

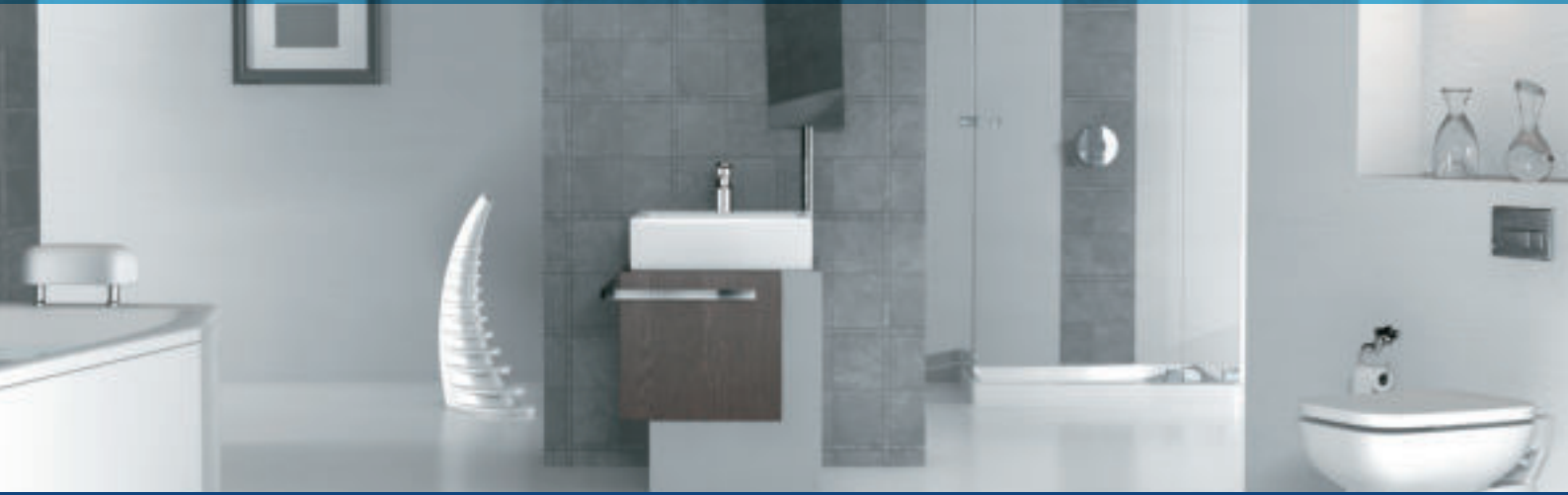


UNITED NATIONS
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Technology Compendium for Energy Efficiency and Renewable Energy Opportunities in Ceramic Sector

Thangadh Ceramic Cluster



UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

September 2020

A photograph of a modern bathroom. In the center is a glass shower enclosure with a showerhead and a handheld shower wand. To the left is a sink on a wooden vanity. To the right is a white bathtub. The walls are covered in light-colored, patterned tiles. The floor is made of light-colored wood.

Disclaimer

This document is prepared to provide overall guidance for conserving energy and costs. It is an output of a research exercise undertaken by Confederation of Indian Industry (CII) supported by the United Nations Industrial Development Organization (UNIDO) and Bureau of Energy Efficiency (BEE) for the benefit of the ***Ceramic Industry located at Thangadh, Gujarat, India***. The contents and views expressed in this document are those of the contributors and do not necessarily reflect the views of CII, BEE or UNIDO, its Secretariat, its Offices in India and elsewhere, or any of its Member States.

Promoting Energy Efficiency and Renewable Energy in Selected MSME Clusters in India

(A GEF funded project being jointly implemented by UNIDO & BEE)



UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION



Compendium of
**Energy Efficiency and Renewable Energy Technologies for
Thangadh Ceramic Cluster**

September 2020

Developed under the assignment

Scaling up and expanding of project activities in MSME Clusters

Prepared by



Confederation of Indian Industry
125 Years - Since 1895

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INDIA

A photograph of two business people shaking hands over a document titled 'CONTRACT'. The image is overlaid with a semi-transparent blue rectangle. The word 'Acknowledgement' is written in white text across the center of this rectangle. The background shows a person in a light-colored blazer and another in a dark blue suit. A pen and a spiral notebook are visible on the table in the foreground.

Acknowledgement

Acknowledgement

This assignment was undertaken by Confederation of Indian Industry (CII) as a project management consultant under the Global Environment Facility (GEF) funded project ‘Promoting Energy Efficiency and Renewable Energy in selected MSME clusters in India.’ The Technology Compendiums are meant to serve as an informative guide to the clusters that the project is currently working in and also to the other potential clusters across the country.

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CII Team



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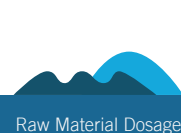


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List of Abbreviations

AC	Alternating Current
APFC	Automatic Power Factor Controller
BEE	Bureau of Energy Efficiency
BLDC	Brushless Direct Current
bn	billion
CAGR	Compound Annual Growth Rate
CFD	Computational Fluid Dynamics
CII	Confederation of Indian Industry
DC	Direct Current
DPR	Detailed Project Report
EE	Energy Efficient
EUR	Euro
GCRT	Grid Connected Roof top
GCV	Gross Calorific Value
GEF	Global Environment Facility
GHG	Greenhouse Gas
GI	Galvanized Iron
HDPE	High Density Poly Ethylene
HHO	Hydroxy gas
INR	Indian Rupee
IoT	Internet of Things
ISO	International Standards Organization
LED	Light Emitting Diode
LSP	Local Service Provider
LT	Low Tension
MNRE	Ministry of New and Renewable Energy
mn	million
MPPT	Maximum Power Point Tracker
MSM	Million Square Metre
MSME	Micro, Small and Medium Enterprises



NG	Natural Gas
O&M	Operation and Maintenance
OEM	Original Equipment Manufacturer
PCU	Power Conditioning Unit
PF	Power Factor
PID	Proportional Integral Derivative
PLC	Programmable Logic Controller
PMU	Project Management Unit
PNG	Piped Natural Gas
PV	Photovoltaic
RE	Renewable Energy
SEC	Specific Energy Consumption
SME	Small and Medium Enterprise
SPV	Solar Photo Voltaic
TOE	Tons of Oil Equivalent
TDS	Total Dissolved Solids
UNIDO	United Nations Industrial Development Organization
UOM	Unit of Measurement
VFD	Variable Frequency Drive
WHR	Waste Heat Recovery



Unit of Measurement

CFM	Cubic Feet per Minute
°C	Degree Celsius
hp	Horsepower
INR	Indian Rupee
kg	Kilogram
kg/cm ²	Kilogram Force per Square Centimetre
kCal	Kilocalorie
km	Kilometre
kVA	kilo-volt-ampere (apparent power)
kVA _r	kilovolt-ampere-reactive (reactive power)
kW	Kilo Watt
kWh	Kilo Watt Hour
kWp	Kilo Watt Peak
LPM	Litre per minute
m	Metre
m ²	Square metre
MT	Metric Ton
mmWc	Millimetres water column
m ³ /hr	Cubic metre per hour
m ³ /min	Cubic metre per minute
m/s	Metre per second
ppm	Parts per million
SCM	Standard Cubic Metre
TCO ₂	Tonne of Carbon dioxide
TOE	Tonne of Oil Equivalent
TPD	Tonne Per Day



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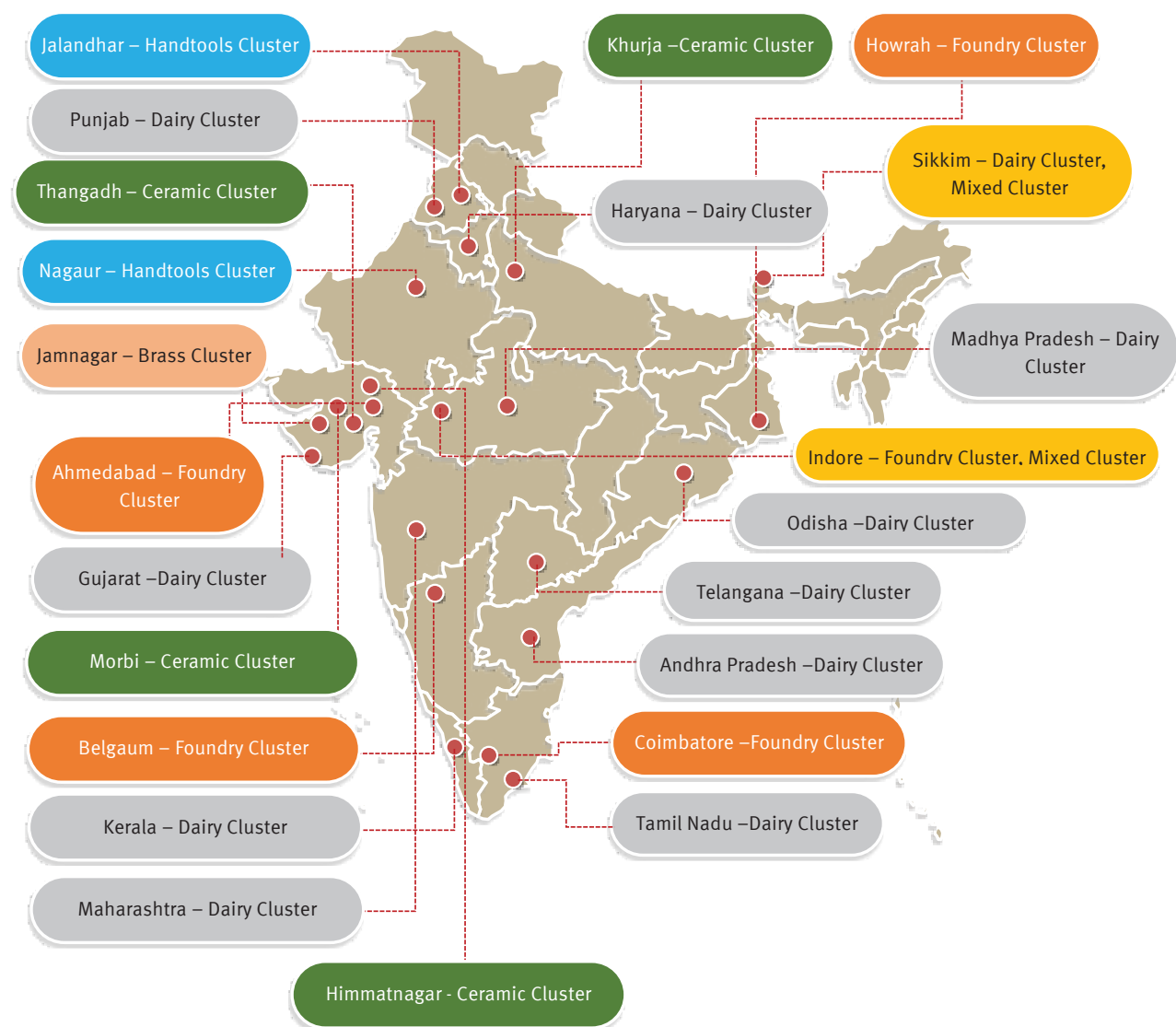


About Project & Technology Compendium

About the Project

The United Nations Industrial Development Organization (UNIDO), in collaboration with the Bureau of Energy Efficiency (BEE), a statutory body under the Ministry of Power, Government of India, is executing a Global Environment Facility (GEF) funded national project titled ‘Promoting energy efficiency and renewable energy in selected MSME clusters in India’. The project was operational in 12 MSME clusters across India in five sectors, respectively: Brass (Jamnagar); Ceramics (Khurja, Thangadh and Morbi); Dairy (Gujarat, Sikkim and Kerala); Foundry (Belgaum, Coimbatore and Indore); Hand Tools (Jalandhar and Nagaur). The Project has now scaled-up and expanded its activities to 11 new clusters, namely in Dairy (Tamil Nadu, Odisha, Madhya Pradesh, Andhra Pradesh & Telangana, Haryana, Maharashtra & Punjab), Foundry (Ahmedabad & Howrah), Ceramic (Himmatnagar) Mixed Cluster (Indore & Sikkim) in order to reach out to MSME’s at national level.

This project so far has supported 303 MSME units in implementing 603 Energy conservation Measures and thus resulted in reduction of about 10,850 TOE energy consumption and avoided 62,868 metric tons of CO₂ emissions as on date.



The key components of the project include:

- ❖ Increasing capacity of suppliers of EE/RE product suppliers / service providers / finance providers
- ❖ Increasing the level of end user demand and implementation of EE and RE technologies and practices by MSMEs.
- ❖ Scaling up of the project to more clusters across India.
- ❖ Strengthening policy, institutional and decision-making frameworks.
- ❖ Significant progress has been made in the project and it is now proposed to scale up and expand. The activities envisaged under the scaling up phase of the project include:
 - ✧ Establishment of field level Project Management Cell (PMC)
 - ✧ Organizing cluster level awareness program and identification of potential MSME enterprises
 - ✧ Development of cluster specific EE and RE based technology compendiums
 - ✧ Providing implementation support and other related activities to the identified enterprises



About the Technology Compendium

The Ceramic industry in India is about 100 years old. It comprises ceramic tiles, sanitaryware and crockery items. Ceramic products are manufactured both in the large and small-scale sector with wide variation in type, size, quality and standard. Though there are many large companies in the ceramics sector, small and medium enterprises (SMEs) account for more than 50% of the total market in India.

The SME players in ceramic sector today face challenges and opportunities resulting from rising energy cost, environmental concerns and competitiveness. The increase in the price of raw materials and fuel increases the total cost of production, which in turn, hampers the profit margin of the manufacturers. The energy consumption is a significant component in the cost structure of almost any manufacturing/ production activity. Adopting energy efficient technologies curtails the cost of energy, thereby reducing production cost and increasing competitiveness.

This technology compendium is prepared with the objective to accelerate the adoption of energy efficient technologies and practices in sanitaryware manufacturing units in Thanagdh cluster. It focuses on equipment upgrades, new technologies and best practices for improving energy efficiency. The case studies included in the compendium provide all the necessary information to enable ceramic units to implement it in their operations. The case studies are supported with technology background, baseline scenario, merits, challenges, technical feasibility, financial feasibility and technology provider details. The energy efficiency measures included in the report cover more than 90% of energy consumption in a ceramic unit.

The thermal energy accounts for 80-90% of the total energy consumption. Tunnel kilns are the major source of fuel consumption. The electricity is mainly used for raw material preparation (ball mills drive, slurry transfer, etc.), blowers in kiln, pumps and compressors. Over the years, there has been significant technological improvement in the process and utilities area and the sanitaryware units in Thangadh have been able to improve energy efficiency in their operations. However, various opportunities still exist for ceramic units to improve their energy efficiency. To be competitive and have environment friendly operations, energy efficiency is critical.

- ❖ The objective of this compendium is to act as a catalyst to facilitate units towards continuously improving the energy performance, thereby achieving world class levels (with a thrust on energy & environmental management).
- ❖ The compendium includes general energy efficiency options as well specific case studies on applicable technology upgradation project which can result in significant energy efficiency improvements.
- ❖ The suggested best practices may be considered for implementation only after detailed evaluation and fine-tuning requirements of existing units.
- ❖ From the wide spectrum of technologies and equipment applicable for sanitaryware manufacturing units for energy efficiency, it is difficult to include all the energy conservation



aspects in this manual. However, an attempt has been made to include the more common and implementable technologies across all the ceramic units.

- ❖ The user of the compendium has to fine-tune the energy efficiency measures suggested in the compendium to their specific unit requirements, to achieve maximum benefits.
- ❖ The technologies collated in the compendium may not necessarily be the ultimate solution, as energy efficiency through technology upgradation is a continuous process and will eventually move towards better efficiency with advancement in technology.
- ❖ The ceramic industry in Thangadh should view this manual positively and utilize this opportunity to implement the best operating practices and energy saving ideas during design and operations stages and thus work towards achieving world class energy efficiency.



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Executive Summary



Executive Summary

The United Nations Industrial Development Organization (UNIDO), in collaboration with the Bureau of Energy Efficiency (BEE), a statutory body under the Ministry of Power, Government of India, is executing a Global Environment Facility (GEF) funded national project called ‘Promoting energy efficiency and renewable energy in selected MSME clusters in India’. The project execution is planned in multiple phases. The aim of the Phase-I of the project was to develop and promote a market environment for introducing energy efficiency and enhanced use of renewable energy technologies in process applications in the selected (12) energy-intensive MSME clusters in India, with feasibility for expansion to more clusters. Phase-II of the project is to scale up and expand the project activities to a greater number of enterprises in existing clusters, as well as 11 new clusters, for better implementation of energy efficiency technologies and practices.

Efficient use of energy in any facility is invariably the most important strategic area for manageability of cost or potential cost savings. Awareness of the personnel, especially of operators in the facility becomes a significant factor for the proper implementation of energy conservation initiatives. With this context, this Technology Compendium has been prepared, which comprises various technologies and best practices to save energy.

The information in this compendium is intended to help the ceramic units in Thangadh ceramic cluster to reduce energy consumption in a cost-effective manner while maintaining the quality of products manufactured. Further analysis on the economics of all measures, as well as on their applicability to different production practices is needed to assess their cost effectiveness at individual ceramic units. Further, this shall also serve as a guide for estimating the feasibility of energy saving project at the first place and ensure accelerated implementation.

Chapter 1 of the compendium provides an overview of Indian Ceramic Industry and Thangadh Ceramic cluster.

Chapter 2 focuses on a brief overview of the sanitaryware process and energy consumption in ceramic units and also includes technology status/mapping of the Thangadh ceramic cluster.

Chapter 3 focuses on the importance of energy efficiency in ceramic industry and some of the common measures applicable in different sections of the ceramic unit. The energy efficiency measures are included for more than 90% of energy consumption areas in a sanitaryware manufacturing unit, such as raw material preparation, mould preparation, slurry transfer, kiln, utilities and utilization of renewable energy. The chapter also includes some of the best practices.

