	*kcal/kg°C*

Heat loss from surfaces of various zone		
Radiation and convection from preheating zone surface		*kcal/h*
Radiation and convection from heating zone surface	67098	*kcal/h*
Radiation and convection from rapid cooling zone surface		*kcal/h*
Radiation and convection from indirect cooling zone surface		*kcal/h*
Radiation and convection from final cooling zone surface		*kcal/h*
Heat loss from all zones	67098	*kcal/h*
For radiation loss in furnace(through entry and exit of kiln car)		
Time duration for which the tiles enters through preheating zone and exits through cooling zone of kiln	0.93	*h*
Area of opening at material inlet	1	*m2*
Coefficient based on profile of kiln opening	0.7	
Average surface temp. of kiln	66	*°C*

Efficiency calculations

Calculations	Values of KILN-1	Unit
Theoretical Air Required	17.23	*kg/kg of fuel*
Excess Air supplied	38.88	*%*
Actual Mass of Supplied Air	23.92	*kg/kg of fuel*
Mass of dry flue gas	22.68	*kg/kg of fuel*
Amount of Wet flue gas	24.92	*Kg of flue gas/kg of fuel*
Amount of water vapour in flue gas	2.24	*Kg of H2O/kg of fuel*
Amount of dry flue gas	22.68	*kg/kg of fuel*
Specific Fuel consumption	33.98	*kg of fuel/ton of tile*
Heat Input Calculations		
Combustion heat of fuel	305845	*Kcal/ton of tiles*
Sensible heat of fuel		*Kcal/ton of tile*
Total heat input	305845	*Kcal/ton of tile*
Heat Output Calculation		
Heat required by 1 ton of ceramics (useful heat)	236720	*Kcal/ton of tile*
Heat loss in dry flue gas per ton of ceramics	13616	*Kcal/ton of tile*
Loss due to H_2 in fuel	3831	*Kcal/ton of tile*
Loss due to moisture in combustion air	792	*Kcal/ton of tile*
Loss due to partial conversion of C to CO	15	*Kcal/ton of tile*
Loss due to convection and radiation (openings in kiln - inlet & outlet of kiln)	(14)	*Kcal/ton of tile*
Loss Due to Evaporation of Moisture Present in Fuel	0	*Kcal/ton of tile*
Total heat loss from kiln (surface) body	5402	*Kcal/ton of tile*
Heat loss due to un burnt in Fly ash	0	*Kcal/ton of tile*
Heat loss due to un burnt in bottom ash	0	*Kcal/ton of tile*
Heat loss due to kiln car	0	*Kcal/ton of tile*
Unaccounted heat losses (Heat loss in rapid cooling)	45483	*Kcal/ton of tile*
Heat loss from kiln body and other sections		
Total heat loss from kiln	5402	*Kcal/tons*
Kiln Efficiency	77.4	*%*

Kiln-2 efficiency calculations

Input parameters

Input Data Sheet		
Type of Fuel	PNG	
Source of fuel	Gujarat Gas	
		Units
Kiln firing zone maximum perating temperature	1083	*°C*
Initial temperature of material (Biscuits)	45	*°C*
Avg. fuel Consumption	409.3	*scm/h*
Flue Gas Details		
Flue gas temp at smog blower	121	*°C*
Preheated air temp./Ambient	80	*°C*
O2 in flue gas	13.73	*%*
CO2 in flue gas	4.06	*%*
CO in flue gas	6.8	*ppm*
Atmospheric Air		
Ambient Temp.	43.4	*°C*
Relative Humidity	45	*%*
Humidity in ambient air	0.03	*kg/kg dry air*
Fuel Analysis		
C	*73.80*	%
H	*24.90*	%
N	*1.30*	%
O	*0.00*	%
S	*0.00*	%
Moisture	*0.00*	%
Ash	*0.00*	%
GCV of fuel	9000	kcal/scm
Ash Analysis		
Un burnt in bottom ash	*0.00*	%
Un burnt in fly ash	*0.00*	%
GCV of bottom ash	*0*	kcal/kg
GCV of fly ash	*0*	kcal/kg
Material and flue gas data		
Weight of Kiln car material	0	*Kg/h*
Weight of ceramic material being heated in Kiln	9142	*Kg/h*
Weight of Stock	9142	*kg/h*
Specific heat of clay material	0.22	*kcal/kg°C*
Specific heat of kiln car material		*kcal/kg°C*
Avg. specific heat of fuel	0.51	*kcal/kg°C*
fuel temp		*°C*
Specific heat of flue gas	0.24	*kcal/kg°C*
Specific heat of superheated vapour	0.45	*kcal/kg°C*
Heat loss from surfaces of various zone		
Radiation and convection from preheating zone surface		*kcal/h*
Radiation and convection from heating zone surface	33,131	*kcal/h*
Heat loss from all zones	33,131	*kcal/h*
For radiation loss in furnace(through entry and exit of kiln)		

Time duration for which the tiles enters through preheating zone and exits through cooling zone of kiln	1.17	*h*
Area of opening at material inlet	1	*m^2*
Co-efficient based on profile of kiln opening	0.7	
Average surface temp. of kiln	66	*°C*