Chapter 4 provides detailed case studies for some of high impact and implementable energy efficient technologies in sanitaryware units. In this chapter, 26 case studies have been included in areas such as raw material preparation, slurry transfer, mould preparation, kilns, utilities, renewable energy, etc. These technologies are described in detail, such as baseline scenario, proposed scenario, merits, demerits, etc., and wherever possible a case reference from a ceramic unit that has implemented the technology has been included. In most of the examples, typical energy saving data, GHG emission reduction, investments, payback period,



etc., have been highlighted. Energy saving potential in this sector is estimated to be about 10-15%. High potential for improving energy efficiency in sanitaryware units exists in the kilns via excess air control system in kiln, reduction in radiation losses, low thermal mass kiln cars, blunger in place of ball mill, high alumina balls in ball mills, installation of energy efficient pumps, blowers, solar PV system, etc.

The following table summarizes the list of technologies included in the compendium:

Table 1: List of Technologies

Sr. No.	Technologies	Investment (INR Lakh)/ TOE	Payback (months)
Kiln			
1	Waste Heat recovery in tunnel kiln	0.40	14
2	Energy efficient coating to reduce the radiation losses in kiln and reduce fuel consumption	0.45	12
3	Low thermal mass for reduction of kiln car losses in sanitaryware units	0.35	13
4	Improvement of kiln insulation to reduce radiation losses	1.12	40
5	Excess air control system to maintain optimum air-to- fuel ratio in Kiln	0.67	24
Raw Material Blending			
6	Reduction in ball mill power by installation of VFD on ball mill drive	1.09	18
7	High speed blunger in place of ball mill	1.40	23
8	High alumina media in glaze ball mill in the place natural stone/ pebbles	1.55	23
Utilities			
9	Installation of VFD in screw compressor to avoid unloading	0.63	11
10	Installation screw compressor with VFD in place of inefficient reciprocating compressor	1.86	29
11	Energy conservation in compressor by modifying airline system	1.09	15
12	Installation of energy efficient ceiling fans in place of conventional fans.	1.08	16
13	Installation of energy efficient pumps	5.33	84
14	Transvector nozzle in compressed air hose pipe for mould cleaning application	0.67	11
15	Installation of energy efficient motors in place of old rewinded motors in ball mill	3.53	38
16	Maximum demand controller for avoiding excess contract demand penalty	--	12
17	Power factor correction & harmonic mitigation at main LT incomer	--	11
18	Installation of VFD on agitator motor	1.27	20
19	Installation of on-off controller system in agitator motor	0.22	4



Sr. No.	Technologies	Investment (INR Lakh)/ TOE	Payback (months)
20	Installation of energy efficient motor in place of existing conventional motors in agitator system	3.00	48
Renewable Energy			
21	Solar rooftop system	2.68	40
New & Innovative Technologies			
22	Solar-Wind hybrid system	5.30	84
23	Energy efficiency in ceramic kiln through utilization of HHO Gas	0.77	28
24	Installation of Energy Efficient burners in place existing old conventional burner in kiln firing	0.82	30
25	Optimization of water consumption by installation of water softener plant	-	-
26	Installation of Energy Management System	0.34	10



A photograph of a white clawfoot bathtub in a bathroom. The bathtub is the central focus, set on a checkered tile floor. The background shows a wall with large, light-colored tiles and a dark wooden beam. A semi-transparent blue overlay covers the middle of the image, with the text 'Indian Ceramic Industry' centered on it. The overlay also features a decorative border of geometric shapes.

Indian Ceramic Industry

1. Indian Ceramic Industry

1.1. Background

The Indian ceramic industry contributes considerably to India's economic progress. With growing urbanization and increasing use of ceramic tiles and sanitaryware in the Indian construction sector, the industry is expected to grow further at an increased rate. Indian ceramic industry is dominated by the ceramic tiles industry. In 2017, India strengthened its position as the world's 2nd largest tile producer and consumer country, accounting for 7.97% (1,080 million sqm)¹ of the global production. Though there are several large companies in the ceramics sector, small and medium enterprises (SMEs) account for more than 50% of the total market in India. Gujarat accounts for 70 per cent of the total output.

Table 2: Top 5 Ceramic Tile Manufacturing Countries of the world (in MSM)

Country	2015	2016	2017	% of world production in 2017
China	5,970	6,495	6,400	47.23
India	850	955	1,080	7.97
Brazil	899	792	790	5.83
Vietnam	440	485	560	4.13
Spain	440	492	530	3.91
Total world	12,460	13,255	13,552	100

MSM: Million Square Meter

Morbi, a small industrial town near Rajkot, is the second largest tiles manufacturing cluster in the world, and accounts for 90% of total production of ceramic products in India. Himatnagar, a town near Ahmedabad also a few major tile manufacturing units.

With an installed capacity of more than 40 million pieces/year, India is the world's second largest sanitaryware producer after China. The rapid growth in sanitaryware production has been concentrated in Morbi & Thangadh in Gujarat.

Khurja, a small town in Uttar Pradesh and Naroda in Ahmedabad, manufactures pottery wares.

¹ Ceramic world review



The share of ceramic product in India is shown below:

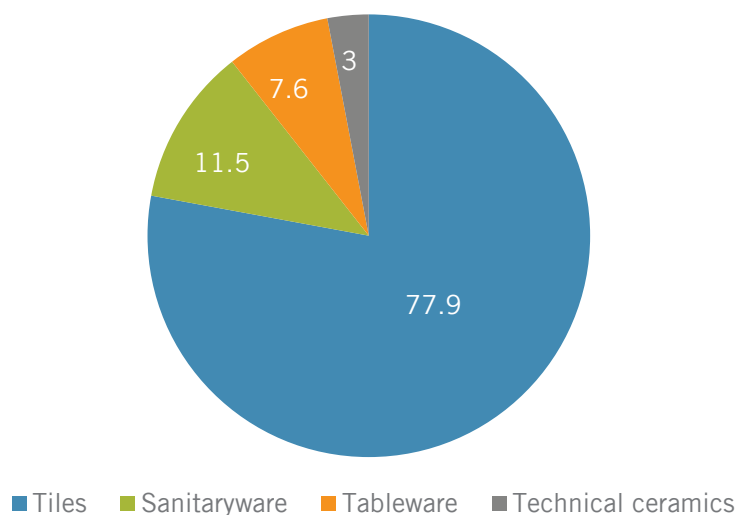


Figure 1: Ceramic Product Market Share (2017)

The SME ceramic industry has developed in clusters in Morbi, Thangadh and Ahmedabad in Gujarat and in Khurja in Uttar Pradesh. Morbi cluster produces mostly tiles and sanitaryware products; Thangadh cluster produces sanitaryware; Khurja cluster produces crockery and electrical insulators; Naroda in Ahmedabad produces crockery items and Himmatnagar in Ahmedabad produces mostly tiles and crockery items. The table below lists the clusters, no. of ceramic units in each cluster and their major products.

Table 3: Cluster Level Details

Location	Products	No. of units (approx.)
Morbi	Ceramic tiles (major product), Sanitaryware, technical & industrial ceramics	700
Thangadh	Sanitaryware (major product), Refractories	160
Himatnagar	Wall & floor tiles	21
Naroda	Crockery	23
Khurja	Crockery, electrical insulators	220

Indian sanitary basic segment is dominated by unorganized players whereas standard, premium and luxury segments are dominated by organized players. Pottery ware signifying crockery and tableware are largely unorganized.

Ceramics industry is a highly energy-intensive industry. After raw materials, electricity and fuel cost is the second largest cost element in the total cost of production. The energy cost accounts for 25-30% of the total production cost. According to the estimates, 10-20% of energy saving is possible in the ceramic units by adoption of latest energy efficient technology, process, best practices, etc.

⁴ Indian Council of Ceramic Tiles and Sanitaryware (ICCTAS) report



1.2. Ceramic Sector Growth Prospects

The key driver for the ceramic products in India is the boom in the housing sector coupled with encouraging government policies that have been fuelling strong growth in the housing sector. The Government's focus on infrastructure development is expected to result in driving demand further for Indian ceramics, sanitaryware and bathroom fittings industry. With many new projects lined up in the country, the construction sector is growing at an approximate rate of 7-8%. The demand for industrial ceramic products such as ceramic tiles, sanitaryware and pipes required in construction applications too is expected to increase.

Indian ceramic industry is dominated by ceramic tiles industry, with a market of 4.9 bn EUR in 2017; the overall ceramic industry is expected to grow at 9% CAGR to become worth 7.5 bn EUR by 2022⁵. Indian sanitaryware market is estimated to be 560 mn EUR in 2017. The basic segment is dominated by unorganized players whereas the standard, premium and luxury segments are dominated by organized players.

Ceramic product manufacturers face challenges due to the rise in the cost of production, which, in turn, hampers the profit margin of the manufacturers. The increase in the price of raw materials such as zirconium and titanium and fuel such as compressed natural gas (CNG), which constitute 30% of the input cost for manufacturing ceramic tiles, increases the total cost of production.

Thangadh Ceramic Cluster

Thangadh, located in Surendranagar district of Gujarat, lies at a distance of 160 km from Ahmedabad. The cluster is older than Morbi. The units here primarily manufacture sanitaryware products. Thangadh cluster is renowned for affordable sanitaryware. Thangadh has about 160 ceramic units manufacturing sanitaryware products, pottery and art tiles. Raw materials used include clay, which is locally available, stone and quartz (from various parts of Rajasthan and Gujarat).

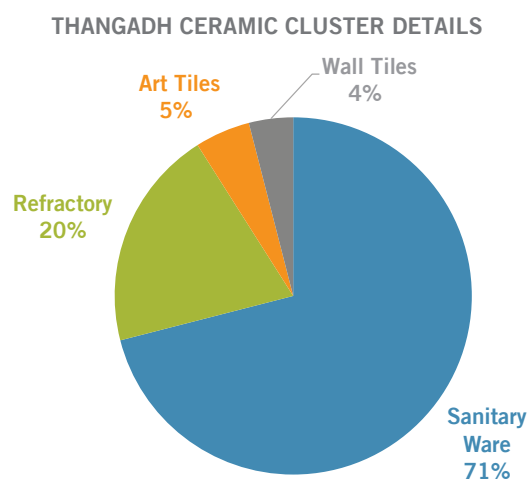


Figure 2: Thangadh Ceramic cluster details

⁵ Status Quo and Outlook 2022: Indian Ceramics Industry, Market study by EAC International Consulting on behalf of Messe Muenchen India, March 2018



The units market their products all across the country. Some of the units export their product overseas, mainly to Middle East, Italy, Europe, African countries. Some of the units have put systems in place to maintain product quality standards required for exporting products.

Panchal Ceramic Association Vikas Trust, an association of ceramic units in Thangadh, is providing support to the ceramic units in Thangadh for improving the product quality and energy efficiency. The association also organizes cluster-level events for the ceramic units.

The main equipment used in production of sanitaryware in Thangadh cluster are ball mills and tunnel kiln. The fuel used in the kiln is PNG. The energy cost accounts for 25-30% of the production cost.



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Manufacturing Process & Energy Consumption

2. Manufacturing process and Energy Consumption

2.1. Ceramic Product Value Chain

The following figure indicates the value chain of ceramic manufacturing industry, from raw materials to final products (end use).

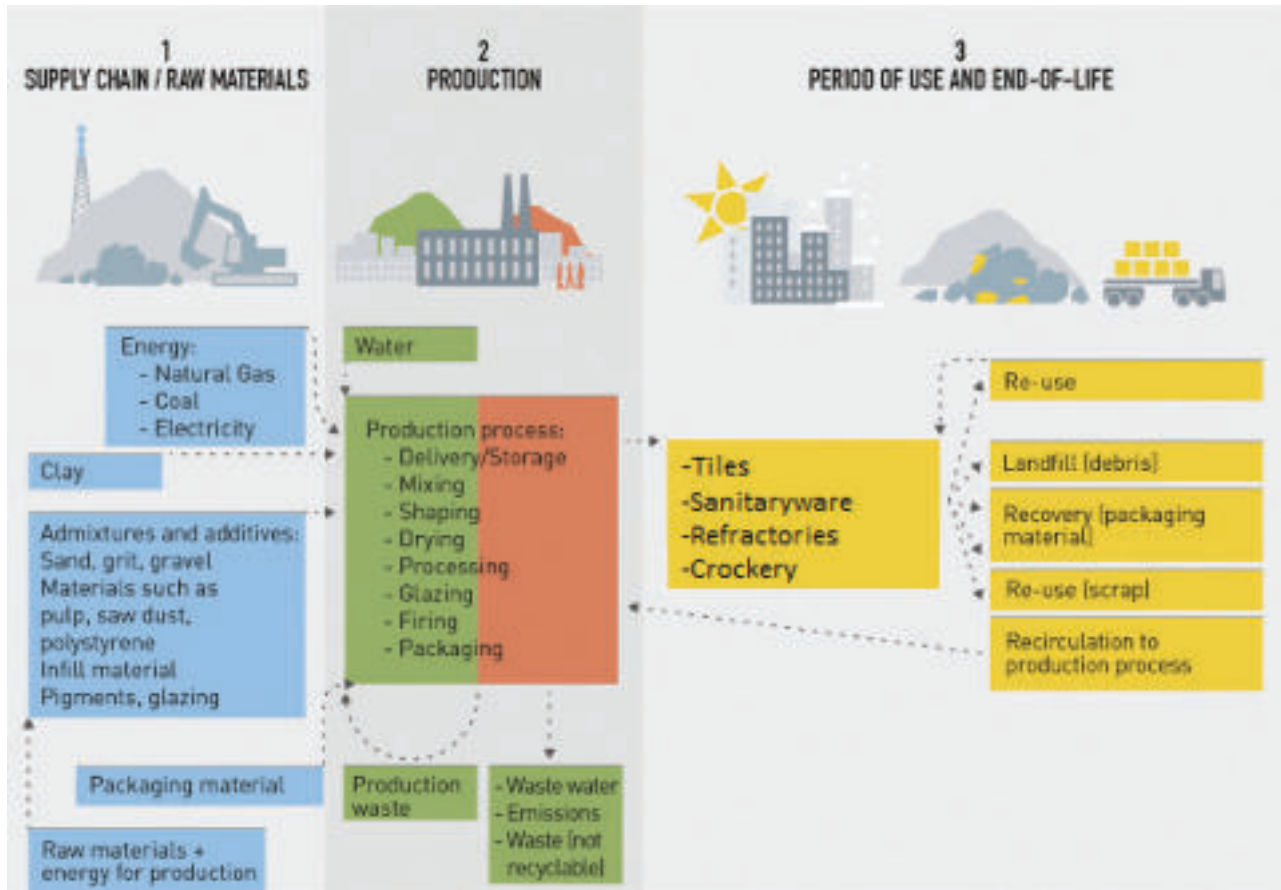


Figure 3: Ceramic Manufacturing Process Value Chain

The major operations in ceramic manufacturing process is described below:

i) Raw Materials: This includes the raw materials and energy used for production.

a. Raw material for production:

Most of the units in Thangadh cluster manufacture traditional clay based ceramic products.

- i. From the available local than clay in Thangadh, wanker and nearby local areas.
- ii. Quartz, flint, feldspar, aluminium silicates, frits and glazes in Gujarat and in the neighbouring state of Rajasthan.

b. Energy for production: Ceramic manufacturing units use both electrical energy and thermal energy for production. Electrical energy constitutes 10-15% of the overall energy consumption and main areas of usage are in kiln, ball mills, pump and compressor. Major amount of thermal energy is used as liquid fuel firing (Natural gas)



in kiln firing and drying.

Energy consumption ranges:

- i. Electrical energy: 20,000 to 30,000 kWh/Month.
- ii. Kiln gas consumption: 110-120 SCM/Tonne.

ii) Production Process:

Ceramic Sanitaryware production process involves the blending (ball mill & slurry handling), mould preparation, drying (cast house), glazing, firing, quality inspection and dispatch. Detailed process is explained in section 2.2.

iii) Final Products usage:

The products are used in building, infrastructures, sanitation and other construction sector.



2.2. Overview: Process Flow in Ceramic Sanitaryware Production

Thangadh ceramic cluster comprises industries majorly manufacturing a variety of sanitaryware, followed by pottery and refractory production. The main difference between the sanitaryware and pottery production is the process of shaping products.



Figure 4: Ceramic Sanitaryware Manufacturing Process Flow

Ceramic sanitaryware manufacturing:

There are various types of sanitaryware available in the market, with mostly a common process of production as shown below.

Raw material blending

Ball mills or blungers are used for raw material grinding. Raw materials such as china clay, bole clay, than clay, talc, potash, feldspar and quartz are mixed with water in proper proportion and grinded in a ball mill to form a homogenous mixture, i.e., slurry. Ball mills have pebbles and inner lining; depending on raw material quality and quantity the blending time varies, hence, ball mills are operated in batch process.

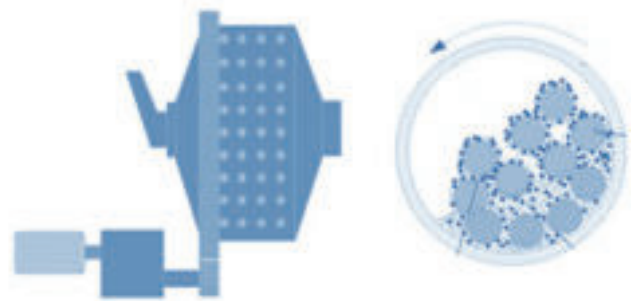


Figure 5: Raw Material Blending (Wet ball milling)



Figure 6: Slip agitation and storage

are prepared as per the requirement of shape and size casting. The case mould is made in the moulding section by mixing of water with Plaster of Paris in a proper proportion. Once the mould is prepared, it will be dried to remove the excess water from the mould. This stage is crucial to increase the life of the mould.

Slurry Agitation and transfer system: After completion of wet grinding in ball mills, the slurry is stored in the underground tanks fitted with agitator motor in each tank, for continuous mixing to maintain uniformity and avoid settling of solid particle. Slurry is then pumped to mould through a slurry transfer pump.

Mould Preparation: In this section the moulds



Figure 7: Mould Preparation



Figure 8: Cast House

Casting: Sanitaryware has different types of casting like normal bench casting, beam casting, low-pressure casting and high-pressure. The slip is poured into the mould and allowed to form the casting layer on the mould. A drain hole is provided for draining excess slip and casted ware is allowed to dried. Casting is removed from the mould. In this stage, the ware known as greenware. This greenware is allowed to dry in atmospheric temperature for 5-7 days in natural drying using the ceiling fans.



Figure 9: Glazing

Glazing: Glaze is separately prepared form Glaze ball mill by grinding the following components silica, alkalis, lead boron, zirconium, iron, chromium and cobalt; and stored in storage tanks. The sanitaryware dried from the casting section enters glazing section; around 1 mm thickness glaze is sprayed on the ware. After glazing, sprayed ware is loaded in kiln car for firing.

Kiln Firing:

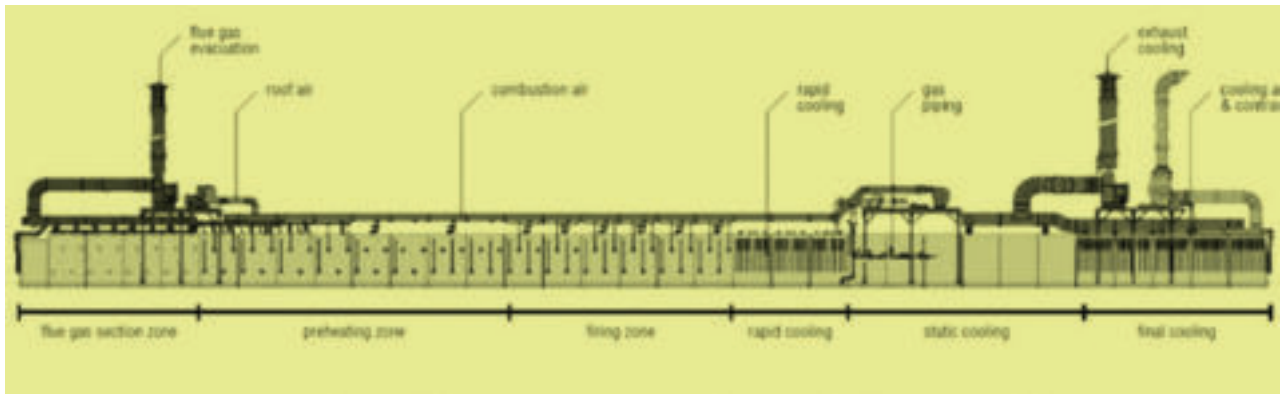


Figure 10: Tunnel Kiln firing

After glazing, dust and other impurities are removed from the ware through blowing air, then the kiln car with wares is sent to tunnel kiln for firing. In preheating zone, mechanically and chemically combined water has been removed from the ware. At firing zone, at $1,250^{\circ}\text{C}$, all the raw material are fused together and glaze is fused evenly. In the cooling zone, sudden cooling is done to create a glossy surface. After firing, the wares are sent to quality inspection.

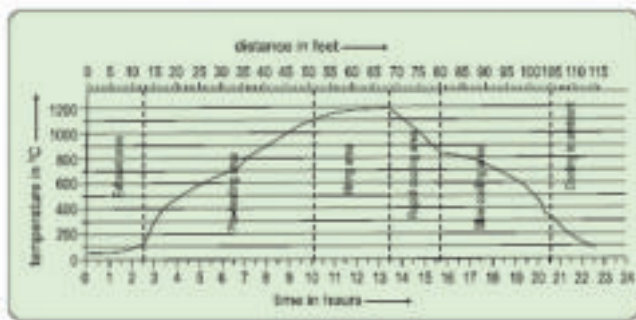


Figure 11: Firing Cycle

The kiln firing is done in two stages:

- 1) Preheating zone ($500-750^{\circ}\text{C}$).
- 2) Firing zone ($1,100-1,250^{\circ}\text{C}$).

After firing, tiles are cooled in two zones:

- 1) Rapid cooling zone ($600-900^{\circ}\text{C}$).
- 2) Cooling zone ($200-500^{\circ}\text{C}$).

Quality Inspection:

In this stage of the process, all wares from the kiln are inspected and sorted according to the defects. If ware is defect-free, it will be sent to the packing section for packing.

Packing:

It is the final stage of the sanitaryware manufacturing/production process. All sanitaryware that pass quality standards are packed and dispatched to the warehouse.

2.3. Energy Consumption in Sanitaryware Manufacturing Units

The sanitaryware industry uses energy in the form of thermal for kiln firing and electricity for process and utilities. The cost of energy sources used in the industry is increasing continuously, which in turn increases the processing expenses and, therefore, the product cost. Energy costs typically constitute 30-40% of the overall manufacturing cost. Following table provides an overview of major energy consuming areas within a sanitaryware unit:

Table 4: Energy Consumption Overview for Sanitaryware unit

S No.	Equipment	Process Requirement	Primary Energy
1	Ball mill	Grinding	Electricity
2	Pumps	Slurry transfer	Electricity
3	Ceiling fans and Compressed air	Casting	Electricity
4	Ball mill and Compressed	Glaze preparation	Electricity
5	Tunnel kiln	Firing	NG

Energy consumption of sanitaryware unit depends on capacity of tunnel kiln and the level of automation in tunnel kiln and ball mills. The industry uses energy in the form of fuel for kiln firing and electricity for process and utilities. The cost of energy sources used in the industry is increasing continuously, which in turn increases the processing expenses and therefore the product cost.

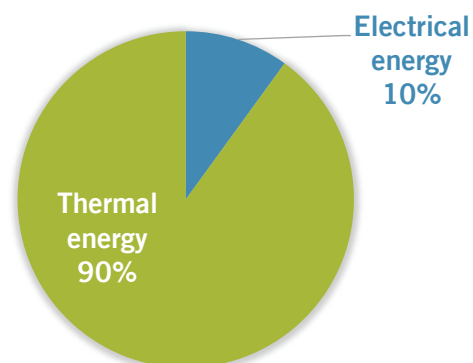


Figure 12: Energy Cost Breakup

The major portion of energy consumption in a typical sanitaryware goes to the use of natural gas for firing in tunnel kiln. A certain portion of energy consumption goes to the blending and other utilities. The major energy consuming equipment includes tunnel kiln firing, ball mills, air compressors, lightings, pumps, motor and ceiling fans. The figure below highlights the overall energy balance of a unit.

About 90% of the total energy is consumed in kiln firing and 10% is consumed in blending, which includes ball mills and slip agitation, while the remaining energy is consumed in other supporting activities such as slip transfer pumps, ceiling fans in cast house, utilities and packing.



Energy Balance in Sanitaryware Unit

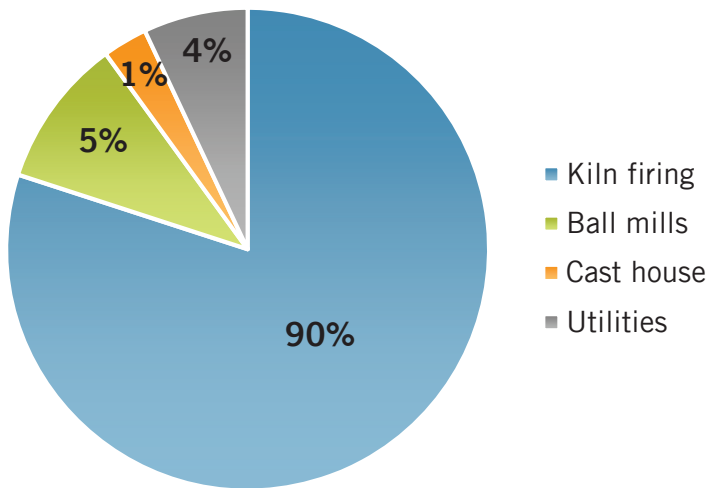


Figure 13: Energy Balance of a Sanitaryware Unit

Sanitaryware manufacturing units in Thangadh have seen significant improvement in energy efficiency and productivity in the past few years due to increased levels of automation and technology development. This has helped in improving product quality and operating conditions while reducing product losses, maintenance time, manpower requirement and energy consumption. Innovations like high alumina lining/alumina balls for grinding in ball mills, low thermal mass in kiln car, etc. have helped immensely. The units have implemented BLDC energy efficient ceiling fans in cast house, VFD in screw compressor, solar roof top, energy efficient compressors and LED lighting, all of which have led to a conservation of energy as well as improvement in operating conditions.

Sanitaryware manufacturing units in Thangadh have seen significant improvement in energy efficiency and productivity in the past few years due to increased levels of automation and technology development. This has helped in improving product quality and operating conditions while reducing product losses, maintenance time, manpower requirement and energy consumption. Innovations like high alumina lining/alumina balls for grinding in ball mills, low thermal mass in kiln car, etc.



2.4. Technology Status in Thangadh Ceramic Cluster

The sanitaryware units in Thangadh have been mostly established during the period of 1980-1990 and have expanded over time with upgradation of equipment and technologies, expansion and automation & process control. Many of the units have also adopted latest technologies in kiln firing and other important areas.

Following is the technology status for the units in Thangadh Ceramic sector:

Table 5: Technology Status – Thangadh Ceramic Cluster

Sr. No	Area	Current Status
1	Energy Sources	Thermal energy accounts for 80 to 90% of total energy use in ceramic units.
		Electrical Energy – The units procure electricity from distribution companies in Gujarat (depending on region) and pay in the range of INR 6-8/kWh.
		Thermal energy is mostly met through natural gas. In Gujarat, the natural gas is available through city/industrial gas distribution network. In sanitaryware manufacturing units, natural gas is used for tunnel kiln firing.
2	Kiln Firing	The sanitaryware manufacturing units in Thangadh use continuous firing techniques in tunnel kiln at 1,250°C.
		Many of the units have upgraded tunnel kiln and have incorporated various energy conservation measures such as excess air control, automation, low thermal mass in kiln car, etc.
		However, not all the units use Waste Heat Recovery and energy efficient burners and it presents a good opportunity for energy saving.
3	Blending	Units use ball mills to blend the raw material and prepare slurry. Many units have installed VFD on ball mills and some units have changed inner lining and grinding balls with alumina.
		However, not many units have implemented blunger technology in place of ball mills and there is a lot of potential for energy saving through blunger technology implementation.
4	Slurry Transfer system	The slurry is transferred from slurry collection tank to casting house using the electro mechanical driven pump. At present, units are using local slurry pumps, leaving a potential for implementation of energy efficient slurry pumps.
5	Cast house	Castings that are made from mould are dried under natural air through ceiling fans. At present, most of the units have implemented the energy efficient BLDC fans and achieved a good amount of energy savings.
6	Renewable Energy	At present, units of Thangadh ceramic cluster have utilized the option of the renewable energy for meeting their partial electrical demand. A total of 26 ceramic units have installed 50 kWp rooftop systems and there's good potential for solar PV installation in other units.
7	Others	The other equipment and technologies to support process are pumping, electrical distribution, compressed air systems and others.



Sr. No	Area	Current Status
7a	Pumps	The pumps are installed for water and slurry transfer. The efficiency of the pumps needs to be evaluated as many pumps are old. There is a good scope for improvement by avoiding throttling (installation of VFD, trimming of impeller) or by installation of high efficiency pumps (more than 70% efficiency).
7b	Electrical Distribution	Most of the units have installed APFC for power factor improvement. However, there are certain opportunities which units can be tapped in electrical distribution, such as installation of energy efficient transformers, optimal loading of transformers, installation of energy efficient motors, installation of VFD, soft starters, auto star delta conversion, power quality, etc.
7c	Compressed Air	Compressed air in units is used for instrument application, mould preparation and glazing. Few units are using screw compressor and have installed VFD to avoid unloading. However, there are certain opportunities which units can tap in compressed air distribution and utilization, such as aluminium piping for leakage reduction, transvector nozzle in cleaning applications, etc.



Energy Efficiency Opportunities

3. Energy Efficiency Opportunities

3.1. Energy Efficiency in Sanitaryware

The sanitaryware manufacturing operations are highly energy intensive as the wares are fired in tunnel kiln. The kiln firing and raw material blending are critical and energy consuming areas for any sanitaryware manufacturing unit and improving energy efficiency in these areas is critical.

Over the years, there has been significant technology improvement in process and utilities area and units have been able to improve the energy efficiency in their operations. However, various opportunities exist for units to improve their energy efficiency further and to be competitive and have environment-friendly operations; energy efficiency is critical to achieve these goals.

The sanitaryware manufacturing units have been implementing various energy conservation measures across various production process. The energy efficiency at a unit can be viewed at two levels – equipment & component level and process level. The energy efficiency at equipment or component level can be achieved by adopting various new technologies, preventive maintenance, optimum utilization, or replacement of old equipment with new and energy efficiency equipment. In addition to improving energy efficiency at equipment or component level, the Thangadh ceramic cluster has made significant improvements in process level efficiency through various energy conservation measures such as automation, process control & optimization, process integration or implementation of new and efficient process.

Often, energy efficiency measures when implemented at the unit operations, not only result in improvement in energy efficiency but also in productivity and quality improvement as well. To summarize, the energy efficiency strategy can be focused at three levels:

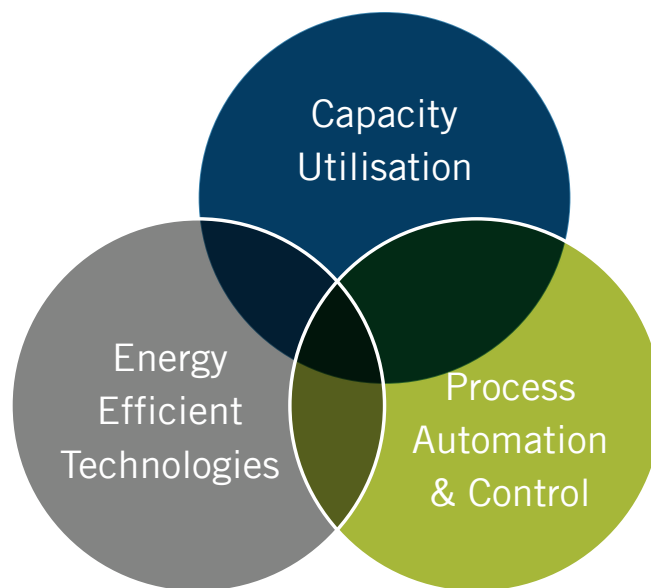


Figure 14: Energy Efficiency Approach – Thangadh Ceramic industry



3.2. Energy Efficiency Measures

There are various energy consuming areas within a sanitaryware manufacturing unit. Thermal energy is used for kiln firing, raw material blending in ball mill, utilities and other process of the unit. Following figure provides an overview of energy usage in a sanitaryware unit:

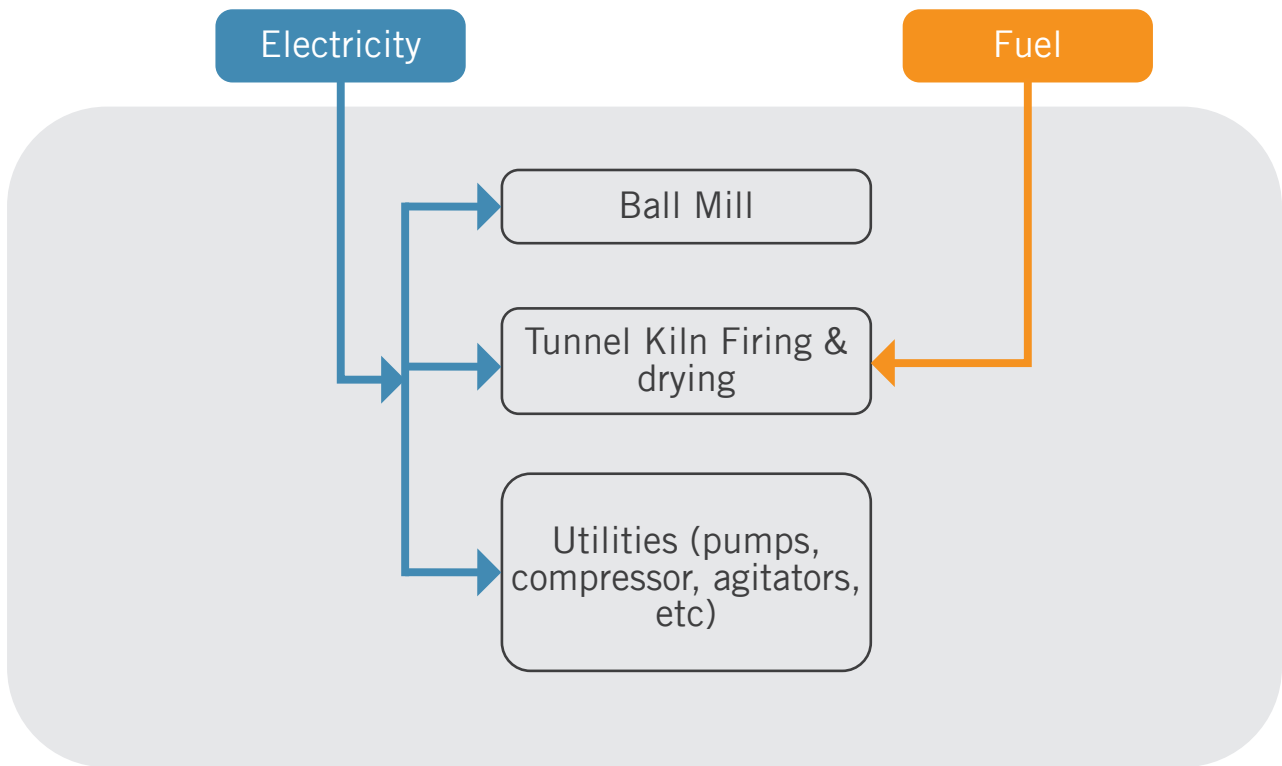


Figure 15: Sanitaryware manufacturing unit – Energy usage area

The following section provides an overview of some of the key energy efficiency measures in the major energy consuming areas in a ceramic sanitaryware unit and in further sections, some of the latest applicable technologies are covered.