Efficiency Calculation

Calculations	Values of KILN-2	Unit
Theoretical Air Required	17.23	*kg/kg of fuel*
Excess Air supplied	188.66	*%*
Actual Mass of Supplied Air	49.72	*kg/kg of fuel*
Mass of dry flue gas	48.48	*kg/kg of fuel*
Amount of Wet flue gas	50.72	*Kg of flue gas/kg of fuel*
Amount of water vapour in flue gas	2.24	*Kg of H2O/kg of fuel*
Amount of dry flue gas	48.48	*kg/kg of fuel*
Specific Fuel consumption	44.77	*kg of fuel/ton of tile*
Heat Input Calculations		
Combustion heat of fuel	402897	*Kcal/ton of tiles*
Sensible heat of fuel		*Kcal/ton of tile*
Total heat input	402897	*Kcal/ton of tile*
Heat Output Calculation		
Heat required by 1 ton of ceramics (useful heat)	228360	*Kcal/ton of tile*
Heat loss in dry flue gas per ton of ceramics	40422	*Kcal/ton of tile*
Loss due to H_2 in fuel	4812	*Kcal/ton of tile*
Loss due to moisture in combustion air	1736	*Kcal/ton of tile*
Loss due to partial conversion of C to CO	31	*Kcal/ton of tile*
Loss due to convection and radiation (openings in kiln - inlet & outlet of kiln)	(24)	*Kcal/ton of tile*
Loss Due to Evaporation of Moisture Present in Fuel	0	*Kcal/ton of tile*
Total heat loss from kiln (surface) body	3624	*Kcal/ton of tile*
Heat loss due to un burnt in Fly ash	0	*Kcal/ton of tile*
Heat loss due to un burnt in bottom ash	0	*Kcal/ton of tile*
Heat loss due to kiln car	0	*Kcal/ton of tile*
Unaccounted heat losses (Heat loss in rapid cooling)	123936	*Kcal/ton of tile*
Heat loss from kiln body and other sections		
Total heat loss from kiln	3624	*Kcal/tons*
Kiln Efficiency	**56.7**	***%***

ANNEX-6: VENDORS

ECM 2: Excess air control in kiln

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, India	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 4: Radiation and convection heat loss reduction from surface of kiln-1

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Morgan Advanced Materials - Thermal Ceramics	P.O. Box 1570, Dare House Complex, Old No. 234, New No. 2, NSC Bose Rd, Chennai - 600001	T 91 44 2530 6888 F 91 44 2534 5985 M 919840334836	munuswamy.kadhirvelu@morganplc.com mmtcl.india@morganplc.com
2	M/s LLOYD Insulations (India) Limited,	2,Kalka ji Industrial Area, New Delhi-110019	Phone: +91-11-30882874 / 75 Mr. Rajneesh Phone : 0161-2819388 Mobile : 9417004025	Email: kk.mitra@lloydinsulation.com
3	Shivay Insulation	20, Ashiyan, Haridarshan Society, Nr. D'mart, New Adajan Road Surat-395009	Mobile- 9712030444	shivayinsulation@gmail.com

ECM – 5: Installation of Electronic timer control for stirrer motors

Sl. No.	Name of Company	Address	Phone No.	E-mail / Website
1	Jagdish Electro Automation	41,Sreenath complex, National Highway 8-A, Trajpar, Morbi-363641	Mr. Paresh Patel 9909458699	www.jagdishautomation.com
2	Amtech Electronics (India) Ltd	E-6 GIDC Electronics Zone, Gandhinagar	Mr. Sachin Patel 079-23289101/102	mktg2@amtechelectronics.com

Sl. No.	Name of Company	Address	Phone No.	E-mail / Website
3	Hitachi Hi-Rel Power Electronics Pvt. Ltd	B-117 & 118 GIDC Electronics Zone, Sector 25, Gandhinagar- 382044	Mr. V.Jaikumar 079 2328 7180 - 8	v_jaikumar@hitachi-hirel.com

ECM 8: VFD installation on compressor-3

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 9: Pumps replacement on cooling tower with efficient pumps

Sl.No.	Name of Company	Address	Phone No.	E-mail
1	Varuna Pumps Pvt Ltd.	La-Gajjar Machineries Pvt.Ltd. Acidwala estate, Nagarwel Hanuman Road, Amraiwadi, Ahmedabad – 380 026	79- 22777485 / 487	www.varunapumps.com crm@lgmindia.com
2	Kirloskar Brothers Ltd	1st floor, Kalapi Avenue, Opp. Vaccine Institute, Old Padra Road, Vadodara	Mr. Sanjeev Jadhav 0265-2338723/2338735	aksur@bdq.kbl.co.in
3	KSB Pumps Ltd	Neel Kamal, Ashram Road, Opposite Sales India, Ashram Road, Ahmedabad, Gujarat 382410	Mr. Jayesh Shah 098794 83210	https://www.ksb.com/ksb-in/ksb-in-india/

ECM 10: Energy efficient lighting

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 - 11: Voltage optimization using Servo-stabilizers

Sl. No.	Name of Company	Address	Phone No.	E-mail / Website
1	Protek Enterprises	Protek House, Opp Swaminarayan mandir, On I.O.C. road, Chandkela, Ahmedabad-382424, Gujarat, India.	Mob: +91 7965216521	info@protekg.com
2	SERVOKON System ltd. (Manufacturer/Exporter)	Servokon House,C-13,Radhu palace road, opp.scope minar,Laxmi Nagar, Delhi-110092	75330088 Toll free:18002001786	http://www.servokonstabilizer.com/contact-us.html
3	SERVOMAX INDUSTRIES LIMITED (Manufacturer)	Plot No:118A, 2nd Floor, Road Number 70, Journalist Colony,Jubilee Hills, Hyderabad, Telangana - 500033	+91 9111234567	customercare@servomax.in www.wervomax.in

ECM 12: Energy Monitoring System

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Iadept Marketing Contact Person: Mr. Brijesh Kumar Director	S- 7, 2nd Floor, Manish Global Mall, Sector 22 Dwarka, Shahabad Mohammadpur, New Delhi, DL 110075	Tel.: 011-65151223	iadept@vsnl.net, info@iadeptmarketing.com

Sl. No.	Name of Company	Address	Phone No.	E-mail
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 13: Solar PV system

PF Improvement 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 56: 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%