3.2.1. Energy Efficiency in Tunnel Kiln firing

Kiln firing is energy intensive and an important process as raw casting in sanitaryware are required to be fired at 1,250°C for fusion of raw materials. The energy efficiency in kiln is an important area as in any ceramic manufacturing unit it accounts for approximately 80-85% of the total energy cost. Following are some of the key energy conservation measures in tunnel kiln firing and insulation system:

Table 6: Energy efficiency measures in kiln

Energy Efficiency in Kiln	
Firing	
❖ Use of energy efficient burner	❖ Recuperation (Use of heat hot air from cooling zone as combustion air)
❖ Excess air control system	❖ Kiln automation & control
❖ Maintaining adequate kiln temperature	❖ Maintaining adequate kiln draft
Heat Losses reduction	
❖ Improved insulation	❖ Low thermal mass in kiln car
❖ Proper kiln maintenance	❖ Waste heat recovery from exhaust flue gas
❖ Energy efficient coating for reduction of radiation loss from kiln	❖ Energy efficient combustion and rapid cooling blowers
❖ VFD on kiln combustion blowers	
Management Systems	
❖ Effective monitoring of key parameters (Fuel consumption, production, energy)	❖ Root cause analysis



3.2.2. Energy Efficiency in Raw Material Preparation Process

Sanitaryware manufacturing process involves blending of raw materials to form slurry, slurry storage and transfer system, coating house for shaping and glazing section. Some of the possible energy efficiency measures in process areas in sanitaryware unit are highlighted in the table below.

Table 7: Energy efficiency in raw material preparation process

Energy Efficiency in Blending Systems (Ball mills)	
Blending (Ball mills)	
❖ Maintaining the adequate media size and composition	❖ Operating the ball mill at 65%–75% of critical speed
❖ Alumina lining inside the mill	❖ High alumina grinding balls
❖ Automation & control of ball mills through timer and PLC	❖ Installation of VFD on ball mill motors
❖ Energy efficient ball mill motor drive	❖ V -belt to flat cogged belt
Slurry Agitation and transfer system	
❖ Use of energy efficient agitators	❖ Energy efficient motors installation for agitation
❖ Delta to star conversion of lightly loaded motors in agitators	❖ Energy efficient slurry transfer pumps
Cast house	
❖ Use of energy efficient BLDC ceiling fans for drying the raw ware	
Others	
❖ Use of blunger technology in place of ball mill	❖ Use of solar energy for pumping



3.2.3. Energy Efficiency in Utilities

The utilities such as compressed air, electrical distribution systems, lighting and other areas are also energy consuming sections in a sanitaryware manufacturing unit and here too, several energy efficiency improvement opportunities are available. Following table provides an overview of possible energy efficiency opportunities in utilities areas:

Table 8: Energy efficiency in utilities

Energy Efficiency in Utilities	
Compressed Air Systems	
❖ Use of energy efficient screw compressors	❖ Transvector nozzle for cleaning purpose
❖ Optimum generation pressure	❖ Use of VFD in compressor
❖ Avoiding compressed air leakage	❖ Energy efficient air dryers
❖ Auto drain valves	❖ Proper distribution systems
❖ Pneumatic equipment to electric equipment	❖ Appropriate ventilation in compressor room
Electrical Distribution Systems	
❖ Automatic power factor controller	❖ Harmonic filters
❖ Energy efficient transformers	❖ Optimum voltage and line balance
❖ Optimum loading of transformers	❖ Energy monitoring systems
Pumps	
❖ Energy efficient pumps	❖ Trimming of impellers
❖ VFD for pumps	❖ Pumping system layout
Motors	
❖ Energy efficient motors	❖ Star to delta conversion
❖ kVAR compensators	❖ Preventive maintenance
❖ Optimum loading	❖ Belt driven to direct coupled
Lighting & Fans	
❖ Use of BLDC ceiling fans	❖ Use of LED
❖ Use of natural light (light pipe)	
Renewable Energy	
❖ Solar PV installation	❖ Hybrid solar-wind system





Energy Efficient Technologies – Case Studies

4. Energy Efficient Technologies – Case Studies

The following chapter focuses on some of the above-mentioned technologies which are promising and have been implemented in a few ceramic units and have great potential for implementation. Over the last few years, the units in Thangadh ceramic cluster have implemented a lot of energy saving measures and these measures have been replicated in most of the other units within the cluster also. These technologies are described in more detail and wherever possible, a case reference from a unit that has implemented the technology has been included. In most of the examples, typical energy saving data, Greenhouse Gas (GHG) emission reduction, investments, payback period, etc., have been highlighted. As these case studies are included to provide confidence to sanitaryware manufacturing unit to implement technologies, the applicability of these measures may vary from unit to unit and further technical and financial analysis would be required for individual units. Following case studies are mentioned in detail in the subsequent section:

Table 9: Case Studies for Thangadh ceramic cluster

Sr. No.	Technologies
Kiln	
1	Waste heat recovery in tunnel kiln
2	Energy efficient coating to reduce the radiation losses in kiln and reduce fuel consumption
3	Low thermal mass for reduction of kiln furniture losses in sanitaryware units
4	Improvement of kiln insulation in kiln to reduce radiation losses
5	Excess air control system to maintain optimum air-to-fuel ratio in Kiln
Raw Material Blending	
6	Reduction in ball mill power by installation of VFD on ball mill drive
7	High speed blunger in place of ball mill for raw material grinding process
8	High alumina media in glaze ball mill in the place natural stone/pebble
Utilities	
9	Installation of VFD in screw compressor to avoid unloading
10	Installation of screw compressor with VFD in place of reciprocating compressor
11	Energy conservation in compressor by modifying airline System
12	Retrofit of energy efficient ceiling fans in place of conventional fans
13	Energy efficient pumps
14	Transvector nozzle in compressed air hose pipe for mould cleaning application
15	Installation of energy efficient motors in place of old rewinded motors.
16	Maximum demand controller for avoiding excess contract demand penalty



Sr. No.	Technologies
17	Power factor correction & harmonic mitigation at main LT incomer
18	Installation of VFD on agitator motor
19	Installation of on-off controller system in agitator motor
20	Installation of energy efficient motor in place of existing conventional motors in agitator system
Renewable Energy	
21	Solar rooftop system
New & Innovative technologies	
22	Solar-Wind Hybrid system
23	Energy efficiency in ceramic kiln through utilization of HHO Gas
24	Installation of Energy Efficient burners in place existing old conventional burner in kiln firing
25	Optimization of water consumption by installation of water softener plant
26	Installation of Energy Management System



4.1. Case studies in ceramic kiln

4.1.1. Waste heat recovery in tunnel kiln

Baseline details

The unit has installed a tunnel kiln of 15 TPD capacity for firing sanitaryware moulds. The open flame tunnel kiln is a continuous type kiln, wherein the raw product is fed at one side and on the other side the finished product is taken out. The raw product undergoes firing and cooling cycles as it moves from the front end to the back end of the kiln. Kiln performance is directly related to the temperature maintained & thermal efficiency at various zones of the kilns. There are three zones in tunnel kiln – preheating zone, firing zone & cooling zone. The temperature of the combustion air plays an important role in increasing the thermal efficiency of kiln. Exhaust heat is released from tunnel kiln by two ways: the first is flue gas released at a temperature of around 200-220°C and the second is hot air from final cooling zone at a temperature of around 120°C. At present, exhaust gas from tunnel kiln is released to atmosphere and combustion air is used at an ambient temperature.

There is a potential to reduce the fuel consumption in tunnel kiln by preheating the combustion air. Using the hot air from final cooling zone as a combustion air in tunnel kiln will lead to a reduction in fuel consumption.

Implementation Details

Hot air which is exhausted from the final cooling zone of tunnel kiln at a temperature of around 120°C, can be used directly as a combustion air in tunnel kiln. This will increase the thermal efficiency of firing and lead to savings of about 2 to 3% on total natural gas consumption in tunnel kiln.

Results:

- ❖ Reduced specific energy consumption
- ❖ Increased thermal efficiency
- ❖ Reduced fuel (natural gas) costs by 2-5%



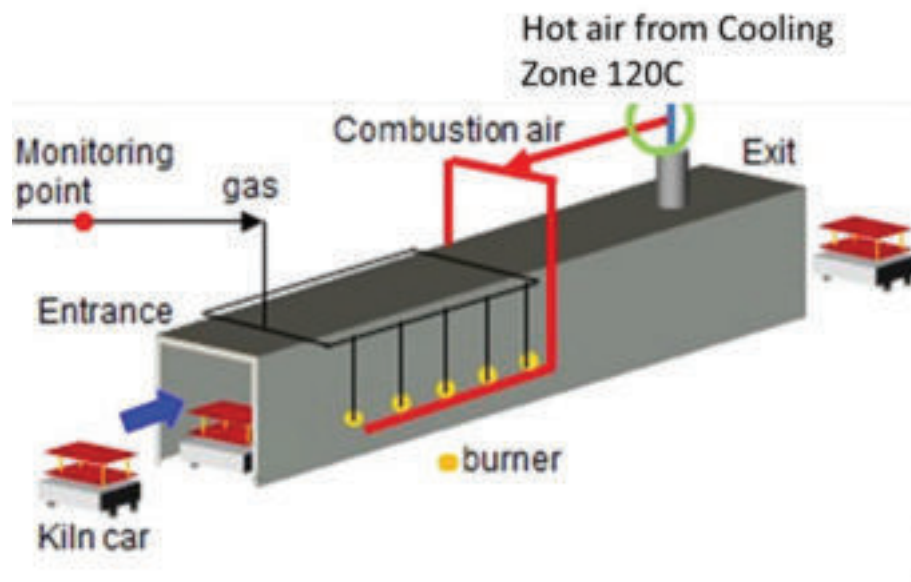


Figure 16: Use of hot air as combustion air

Cost Benefit Analysis

The expected energy savings to be achieved by using hot air as combustion air in tunnel kiln is 1,030 Lakh kCal annually. The annual monetary saving for this project is INR 3.44 Lakh, with an investment of INR 4 Lakh and a payback period of 14 months.

Table 10: Cost benefit analysis – Waste heat recovery

Parameter	Value	UOM
Production	14.00	Tonne/day
Natural gas consumption before installation of WHR system	1,540	SCM/day
Inlet combustion air temperature (before)	40	°C
Inlet combustion air temperature (after installation of WHR system)	120	°C
Natural gas consumption after installation of WHR system	1,505.35	SCM/day
Operational hours	24	Hours/day
Operational days	330	Days/annum
Saving in natural gas consumption	11,435	SCM/ annum
Cost of natural gas	30	INR/SCM
Annual monetary saving	3.44	INR Lakh/annum
Investment	4.00	INR Lakh
Simple payback period	14	Months

Energy & GHG Savings



Replication Potential

Implementation can be done in all other units where similar kilns are used for production. However, periodic monitoring and measurement of kiln excess air level in flue gas is essential.

Technology Supplier Detail:

Table 11: Technology supplier details – Waste heat recovery

Description	Details
Supplier Name	Neptune Industries Pvt Ltd
Contact Person	Mr Chandresh
Designation	General Manager
Contact	Mobile:+919879206992
Address	VT Industrial Park, Ahmedabad Mehsana High way, Jagudan, Mehsana 382710 (Gujarat) INDIA.



4.1.2. Energy efficient coating inside kiln to reduce the radiation losses in kiln and reduce fuel consumption

Baseline details

Maximum efficiency of the kiln is in the range of 30% to 40% and remaining 60% to 70% are losses from the kiln. Radiation losses accounts for 15% to 20% of total energy loss. In a kiln, the kiln surface temperature at firing zone is in the range of 80 to 100°C. Minimizing the radiation loss from the kiln surface will result in reducing the fuel consumption.

The figure shows the various zones in kiln.

The surface temperature recorded at various zone is indicated in below table.

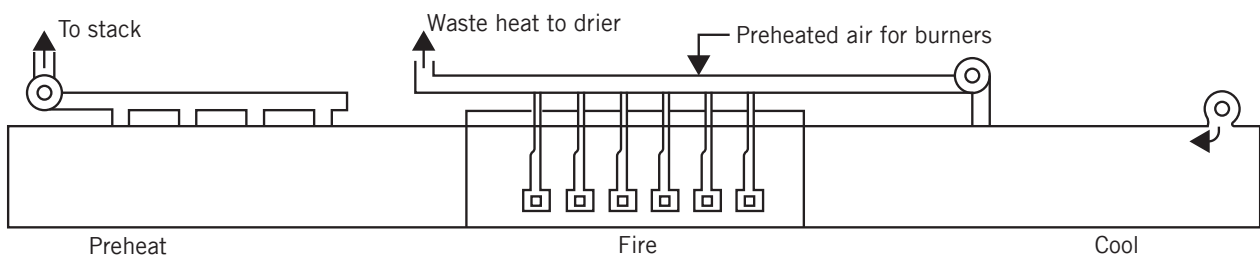


Figure 17: Various zones in kiln

Table 12: Zone wise average temperature in a kiln

Zone	Left wall Avg temp (°C)	Right wall Avg temp (°C)
Pre Heating	57	58
Firing	83	94
Cooling Zone	72	62

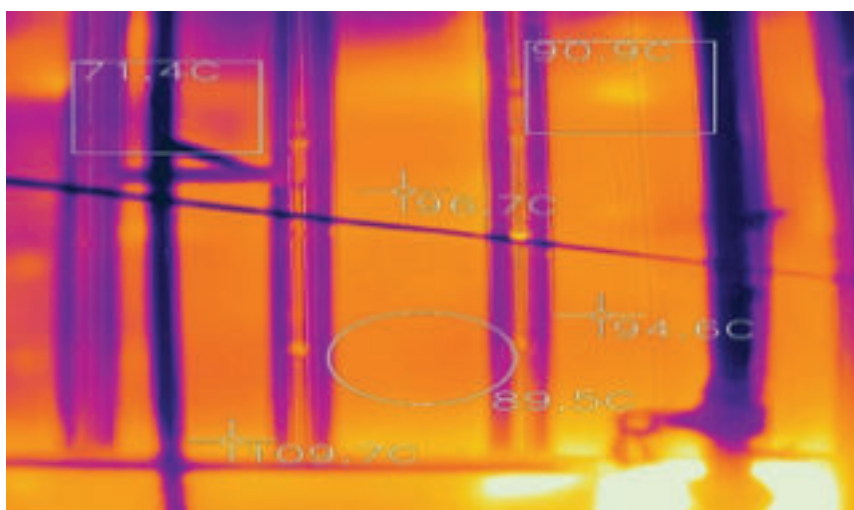


Figure 18: Surface temperature at firing zone in a kiln

Implementation Details

The energy efficient coating is most suitable for ceramic kiln. It is applied in the kiln on bricks as well as on the exterior of the kiln. The coating is applied in multiple layers and allowed to dry. The coating can withstand temperature up to 1,500°C. This will reduce the surface temperature by 10 to 15°C.

Table 13: Zone wise temperature after applying energy efficient coating in kiln

S.No	Before	After (Expected)
1	Preheating: 58°C	Preheating: 45-50°C
2	Firing Zone: 90°C.	Firing zone: 75-82°C

Results:

- ❖ Savings of up to 2 to 5% in fuel consumption.
- ❖ Life of coating would be 4-5 years.
- ❖ Life of ceramic fibre and refractory bricks will increase resulting in indirect savings

Cost Benefit Analysis

The expected energy savings achieved by use of energy efficient coating is 1,370 Lakh kCal annually. The annual monetary saving for this project is INR 4.57 Lakh, with an investment of INR 7.00 Lakh and a payback period of 18 months.

Table 14: Cost benefit analysis – Energy Efficient coatings in kiln

Particular	Existing Situation	UOM
Production	14	Tonne/day
Natural gas consumption (before)	1,540	SCM/day
Natural gas consumption (after)	1,494	SCM/day
Operational days	330	Days
Savings in natural gas consumption	15,246	SCM/annum
Cost of natural gas	30	INR/SCM
Annual monetary savings	4.57	INR Lakh/annum
Investment (for firing & preheating zone coating area of 2,000 sq ft)	7.00	INR Lakh
Simple payback period	18	Months



Energy & GHG Savings



Technology Supplier Details

Table 15: Technology Supplier Details – Energy efficient coating in kiln

Description	Details
	Supplier-1
Supplier Name	Innovative Surface Coating Technology, Nagpur
Contact Person	Mr. Nikhilesh R
Designation	Co-Founder
Contact	+918788384913
	Supplier-2
Supplier Name	HIR Industries, Himatngar, Gujarat
Contact Person	Mr. David Patel
Designation	Director
Contact	+919099021334



4.1.3. Low thermal mass for reduction of kiln car losses in sanitaryware units

Baseline details

The unit has installed a tunnel kiln of 15 TPD capacity for firing sanitaryware moulds. The open flame tunnel kiln is a continuous type kiln, wherein the raw product is fed at one side and on the other side the finished product is taken out. The raw product undergoes firing and cooling cycles, as it moves from the front end to the back end of the kiln. The material movement through the tunnel kiln is by kiln cars, run on rails. The kiln cars are like train bogies designed to hold the products. Natural gas is used as a fuel in tunnel kiln. The kiln cars are constructed with refractory and insulating bricks. Due to high thermal mass, kiln cars consume considerable amount of heat energy supplied to the kiln.



Figure 19: Existing high thermal mass refractory in kiln car

Implementation Details

The weight reduction of the kiln cars gives the significant amount of energy savings in tunnel kiln. Low thermal mass materials (LTM) are now being used for kiln car construction, which reduces the weight of the kiln car considerably. Weight of car furniture was reduced from 465 kg per car to 358 kg per car (23% weight reduction).



Figure 20: Low thermal mass in kiln car

Results:

- ❖ Reduced specific energy consumption in tunnel kiln
- ❖ Increased thermal efficiency
- ❖ Reduced fuel (natural gas) costs by 10-15%

Cost Benefit Analysis

The expected energy savings to be achieved by use of low thermal mass in kiln car is 3,921 Lakh kCal annually. The annual monetary saving for this project is INR 13.10 Lakh, with an investment of INR 14.00 Lakh and a payback period of 13 months.

Table 16: Cost benefit analysis – Low thermal mass in kiln car

Parameter	Value	Units
Production	14	Tonne/day
No of kiln cars	40	Nos.
Present natural gas consumption for heating of car structure	680	SCM/day
Operational hours	24	Hours/day
Operational days	330	Days/annum
Natural gas consumption after implementation of LTM car	548	SCM/day
Saving in natural gas consumption	132	SCM/day

Parameter	Value	Units
Saving in natural gas consumption	43,560	SCM/annum
Cost of natural gas	30	INR/SCM
Annual monetary saving	13.10	INR Lakh/annum
Investment	14.00	INR Lakh
Simple payback period	13	Months

Energy & GHG Savings



Replication Potential

Low thermal mass car technology can be replicated in all the ceramic units in the cluster. It is advised to take proper care regarding the strength of the kiln car during the redesigning. Implementation of the technology can be done in one kiln car and later replicated to the other kiln cars based on the results.

Technology Supplier Details

Table 17: Technology supplier details – Low thermal mass

Description	Details
Supplier Name	Interkiln Advanced Technical LLP, Ahmedabad
Contact Person	Mr.Kushang Sanghavi
Designation	Managing Partner
Contact	+919998980044
Email – ID	kushang@interkiln.co.uk
Address	Sanghavi Chamber, Near Navrangpura Police Station, Opp. Sweet Home Shop, Navrangpura, Ahmedabad – 380009. Gujarat. INDIA..



Cluster Level Reference

1. Details of the project: Morbi

Table 18: Low thermal mass – Morbi cluster reference

Name of the company	Shree Neelkanth Sanitaryware
Person to be contacted	Mr Kantibhai Patel
Designation	Director
Contact number	+919925259179
Address for communication	N.H. -8, Opp. Dariyalal Resort, Morbi.

2. Details of the project: Thangadh

Table 19: Low thermal mass – Thangadh cluster reference

Name of the company	Anchor Sanitaryware
Person to be contacted	Mr Dushyant Sompura
Designation	Director
Contact number	+919825077447

3. Details of the project: Naroda

Table 20: Low thermal mass – Naroda cluster reference

Name of the company	Shiva Shakti Ceramics
Person to be contacted	Mr Dinesh Patel
Designation	Director
Contact number	+919879057081
Address for communication	Plot No.611, Ph-4, GIDC Naroda, Ahmedabad



4.1.4. Improvement of kiln insulation to reduce radiation losses

Baseline details

The unit has installed a tunnel kiln of 15 TPD capacity for firing sanitaryware moulds. Kiln performance is directly related to the temperature maintained & thermal efficiency at various zones of kilns. Kiln has three zones – preheating zone, firing zone & cooling zone. Firing cycle of the typical kiln is as follows.

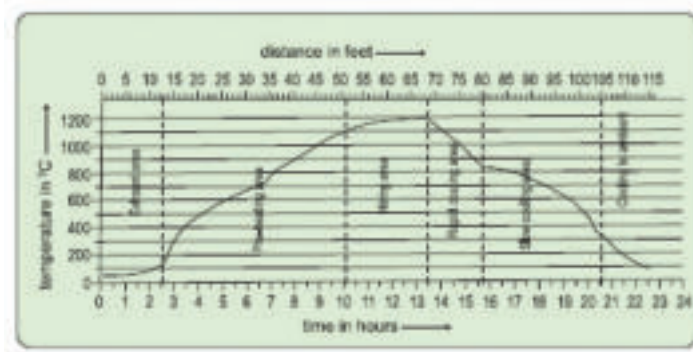


Figure 21: Firing Cycle

The kiln firing is done in two stages:

- 1) Preheating zone (500-750°C).
- 2) Firing zone (1,100-1,250°C).

After firing, tiles are cooled in two zones:

- 1) Rapid cooling zone (600-900°C).
- 2) Cooling zone (200-500°C).

Maximum efficiency of the Kiln is in the range of 30% to 40% and remaining 60% to 70% are losses from the kiln. Radiation losses accounts for 15% to 20% of total energy loss in a kiln.

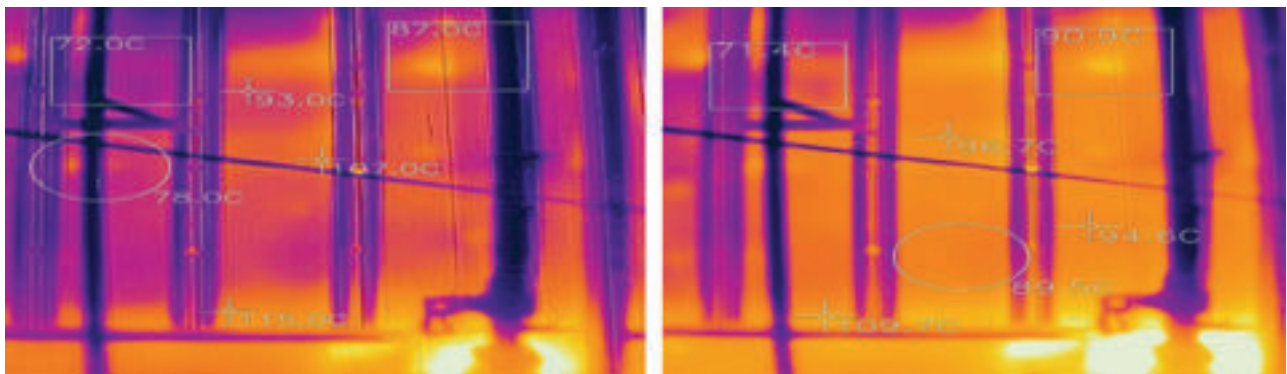


Figure 22: Thermal image of tunnel kiln

Implementation Details

The radiation loss in a kiln can be reduced by replacing the damaged insulation and improving the existing insulation of the kiln. Insulation improvement leads to saving in fuel consumption in kiln.

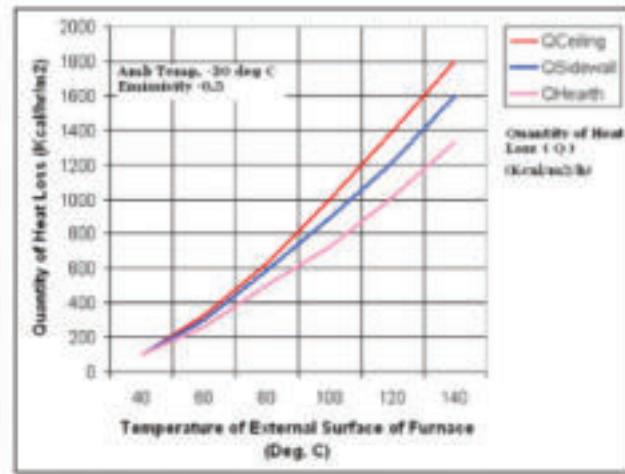


Figure 23: Quantity of heat loss from surface vs temperature

Results:

- ❖ Reduced specific energy consumption in kiln
- ❖ Increased thermal efficiency

Cost Benefit Analysis

The expected energy savings by replacing the damaged insulation with new is 1,370 Lakh kCal annually. The annual monetary saving for this project is INR 4.57 Lakh, with an investment of INR 14.00 lakh and a payback period of 36 months.

Table 21: Cost benefit analysis – Kiln insulation improvement

Parameter	Value	UOM
Production	14	Tonne/day
Natural gas consumption before intervention	1540	SCM/day
Operational hours	24	Hours/day
Operational days	330	Days/annum
Natural gas consumption after implementation of Intervention	1,494	SCM/day
Annual gas savings due to implementation of measure	15,246	SCM/annum
Cost of natural gas	30	INR/SCM
Annual monetary saving	4.57	INR Lakh/annum
Investment	14.00	INR Lakh
Simple payback period	36	Months

Energy & GHG Savings



Replication Potential

Implementation can be done in all other units where a similar kiln is used for production. However, periodic monitoring and measurement of the kiln outside surface temperature is essential.

Technology Supplier

Table 22: Technology supplier details – Kiln insulation

Description	Details
Supplier Name	Cumi Morgan Advance Materials
Contact Person	Mr Alpesh Gupta
Designation	Director
Contact	Mobile: +91 9824013885



4.1.5. Excess air control system to maintain optimum air to fuel ratio in kiln

Baseline details

Kiln performance is directly related to the temperature maintained at various zones & thermal efficiency of kiln. Excess air level in the combustion play a vital role in optimizing the fuel consumption and combustion efficiency of kiln firing. The excess air level is calculated based on the amount of oxygen in the exhaust flue gases.

$$\text{Excess air} = (O_2)/(21-O_2) \times 100\%$$

Where O_2 = % oxygen in flue gas

Excess air level in combustion air to be maintained at optimum level as too much of excess level results in excessive heat loss in exhaust flue gas and maintaining little excess air results in incomplete combustion and formation of carbon monoxide in flue gases. One of the causes of high excess air is improper or outdated control system in burner firing.

Table 23: Flue gas analysis & excess air in one of the kiln

Parameter	Value		Unit
	At kiln exhaust	At kiln firing	
O ₂	17.3	8%	%
CO	131	65	PPM
CO ₂	2.4	6.1	%
Excess air	467	61.54%	%

Implementation Details

It is recommended to maintain %O₂ in flue gas in the range of 3-5%. For maintaining the optimum excess air level and air to fuel ratio, a PID based air and gas flow control system is to be installed in burner firing circuit.

In air flow control system, an O₂ sensor is to be installed in exhaust fuel gas and VFD on combustion air fan. The sensor senses the O₂ & provides the feedback/input to PID controller. The PID controller provide input to the combustion air fan VFD to control the speed and thereby control the volume of air to be required for complete combustion with optimum excess air.

Results:

- ❖ Reduced specific energy consumption in kiln
- ❖ Increased thermal efficiency
- ❖ Reduced fuel (Natural Gas) costs by 10%.

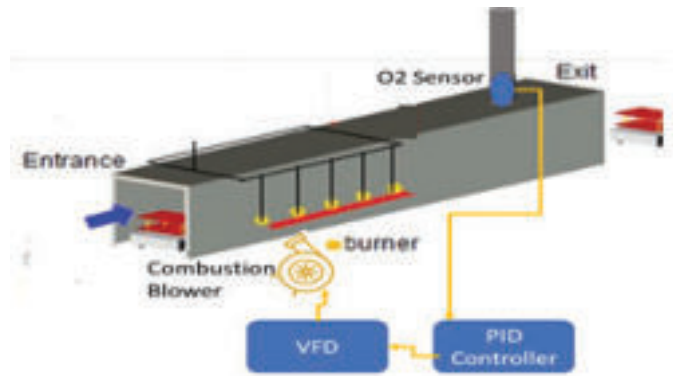


Figure 24: PID & VFD based excess air control system

Cost Benefit Analysis

The expected energy savings to be achieved by optimizing the excess air is 1,827 Lakh kCal annually. The annual monetary saving for this project is INR 6.09 Lakh, with an investment of INR 12.00 lakh and a payback period of 24 months.

Table 24: Cost benefit analysis – Excess air control in kiln

Parameter	Value	UOM
Production	14	Tonne/day
Natural gas consumption before intervention	1,540	SCM/day
Operational hours	24	Hours /day
Operational days	330	Days/annum
Natural gas consumption after implementation of intervention	1,478	SCM/day
Annual gas savings due to implementation of measure	20,328	SCM/annum
Cost of natural gas	30	INR/SCM
Annual monetary saving	6.09	INR Lakh/annum
Investment	12.00	INR Lakh
Simple payback period	24	Months

Energy & GHG Savings



Replication Potential

Implementation can be replicated in all the kilns.

Technology Supplier

Table 25: Technology supplier details – Excess air control system

Description	Details
Supplier Name	Wesman Thermal Engineering
Contact Person	Mr Tushar Shah
Designation	General Manager
Contact	+919879206992



4.2. Case studies in raw material blending

4.2.1. Reduction in ball mill power by installation of VFD on ball mill drive

Baseline details

The unit has installed a ball mill with 6 MT capacity having 40 hp drive for grinding of raw materials. Ball mill is a batch type grinding process and used in all type of ceramic unit. As per the process requirement, motor should run at full speed during the start of batch and after a particular time period, it should rotate at lower speed. Existing unit has no control system installed and operates directly on starter.

Implementation Details

A VFD is a system for controlling the rotational speed of an alternating current (AC) electric motor by controlling the frequency of the electrical power supplied to the motor. A variable frequency drive is a specific type of adjustable-speed drive which controls the speed of motor according to the requirement. The speed of the motor can be reduced by installing variable frequency drive on ball mill motor and operating speed can be programmed based on time. This will result in saving in power consumption to the extent of 15% in ball mills and blunger. This concept is applicable to glaze preparation ball mill in glaze section also. The project is successfully implemented in few ceramic units.

Results:

- ❖ Reduced specific energy consumption
- ❖ Reduction in electricity consumption in grinding process by 15%

Cost Benefit Analysis

In Thangadh cluster as majority units are sanitaryware, the maximum capacity of ball mill drive is 40 hp. The expected energy savings to be achieved by installing VFD in ball mill drive in sanitaryware unit would be 0.10 Lakh kWh annually. The annual monetary saving for this project is INR 0.69 Lakh, with an investment of INR 1.00 Lakh and a payback period of 12 months.



Table 26: Cost benefit analysis – VFD in ball mil in sanitaryware unit

Parameter	Values	UOM
Capacity of ball mill	6	Tonne
Ball mill motor capacity	40	hp
Mill charge per day	12	MT/day
Power consumption	23.8	kWh
Operational hours	10	hrs/day
Operational days	330	Days/annum
Ball mill annual energy consumption (before)	70,686	kWh/annum
Ball mill annual energy consumption after installation of VFD and optimizing the speed (15% savings)	60,083	kWh/annum
Annual energy savings	10,602	kWh/annum
Annual monetary savings	0.69	INR Lakh/annum
Investment for VFD	1.00	INR Lakh
Simple Payback Period	18	Months

Energy & GHG Savings



Replication Potential

The project can be implemented in all other units where a similar kind of ball mill is used. Also, all new units & green field projects can implement this project.



Technology Supplier Details

Table 27: Technology supplier details for VFD

Description	Details
Supplier Name	Danfoss Industries Pvt Ltd
Contact Person	Mr Hiran Thakkar
Designation	Manager
Contact	+917940327341
Address	No. 703, 7th Floor, Kaivanna Complex, Opp. Bank of Baroda, Near Panchwati Cross Road, Ahmedabad-380015



4.2.2. High speed blunger in place of ball mill for raw material grinding process

Baseline details

In ceramic product manufacturing process, ceramic body preparation is one of the important processes. This process includes mixing of raw material with water to produce slurry. Most of the units in the cluster use ball mills for this operation ranging 2 MT to 6 MT capacity. Generally, ball mills will consume more time in loading and unloading as material is to be fed from small opening at the top. This in turn requires more manpower. It also requires grinding media for the operation, which will consume half of the space, so less productivity is achieved when compared to blunger technology.

The starting torque of ball mill motor is high due to uneven starting load, which consumes more power than the normal operation.



Figure 25: Conventional Ball Mill system

Implementation Details

Blunger is a machine which can rapidly blunge raw material without changing non plastic raw material structure using stator rotor mechanism. The turbo blunger is a heavy-duty blunger used for rapid preparation of slip, achieving an 80% reduction in the blunging time compared to normal propeller-type dissolvers. It is operated by means of a special rotor fixed to the bottom of

the tank, which propels the material against a ring of fixed paddles (1st phase). An auxiliary impeller, available on request, is fixed at a point halfway up in the tank for the blending of material in powder form (quartz, feldspar) with the slip (2nd phase). The average dissolving time for raw or already treated clay, including loading and unloading operations, is approx. 2 hours for a liquid with a specific weight of 1.4 kg/m³. The average duration of the 2nd phase is 1 hour for a liquid with a specific weight of 1.8 kg/m³. Due to less cycle time (2 to 2.5 hrs) as compared to ball mill and lower weight, energy saving is achieved.

All parts involved in the dissolving process (rotor, fixed paddles, base of tank) are constructed in special steel of high wear resistance and are easy to replace. All heavy-duty blungers are furthermore provided with a trap for collection of stones, which are periodically removed. Maintenance is extremely simple and reduced to a minimum.

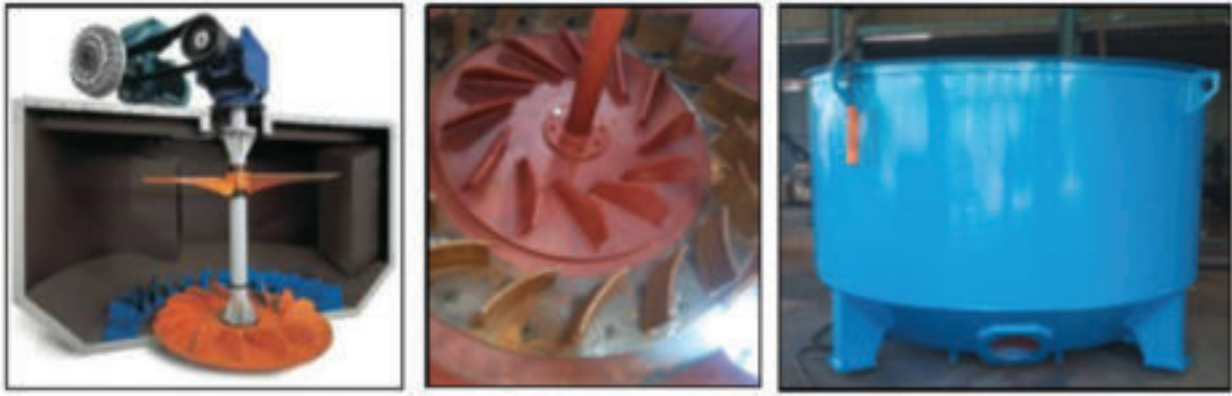


Figure 26: High Speed Turbo Blunger

Cost Benefit Analysis

The expected energy savings to be achieved by use of high speed blunger is 0.99 Lakh kWh annually. The annual monetary saving for this project is INR 6.45 Lakh, with an investment of INR 12.00 Lakh and a payback period of 23 months.

Table 28: Cost benefit analysis – High speed blunger

Parameter	A	B	UOM
	Ball mill	High speed blunger	
Charge Production	24	24	MT/day
Capacity	6	5	MT
No of ball mills/blunger	2	2	Nos
Motor capacity	40	20	hp
Power consumption	23.8	14	kW
Operational hours for one charging	5	3	hrs/batch
Power consumed in 720 MT charges per month	14,323	6048	kWh/month
Total power consumption per annum	1,71,876	72,576	kWh/annum
Electricity cost per annum	11.17	4.71	INR Lakh
Annual monetary saving		6.45	INR Lakh/annum
Investment		12.00	INR Lakh
Simple payback period		23	Months

Energy & GHG Savings



Replication Potential

Learnings from successfully implementing high speed blunger technology in two ceramic units can be used very well to replicated in the other units in the cluster.

Technology Supplier Details

Table 29: High speed blunger technology supplier details

Description	Details
Supplier Name	Dynovo Global Solutions Pvt Ltd, Mumbai
Contact Person	Mr. Jatan Shah
Designation	Managing Partner
Contact	+919699817245
Address	203, Crystal Tower, 75 Gundavali Road No. 3, Off, Sir Mathuradas Vasanji Rd Andheri East, Mumbai, Maharashtra 400069



4.2.3. High alumina media in glaze ball mill in the place natural stone/pebble

Baseline details

Ball mills are used for raw material and glaze grinding. The grinding of the material takes place due to the impact of the balls inside the ball mill. Most of the units in the cluster use natural stone as a media for grinding. Generally, these media are mined or naturally available stoned pebbles and are very irregular in shape and size. Such non-uniform grinding media take higher time for grinding and generate higher residue.



Figure 27: Mined Stone Pebble



Figure 28: High Alumina Ball

Implementation Details

As compared with natural pebbles grinding media, the alumina grinding balls have better performance in terms of wear resistance, uniform size, high density and high mechanical strength. The high density and ultra-hardness of the alumina grinding ball enable increased loading of ball mill. The alumina grinding ball is compact and uniform in shape, increasing the colliding probability and grinding efficient. The

alumina grinding ball can help in less contamination to the raw material and keep the chemical composition stabilized. Thus, the alumina grinding ball is a better option for glaze grinding that ensures quality of production. Other benefits of using alumina balls is wear & tear of balls which is about 0.2%, is very less as compared to natural stone/pebble, which is about 2.0%.

Cost Benefit Analysis

The expected energy savings to be achieved by use of high alumina balls in place of stone/pebble is 0.375 Lakh kWh annually. The annual monetary saving for this project is INR 2.52 Lakh, with an investment of INR 5.00 Lakh and a payback period of 23 months.



Table 30: Cost benefit analysis – High alumina ball in ball mill

Parameters	Natural Media	High Alumina Media	Units
Electrical motor capacity*	15	15	hp
Grinding hour for one charge	21	11	Hrs
Power consumed per one charge	234.4	122.7	kWh
Total Charge per month	28	28	
Total power consumption per month	6,562	3,437	kWh
Cost of power per unit	7	7	INR/kWh
Cost of power consumption per month	0.45	0.24	INR Lakh
Monetary savings		2.52	INR Lakh/annum
Investment		5.00	INR Lakh
Simple payback period		23	Months

* Considering ball mill size of 6 FT X 6 FT with material load of 2,000 kg

Energy & GHG Savings



Replication Potential

It can be replicated in all ball mills operating with natural stone/pebble as grinding media.



Technology Supplier Details

Table 31: Technology supplier details – Alumina lining and grinding pebbles

Description	Details
Supplier Name	Parishram Enterprise, Thangadh
Contact Person	Mr. Vinu Bhai
Designation	Managing Partner
Contact	+9198253 75834
Address	Near Ranuja ceramic, Thangadh, Gujarat 363530



4.3. Case studies in Utilities

4.3.1. Installation of VFD in screw compressor to avoid unloading

Baseline Scenario

Compressed air in ceramic unit is used for instrument air application, mould preparation and glazing. The ceramic unit under consideration has installed a 30 hp screw compressor to cater to the requirements in the process & instrumentation section. The maximum working pressure of the compressed air in the system is in the range of 6-7 kg/cm². The operating characteristics of the compressor is as shown:

Table 32: Unit compressor loading pattern

Tag No	Load %	Unload %	Load power, kW	Unload power, kW
Unit air compressor-22kW	60.5	39.5	22 kW	7.6 kW

It can be seen that the loading of the compressor is only 60.5%. As the actual compressed air requirement for the process is lesser than the capacity of the compressor, compressor is operating in unloading condition for 39.5 % of the time resulting in waste of energy. During the unload condition, there is no useful work done by the compressor but the motor is in operating condition resulting in wastage of power. Avoiding or reducing the compressor unloading will result in power saving.

Concept of VFD

Any compressor is designed to go into load & unload conditions. The load & unload pressures for any compressed air system is set such that the average pressure delivered will be the required system pressure. The higher the pressure set point, more will be the power consumption of the compressor.

Also, in the present scenario, the installed compressor is of much higher capacity as compared to the system requirement, which is clear from the 39.5% unload that the compressor is operating with.

The compressor unloading can be avoided by installing variable frequency drive (VFD) in the compressor. The difference between the normal & VFD condition in a compressor is as shown below:



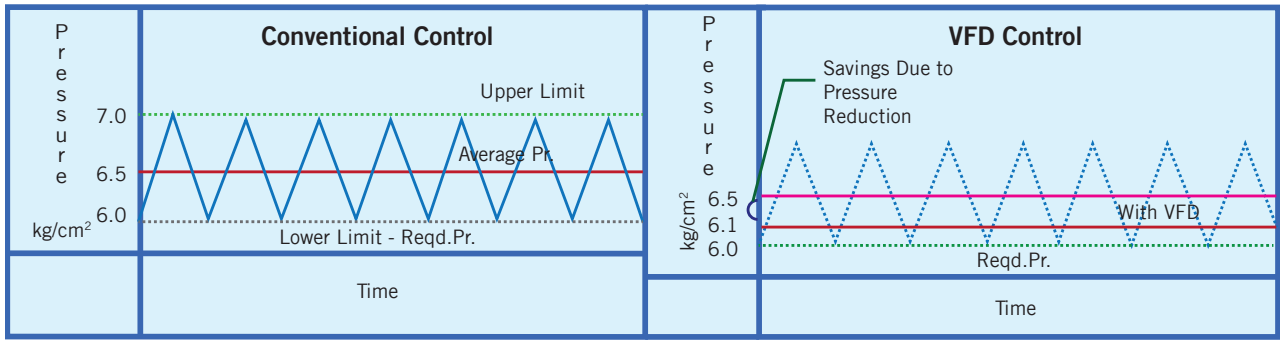


Figure 29: Capacity control of compressor

For example, for a compressor operating between load pressure of 6 kg/cm² & unload pressure of 7 kg/cm²; the average pressure is 6.5 kg/cm², (bandwidth 1 kg/cm²). The power consumption of the compressor operating constantly at 6 kg/cm² with VFD comes down by 5 to 6%. By installing a VFD, it is possible to maintain a bandwidth of 0.1 kg/cm². As can be seen from the figure, the VFD can be given a set point equal to that which is required in the system. The additional power that the compressor consumes over the required pressure will be the savings achieved.

Implementation details

It is recommended to install VFD and operate that with closed loop for all the above listed compressor to avoid the unloading of the compressor. The feedback for VFD can be given as required receiver pressure. By installing VFD, the compressor can be operated in a pressure bandwidth of ± 0.1 bar. Saving potential of 7.6 kW is possible by installation of VFD in the unit air compressor.

Cost Benefit Analysis

The expected savings by installation of VFD in the compressor is 18,249 units annually. The annual monetary saving for this project is INR 1.03 Lakh with an investment of INR 0.90 Lakh. Payback period for the project is 11 months.

Table 33: Cost benefit analysis – VFD in screw compressor

Parameters	Value	Unit
Unloading power of compressor	7.6	kW
Percentage unloading	30.5	%
Power savings	2.31	kW
Annual operating hours	7,900	hrs
Annual energy savings	18,249	kWh
Power cost	5.66	INR/kWh

Parameters	Value	Unit
Annual savings	1.03	INR Lakh/annum
Investment	0.99	INR Lakh
Simple payback period	11	Months

Energy & GHG Savings



Technology Supplier details

Table 34: Technology supplier details – VFD in screw compressor

Description	Details
Supplier Name	Tirupati Automation, Morbi
Contact Person	Mr. Bhavesh Vamja
Phone No	+919879411415, 8000682152
Address	Shiv Plaza-2, Shop No-14 & 15, Matel Road, At- Dhuva, Ta. Wankaner, Dist. Morbi (Guj)



4.3.2. Installation of screw compressor with VFD in place of reciprocating compressor

Baseline Scenario

Compressed air in ceramic units is used for instrument air, mould preparation and glazing process. Most of the units are using reciprocating type compressors without any automation; these compressors run on load/unload mode. The percentage of loading depends on the process requirement.

Generally, compressor in ceramic units run on 60–70% in loaded condition remaining 30–40% in unload condition. During unload condition, the compressor does not deliver any air, but consumes unload power, which increases the specific power consumption.



Figure 30: Reciprocating Compressor

On other hand, reciprocating compressor due to its design is prone to wear & tear and thus the compressor volumetric efficiency reduces over a period of time.

Implementation Details

The existing compressor has been replaced with energy efficient screw air compressor with VFD. VFD operated screw compressor has two functions: one, it varies RPM of compressor based on pressure variation at the load or perform end and two, it also reduces no load power consumption during unloading condition by bringing the motor to a halt. Such operation prevents consumption of power during unload condition.

Merits

- ❖ Maintenance is simple in screw-based air compressors.
- ❖ By using VFD in screw air compressors, the operating pressure of air compressor can be precisely controlled.
- ❖ The leakage in the compressed air system is proportional to the operating pressure.

Cost Benefit Analysis

The expected savings by installation of energy efficient screw compressor in place of reciprocating compressor is 61,285 kWh annually. The annual monetary saving for this project is INR 4.01 Lakh with an investment of INR 9.80 Lakh and payback for the project is 29 months.

Table 35: Cost benefit analysis – Energy efficient screw compressor

Parameters	Value	UOM
Total installed capacity	4.25	m ³ /min
Actual air delivery	3.05	m ³ /min
Volumetric efficiency	71.66	%
Input motor power	28	kW
Specific power consumption	9.19	kW/m ³ /min
Proposed power consumption	6	kW/m ³ /min
Reduction of power consumption	18	kW
Reduction in annual energy consumption	61,285	kWh/annum
Monitory savings	4.01	INR Lakh/annum
Investment	9.8	INR Lakh
Simple payback period	29	Months

Energy & GHG Savings



Replication Potential

The project can be replicated in the units operating with old reciprocating compressor.

Technology Supplier Details

Table 36: Technology supplier details – Screw compressor with VFD

Description	Details
Supplier Name	Kaeser Compressor
Contact Person	Mr Jignesh
Phone No	+919909944506
Address	Sakar-9, 1105, Ashram Rd, beside Old Reserve Bank, Muslim Society, Navrangpura, Ahmedabad, Gujarat 380009



4.3.3. Energy conservation in compressor by modifying airline system

Baseline Scenario

The existing system is made up of metallic pipeline having a lot of joints & weldings, due to which there was a lot of frictional loss & leakage, which lead to energy loss. The new pipe material has a smooth surface inside, which can minimize frictional losses. This material can be bent easily so that there is no necessity to use joiners. With the use of this material, we can minimize joints and hence avoid air leakage. This will help to minimize energy consumption.



Figure 31: Existing compressed air piping

Implementation Details



Figure 32: HDPE Aluminium Pipe line

Multilayer pipes (MLC) (Generic Name Pe-Al-Pe Pipe) are made of five layers. The inside & outside layers comprise of HDPE (High Density Polyethylene) tightly bonded with melt adhesives to intermediate layer of Aluminum Core, which is longitudinally overlapped. These pipes offer the advantages of both metal and plastic pipe, with none of their shortcomings. The working life of MLC pipes is more than 20 years.

Because the internal surface of the MLC pipes is smooth, the pressure drop / friction losses in these pipes is 30% lower than GI pipes. MLC Pipes are bendable and hence require a smaller number of fittings and require minimum joints. MLC Pipes are corrosion resistant and scale free. Plastic layer resist deterioration by corrosion due to moisture. There will be some friction loss in MLC pipe due to internal fittings but the overall performance of the Piping System will be better than other pipes as there are a smaller number of fittings required.

Merits

- ❖ Reduction in air leakages.
- ❖ Life cycle is more than 12 to 15 years.

Cost Benefit Analysis

The expected savings by installation HDPE aluminium piping is 0.38 Lakh kWh annually. The annual monetary saving for this project is INR 2.85 Lakh, with an investment of INR 3.50 Lakh and the payback for the project is 15 months.

Table 37: Cost benefit analysis – Aluminum pipeline

Parameters	Value	UOM
Before: 50 hp Compressor operating		
Energy consumption per hour	37.5	kW
Energy consumption for two shifts/day	600	kWh
Energy consumption for 26 working days	15,600	kWh
After Implementation: 40 hp Compressor operating		
Energy consumption per hour	30	kW
Energy consumption for two shift/day	480	kWh
Energy consumption for 26 working days	12,480	kWh
Saving in energy/annum	37,440	kWh/annum
Saving in energy/annum	2.85	INR Lakh/annum
Investment	3.50	INR Lakh
Simple payback period	15	months

Energy & GHG Savings



Replication Potential

This technology has been adopted by the foundry unit and similar application can be done in all ceramic manufacturing units.



Technology Supplier Details

Table 38: Technology supplier details – HDPE aluminium piping

Description	Details
	Supplier – 1
Supplier Name	S R Engineers
Contact Person	Mr Rajesh
Phone No	+918688876444
Address	Chennareddy Enclave Road, Indira Nagar Colony, Shanakar Nagar, Peerzadiguda, Hyderabad, Telangana -500039
	Supplier – 2
Supplier Name	Godrej & Boyce Mfg. Co. Ltd.
E-mail	casene@godrej.com
Phone No	91-22-67962258 / 1104
Address	E & E Services – Compressed Air Management Solutions Pirojshanagar, Vikhroli, Mumbai – 400 079, India.



4.3.4. Retrofit of energy efficient ceiling fans in place of conventional fans

Unit: M/s Eros Sanitary, Shobheshwar Road.

Baseline details

In cast house, moulds slow drying process is an essential component of sanitaryware production process. The moulds drying process takes minimum 20-22 hours depending on the atmospheric conditions. The moulds are kept in storage area and are dried by air from the ceiling fans. There are close to 300 to 500 ceiling fans installed for drying purpose. The drying process leads to loss of moisture in the moulds/casting & the process has to be slow, otherwise cracks will develop in the casting. After drying, the moisture content is 1.5% to 0.5%. During this process, the ware loses its weight & shrink in size.

Implementation Details

The BLDC Technology or Brushless DC Motor: A BLDC fan takes in AC voltage and internally converts it into DC using switch mode power supply (SMPS). The main difference between BLDC and ordinary DC fans is the commutation method. A commutation is basically the technique of changing the direction of current in the motor for the rotational movement. In a BLDC motor, as there are no brushes, so the commutation is done by the driving algorithm in the electronics. The main advantage is that over a period of time, due to mechanical contact in a brushed motor, the commutators can undergo wear and tear. This thing is eliminated in BLDC Motor, making the motor more rugged for long-term use and also using less energy for rotation due to no mechanical contact. The expected electrical energy reduction is approximately 60% from the actual consumption. The fans are provided with timer-based remote control. This feature can be utilized for auto switching off the fan after the required process time.

Results:

- ❖ Reduced specific energy consumption for products manufactured.
- ❖ Reduced electrical bill costs by 60%.
- ❖ Increased production.

Cost Benefit Analysis

The expected energy savings to be achieved by replacement of existing ordinary fans with energy efficient BLDC fans is 0.677 Lakh kWh annually. The annual monetary saving for this project is INR 4.73 Lakh, with an investment of INR 6.3 Lakh and a payback period of 16 months.



Table 39: Cost benefit analysis – Energy efficient BLDC ceiling fan

Parameter	Value	Units
Quantity of conventional fans	300	Nos.
Operating hours	16	Hrs/day
Energy consumption with existing fans	360	kWh/day
Energy consumption with BLDC fans	134.4	kWh/day
Energy savings	225.6	kWh/day
Annual energy saving	67,680	kWh/annum
Energy cost saving	4.73	INR Lakh/annum
Investment	6.30	INR Lakh
Simple payback period	16	Months

Energy & GHG Savings



Replication Potential

This method can be adopted in all other units, where a similar kind of cast house drying is done. Also all new units & green field projects can implement this project.



Technology Supplier Details

Table 40: Technology supplier details – BLDC ceiling fan

Description	Details
	Supplier – 1
Supplier Name	Atomberg
Contact Person	Mr Rohit Sharma
Designation	Manager
Contact	+919980993600
Address	Plot No. 130 B, TTC Industrial Area Shirawane, Navi Mumbai - 400706
	Supplier – 2
Supplier Name	Canfan Private Limited
Contact Person	Mr Rajesh
Designation	Manager
Contact	+919372413113
Address	20, Jeevarathnam, 2nd Street, Shanthi Nagar, Ksr Nagar, Ambattur, Chennai, Tamil Nadu - 600053



4.3.5. Installation of energy efficient pumps

Baseline Details

The ceramic unit uses water for wet grinding in ball mill to prepare the ceramic product body raw materials. The units have borewell pumps installed for pumping raw water for use in grinding and also for other purpose. Many units are using conventional pumps with standard motors which is having low operating efficiency. There exists a good potential to optimize the power consumption for raw water pumping.

Brief about the technology innovation

The S₄RM (Shakti Slip Start Synchronous Run Motor) offers one of the most energy efficient pump system. This innovation is based on incremental efficiency improvement in both i.e. pump as well as motor. The S₄RM technology-based motors are magnetic motors which are line start i.e. they do not require any VFDs to operate; thus, they are a direct replacement of conventional induction motors. The motor with this technology starts asynchronously, and runs at a synchronous speed in steady state, thereby leading to combined advantages of induction (self-start), and synchronous motor (high efficiency). This technology is implemented for both surface and submersible type of motor-pump applications.

As it is a magnet-based motor, the runtime efficiency of the S₄RM motor is 5–10% higher than that of an induction motor on account of reduction in stator copper losses and removal of rotor electrical losses. The S₄RM takes reduced starting current up to 50% as compared to other motors. It thus offers a long life of motor insulation as the starting current is lesser. Power factor is close to unity which reduces distribution losses and PFC capacitors.

The S₄RM is a retrofit energy efficient technology. The technology is available till 75 hp of power range. The overall energy consumption can be reduced to 50% in some cases. S₄RM runs at full speed irrespective of voltage and load therefore can improve production in industry environment.

Table 41: Comparison between conventional pump set and S₄RM pump

Description	Unit	Conventional pump set	S ₄ RM pump
Capacity of motor	hp	20	20
Head developed by pump	M	64	64
Discharge by pump	LPM	467	467
Motor efficiency	%	74	93.3
Pump efficiency	%	61	76
Overall efficiency of pump set	%	45.1	72.8
Input power	kW	9.0	6.71



Cost Benefit Analysis

The expected energy savings to be achieved by installation energy efficient pump is 1,773 kWh annually. The annual monetary saving for this project is INR 0.12 Lakh, with an investment of INR 0.80 Lakh, and a payback period of 84 months.

Table 42: Cost Benefits Analysis – Energy efficient pumps

Parameter	Value	UOM
Existing pump capacity	5	hp
Operational hours	4	hrs/day
Operational days	330	Days/annum
Existing pump power	4.50	kW
New pump power	3.35	kW
Energy saving	1,773	kWh/annum
Annual monetary savings	0.11	INR Lakh/annum
Investment	0.80	INR Lakh
Simple payback period	84	Months

Energy & GHG Savings



Replication Potential:

This energy efficient pump set can be installed to replace existing conventional pump sets in the entire sector.



Technology Supplier Details

Table 43: Technology Supplier Details – Energy efficient pumps

Description	Details
Supplier Name	Shakti Pumps Limited
Contact Person	Mr. Kaushal Patel
Contact	Mobile: +91-7600030825
Address	501, Sarkar 5 , Behind Natraj Cinema, Ashram Road, Ahmedabad -380009



4.3.6. Installation of energy efficient motors in place of old rewinded motors

Baseline details

The unit has installed a ball mill of 6 MT capacity with 40 hp drive for grinding of raw materials. As per the process requirement, motor should run at full speed during the start of batch and after a particular time period it should rotate at less speed. The detailed assessment study of the ball mill, actual power consumption was done. The electrical motor drives associated with ball mills were found to be rewinded multiple times because of which the body temperature and electricity consumption was observed to be very high as compared to similar size ball mill motor.

Implementation Details

IE3 standard motors will improve motor operating efficiency as compared to old rewinded motors. IE3 motors have superior efficiency and can be operated from 50% to 100% since they have flat curve than conventional motors due to:

- ❖ Increasing the mass of rotor conductors/ conductivity
- ❖ Precision air gaps to reduce current requirements
- ❖ Improved winding and lamination design to minimize power consumption

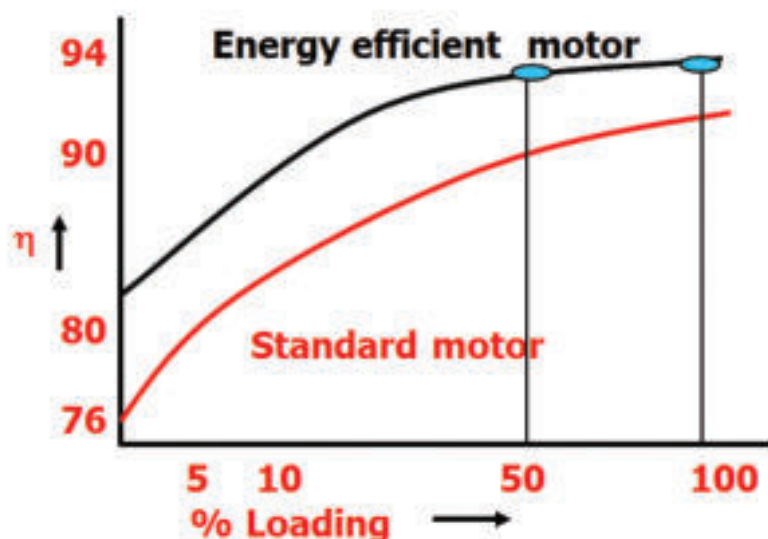


Figure 33: Percentage loading for Energy Efficient motors

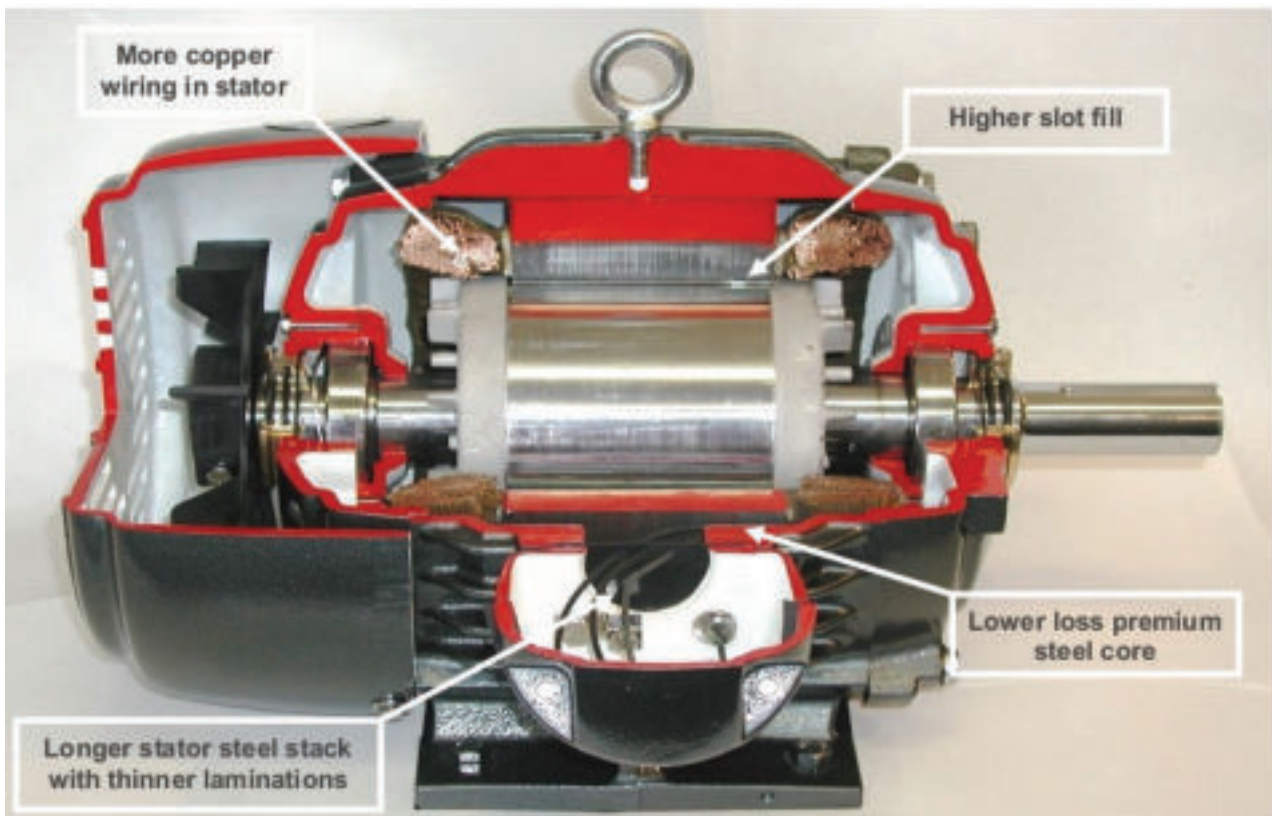


Figure 34: Energy Efficient Motors

To optimise batch timing, replace existing 40 hp rewinded motor drives with energy efficient IE3 standard motor drives of same rating. The expected electrical energy reduction is approximately 10% from the actual consumption. The electrical wiring and associated infrastructure will remain same and only motor is to be changed from the gear coupling. The belt drive is attached to the gearing arrangement for transfer of motion to the Ball mill.

Results:

- ❖ Reduced specific energy consumption for products manufactured.
- ❖ Increased electrical efficiency.
- ❖ It results in reduction in GHG emissions.

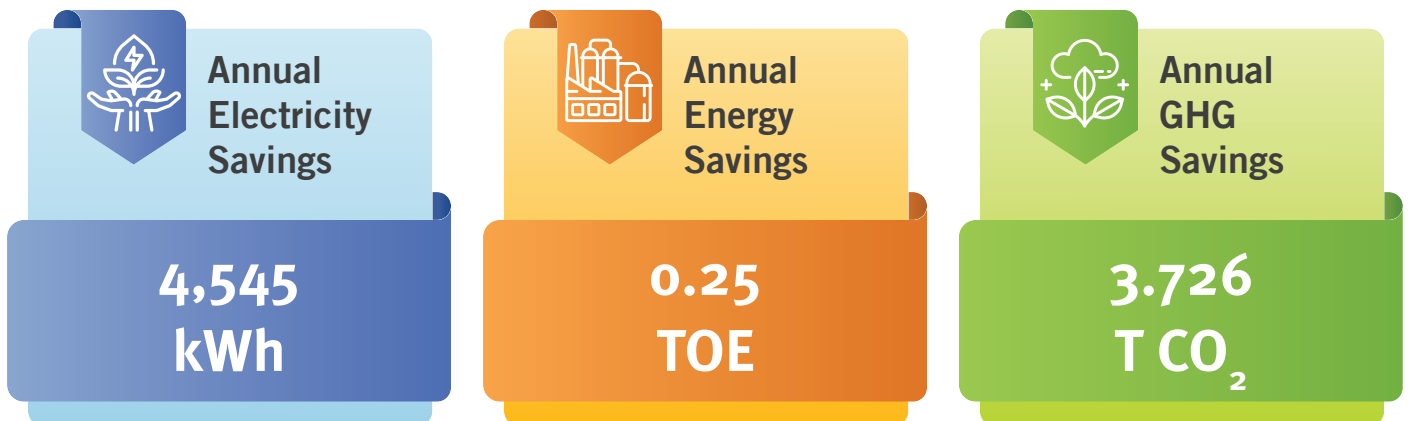
Cost Benefit Analysis

The expected energy savings to be achieved by installing energy efficient motor is 4,545 kWh annually. The annual monetary saving for this project is INR 0.30 Lakh, with an investment of INR 0.97 lakh and a payback period of 38 months.

Table 44: Cost benefit analysis – Energy efficient motor

Parameter	Values	Units
Ball mill drive capacity	40	hp
Existing Efficiency (Old motor)	88.00	%
EE motors Energy Efficiency(IE ₃)	94.00	%
Operational days	330	Days
Power consumption old motor	71,209	kWh/annum
Power consumption by IE ₃ motor	66,664	kWh/annum
Power saving	4,545	kWh/annum
Annual monetary savings	0.30	INR Lakh/annum
Investment	0.97	INR Lakh
Simple payback period	38	Months

Energy & GHG Savings



Replication Potential

This method can be adopted in all other units where old motors are installed and rewinded more than twice. Also, all new units & green field projects can implement this project.



Technology Supplier Details

Table 45: Technology suppliers details – Energy efficient motor

Description	Details
Name of Company	Rotomotive Drives
Contact person	Mr Gagendra
Designation	Manager
Contact	+91 9377511911
Address	223, Napa Talpad, Gana Borsad Road, Taluka Borsad., Anand, Gujarat 388560.



4.3.7. Transvector nozzle for compressed air sanitaryware mould cleaning application

Baseline details

Utilization of compressed air for servicing application such as cleaning and drying is not uncommon and is also not a recommended practice for such applications. The service air points are being used at a pressure of 5.5 kg/cm², resulting in wastage of energy.

For instance, using cleaning air from a hose of ½” dia., at 5.5 kg/cm², the amount of air consumed is approximately 336 CFM. Considering that the compressor operates at a specific energy consumption of 0.18 kW/CFM, the total energy consumed is 60 kW/hr.

For cleaning applications, the volume of airflow is the governing factor and not the operating pressure of the compressed air. Therefore, cleaning can be effectively achieved with a low pressure compressed air as well, thereby saving significant amount of energy.

As per the standards, reduction in the delivery pressure by 1 bar in a compressor would reduce the power consumption by 6 – 10 %. As the compressor is operated a higher pressure than is required, there is a scope of saving energy.



Figure 35: Transvector Nozzle

When compressed air enters the nozzle or jet, it fills a chamber with only one exit path – a thin annular orifice. As air passes through this orifice, the venturi effect of the orifice entrains the free surrounding air as it exits. This results in increased airflow volume more than supplied by the compressed air.

Hence the required volume and pressure required for cleaning application is met by consuming minimum amount of compressed air. Results show that as much as 30 to 40% of the atmospheric air is utilized, thereby reducing the compressed air consumption, which indirectly saves load on the compressor and saves the energy consumed by the compressor.

Cost Benefit Analysis

The expected energy savings by replacing 30 nozzles would be INR 0.84 Lakh with an investment of INR 0.90 Lakh with a payback period of 12 months.

Table 46: Cost Benefit Analysis – Transvector Nozzle

Description	Value	Unit
Number of cleaning points considered	30	Nos.
Flow through 0.5” hose at 5.5 bar pressure (as per standard)	138	CFM
Savings in cfm consumption with per transvector nozzle	69	CFM
Present SEC (Average)	0.18	kW/CFM
Total savings per transvector nozzle	12.42	kW
Average annual operating hours	1,000	Hours
Annual savings	0.84	INR Lakh/annum
Investment required	0.90	INR Lakh
Simple Payback period	12	Months

Benefits and Replication potential

Application of compressed air is common in all sanitaryware mould cleaning application in sanitaryware manufacturing units and implementation of transvector nozzle can be replicated in all the production units.

- ❖ Implementing transvector nozzle indirectly saves load on the compressor and saves the energy consumed by the compressor.
- ❖ By using transvector nozzle, around 40% of the compressed air usage can be reduced

Energy & GHG Savings



Technology Supplier Details

Table 47: Technology Supplier Details – Transvector Nozzle

Description	Details
Equipment Detail	Transvector Nozzle
Supplier Name	General Imsubs P. Ltd
Contact Person	Mr. Kaushalraj
Phone No	+91 9327030174
Address	General Imsubs P. Ltd. 3711/A, GIDC, Phase-IV, Vatva Ahmedabad 382445, India



4.3.8. Maximum demand controller for avoiding excess contract demand penalty

Unit: M/s ESSCE Infrastructure Pvt. Ltd., Tuticorin, Tamil Nadu

Baseline details

In the above unit, from electricity bill it is observed that monthly average actual maximum demand is 291.55 kVA, which exceeds stipulated quota demand of 164.5 kVA. Whereas from the study it is observed that unit's average normal demand at full load operation (with all sections in load) should not go beyond 200 kVA. As a result, unit is paying demand charges @ INR 350/kVA on basic recorded kVA demand as well as excess kVA demand charges after adjustment @ INR 700/kVA. Hence, unit must pay attention more on maximum demand reduction strategy.

Proposed system

Unit has installed a new generation Maximum Demand Controller with at least four relay outputs able to disconnect non-critical loads, on different time periods and avoid connecting loads simultaneously to reduce the instantaneous power.

Non-critical loads are those that do not affect the main production process or that are not essential, such as:

- ❖ Lighting
- ❖ Compressor
- ❖ Office Air-conditioning systems
- ❖ Field Pumps
- ❖ Packaging machines
- ❖ Canteen loads

Maximum Demand Controller should incorporate an internal power analyzer for the maximum demand calculation (it also records electrical parameters such as voltage, current and power). Every time controller detects a power excess, this will disconnect several lines with non-critical loads, reducing automatically the instantaneous power. This will ensure that the installation will reduce the demand, hence reduction of penalties or excess over drawl charges beyond quota limit of electricity bill.



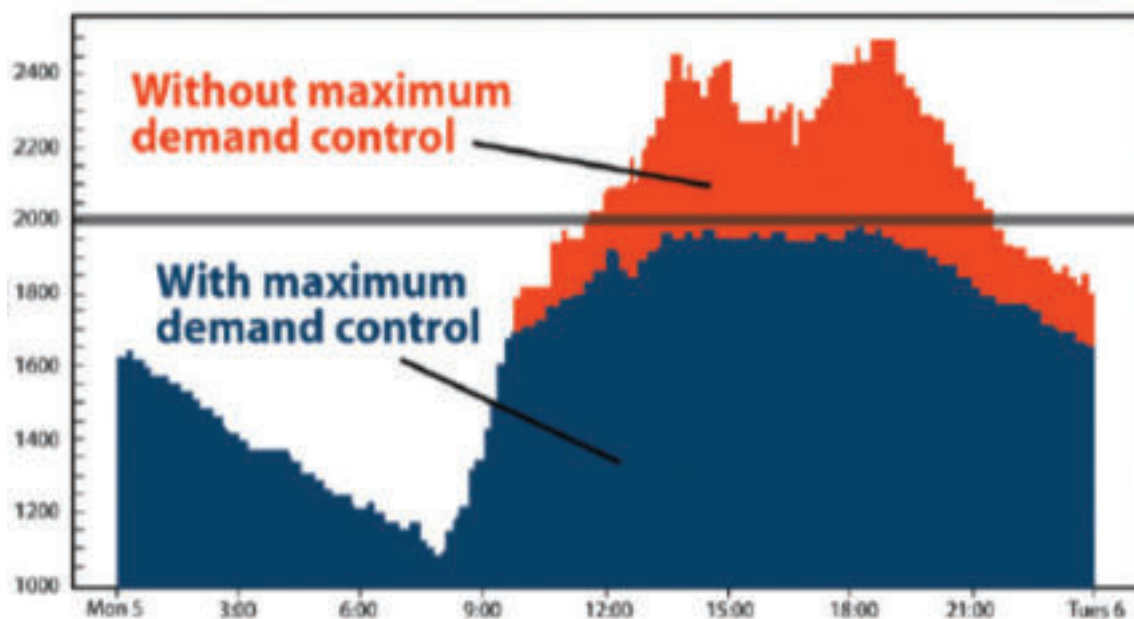


Figure 36: Demand variation with and without demand control

Cost Benefit Analysis

By installing new generation maximum demand controller cost saving potential of INR 2.30 Lakh can be achieved with an investment of INR 2.10 Lakh with a payback period of 11 months.

Table 48: Cost Benefit Analysis – Maximum Demand Controller

Parameter	Value	Unit
Excess demand	27.4	kVA
Excess Demand charges	700	INR/kVA
Annual savings	2.30	INR Lakh/annum
Investment required	2.10	INR Lakh
Simple Payback period	11	Months

Technology Supplier Details

Table 49: Technology supplier details – Maximum demand controller

Description	Details
	Supplier – 1
Supplier Name	Youdit Approaches Private Limited
Contact Person	Mr. Priyaranjan Sinha
Phone No	+919811456950
Address	RPS Palms, Sec-88, Faridabad-121002
	Supplier – 2
Supplier Name	Tirupati Automation
Contact Person	Mr Bhavesh Vamja
Phone No	+919879411415
Address	Shiv Plaza-2, Shop No-14 & 15, Matel Road, At- Dhuva, Ta.Wankaner, Dist. Morbi (Guj)



4.3.9. Power factor correction & harmonic mitigation at main LT incomer

Baseline details

In the existing unit facility, due to harmonic and capacitor deration the power factor at the LT Main incomer is observed to be lower than 0.95 and the total harmonic distortion is observed to be 40%. Existing detuned APFC and normal APFC for reactive compensation was ineffective. Harmonics was very high at load level as well as at LT incomer. Due to reduction of power factor, the kVA billing in the unit facility increased.

Effect of Harmonics:

- ❖ Extra heating/noise of transformers
- ❖ Circuit breaker & protective relays malfunction
- ❖ Erratic operation of computers, telecommunication, video monitors & electronic test equipment
- ❖ Failure of capacitors
- ❖ De-rating of generators
- ❖ Malfunction of measuring instruments
- ❖ Overheating of motors

Proposed system

Fast acting hybrid filter solution at the main LT incomer to improve power factor and active filter for the harmonic mitigation.

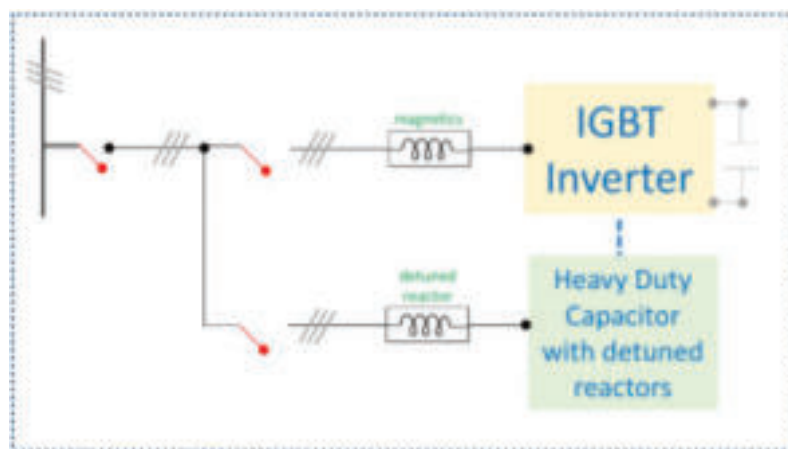


Figure 37: Operation of hybrid filter

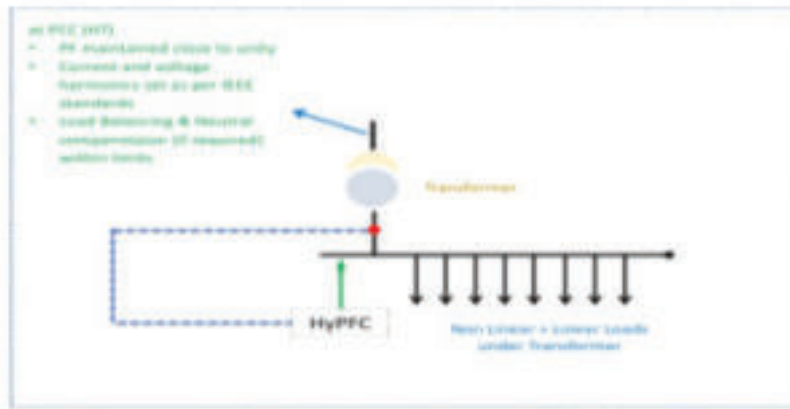


Figure 38: Connection diagram

Hybrid power factor correction system has the following advantages over conventional system (detuned APFC/RTPFC):

- ❖ Instantaneous True PF compensation up to unity
- ❖ Step less reactive compensation
- ❖ Responses in microseconds
- ❖ Leading/Lagging both compensation
- ❖ Harmonics compensation as per IEEE-519 standards
- ❖ Runs on DG as well as grid
- ❖ Maintenance free

S.No.	Feeder Name	Filter Status	Arms (A)				I(THD%)				Power			PF Mean	dPF Mean	Reduction in kVA	Reduction in kVA (%)		
			R	Y	B	N	R	Y	B	N	LW	kVAr	kVA						
ESS-3 Transformer (2000kVA, 11/0.433kV), HPFC (600kVAr)																			
1	Main LT Incomer	OFF	940	884	852	83	10	10	11	8	7	8	726	300	825	0.88	0.88	99	12%
		ON	1019	1012	986	83	7	5	7	6	5	6	726	0	726	1.00	1.00		
ESS-3 Transformer (2000kVA, 11/0.433kV), HPFC (600kVAr)																			
2	Main LT Incomer	OFF	1147	1215	1148	8	6	6	6	4	4	4	792	309	852	0.93	0.93	60	7%
		ON	1093	1156	1091	8	2	3	2	2	2	2	792	-18	792	1.00	1.00		
2.1	ABS Paint shop, A/F-3,	OFF	422	500	458	-	35	33	37	27	30	31	300	83	329	0.91	0.96	10	3%
		ON	405	474	447	-	20	19	20	15	16	16	300	81	319	0.94	0.96		
ESS-4A Transformer (2000kVA, 11/0.433kV), HPFC (400kVAr)																			
3	Main LT Incomer	OFF	1049	946	985	90	14	18	15	12	14	12	765	120	789	0.97	0.99	16	2%
		ON	1107	1006	1045	90	5	6	5	4	5	4	765	69	773	0.99	1.00		

Figure 39: Reduction in KVA with & without operation of hybrid filter

Improvement in power factor leads to reduction in kVA demand thereby reduction in energy consumption and leads to saving in cost.

Cost Benefit Analysis

By installing new generation maximum demand controller cost saving potential of INR 5.00 Lakh can be achieved with an investment of INR 4.50 Lakh with a payback period of 11 months.

Table 50: Cost Benefit Analysis – power factor improvement

Parameter	Values	UOM
Reduction in kVA	15	kVA
Operational hours	16	Hours/day
Operational days	330	Days
Annual savings	79,200	kVAh/annum
Annual monetary savings	5.00	INR Lakh/annum
Investment	4.50	INR Lakh
Simple payback period	11	Months

Technology Supplier Details

Table 51: Technology supplier for power factor improvement hybrid filter

Description	Details
Supplier Name	P2P Power solutions
Contact Person	Mr. Priyaranjan Sinha
Phone No	+91 9811456950
Address	RPS Palms, Sec-88, Faridabad-121002



4.3.10. Installation of VFD on agitator motor

Baseline details

The ceramic unit has underground tanks fitted with agitator motor of capacity 3 hp in each tank for continuously mixing to maintain uniformity and avoid settling of solid particle. Initially when the fresh charge comes from ball mill/blunger, loading on motor is in between 60 to 75%. After some time as the raw material become uniform then loading on motor decreases, the loading on agitator motors is in between 30% to 65%. Also, speed of motors is higher than the required speed for most of the time during agitation process.

Implementation Details

A variable frequency drive (VFD) is a specific type of adjustable-speed drive which controls the speed of motor according to the requirement. The speed of the agitator motor can be reduced by installing variable frequency drive and operating speed can be programmed based on time. This will result in saving in power consumption to the extent of 15% in agitation section.

Cost Benefit Analysis

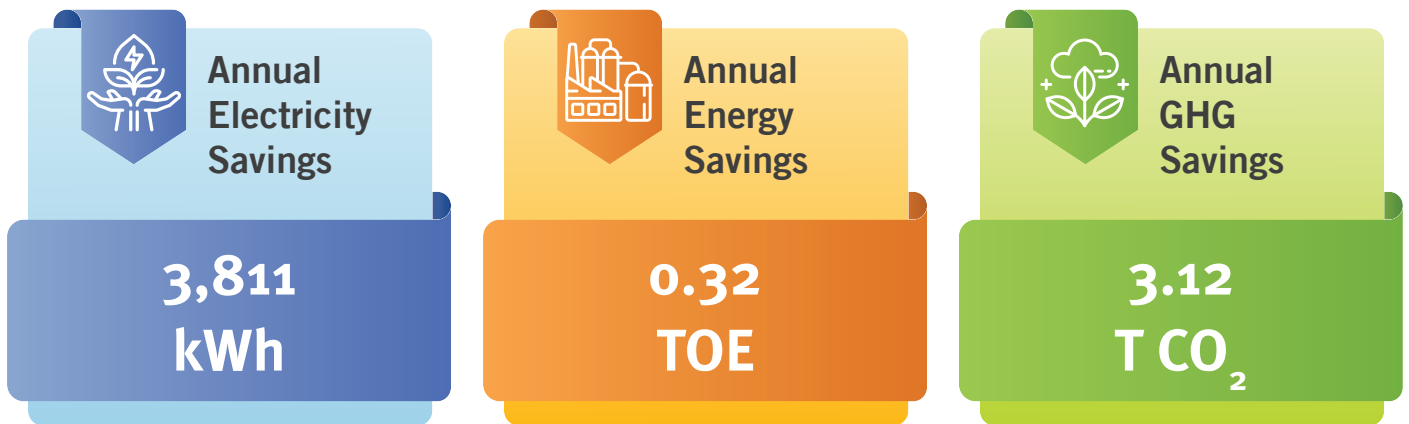
The expected energy savings to be achieved by installing VFD in agitator motor drive is 3,811 kWh annually. The annual monetary saving for this project is INR 0.25 Lakh, with an investment of INR 0.40 Lakh and a payback period of 20 months.

Table 52: Cost benefit analysis – VFD in agitator motor

Parameter	Values	UOM
Motor capacity	3	hp
Agitator quantity	4	Nos
Operational hours	10	Hours/day
Operational days	330	Days
Present power consumption in agitator	25,410	kWh/annum
Power saving	3,811	kWh/annum
Annual monetary savings	0.25	INR Lakh/annum
Investment	0.40	INR Lakh
Simple payback period	20	Months



Energy & GHG Savings



Replication Potential

This method can be adopted in all other units. Also, all new units & green field projects can implement this project.

Technology Supplier Details

Table 53: Technology supplier details for VFD

Description	Details
	Supplier – 1
Supplier Name	Danfoss Industries Pvt Ltd
Contact Person	Mr Hiran Thakkar
Designation	Manager
Contact	Mobile:+ 7940327341
Address	No. 703, 7 th Floor, Kaivanna Complex, Opp. Bank of Baroda, Near Panchwati Cross Road, Ahmedabad-380015
	Supplier – 2
Name of Company	Tirupati Automation
Contact Person	Mr Bhavesh Vamja
Phone No	+91 9879411415
Address	Shiv Plaza-2, Shop No-14 & 15, Matel Road, At- Dhuva, Ta. Wankaner, Dist. Morbi (Guj)



4.3.11. Installation of on-off controller system in agitator motor

Baseline details

The ceramic unit has underground tanks fitted with agitator motor of capacity 3 hp in each tank, for continuously mixing to maintain uniformity and avoid settling of solid particle. Initially when the fresh charge comes from ball mill/blunger, loading on motor is in between 60 to 75%. After some time as the raw material become uniform then loading on motor decreases, the loading on agitator motors is in between 30% to 65%. These motors operate for about 10 hours in a day.

Implementation Details

Installation of automatically ON – OFF control system on the agitator motors do not affect the uniformity (quality) of slurry. It results in 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. This could result in approximately 30% saving in electricity consumption of agitator motors.

Cost Benefit Analysis

The expected energy savings to be achieved by installing on-off controller system is 7,263 kWh annually. The annual monetary saving for this project is INR 0.50 Lakh, with an investment of INR 0.15 Lakh and a payback period of 4 month.

Table 54: Cost Benefit analysis – On-off controller system in agitation system

Parameter	Values	UOM
Motor capacity	3	hp
Agitator quantity	4	Nos
Operational hours	10	Hours/day
Operational days	330	Days
Present power consumption in agitator	25,410	kWh/annum
Power saving	7,623	kWh/annum
Annual monetary savings	0.50	INR Lakh/annum
Investment	0.15	INR Lakh
Simple payback period	4	Months



Energy & GHG Savings



Replication Potential

This method can be adopted in all other units. Also, all new units & green field projects can implement this project.

Technology Supplier Details

Table 55: Technology Supplier details for on-off controller system

Description	Details
Supplier Name	Tirupati Automation
Contact Person	Mr Bhavesh Vamja
Phone No	+919879411415
Address	Shiv Plaza-2, Shop No-14 & 15, Matel Road, At- Dhuva, Ta. Wankaner, Dist. Morbi (Guj)



4.3.12. Installation of energy efficient motor in place of existing conventional motors in agitator system

Baseline details

The ceramic unit has underground tanks fitted with agitator motor of capacity 3 hp in each tank, for continuously mixing to maintain uniformity and avoid settling of solid particle. Initially when the fresh charge comes from ball mill/blunger, loading on motor is in between 60 to 75%. After some time as the raw material become uniform then loading on motor decreases, the loading on agitator motors is in between 30% to 65%. This reduction in motor loading decreases the motor efficiency and thereby results in more electricity consumption. These motors operate for about 10 hours in a day.

Implementation Details

IE3 standard motors will improve motor operating efficiency as compared to old rewinded motors. IE3 motors have superior efficiency and can be operated from 50% to 100% since they have flat curve than conventional motors due to:

- ❖ Increasing the mass of rotor conductors/ conductivity.
- ❖ Precision air gaps to reduce current requirements.
- ❖ Improved winding and lamination design to minimize power consumption.

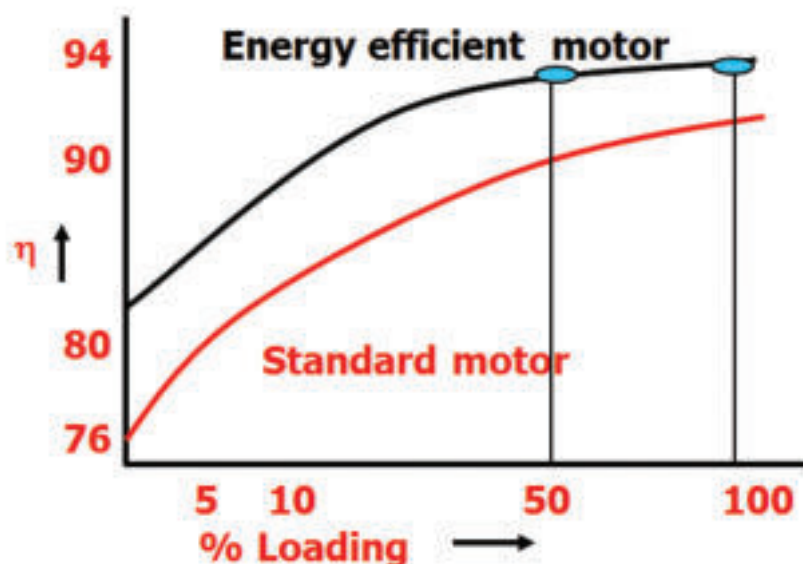


Figure 40: Percentage loading for Energy Efficient motors

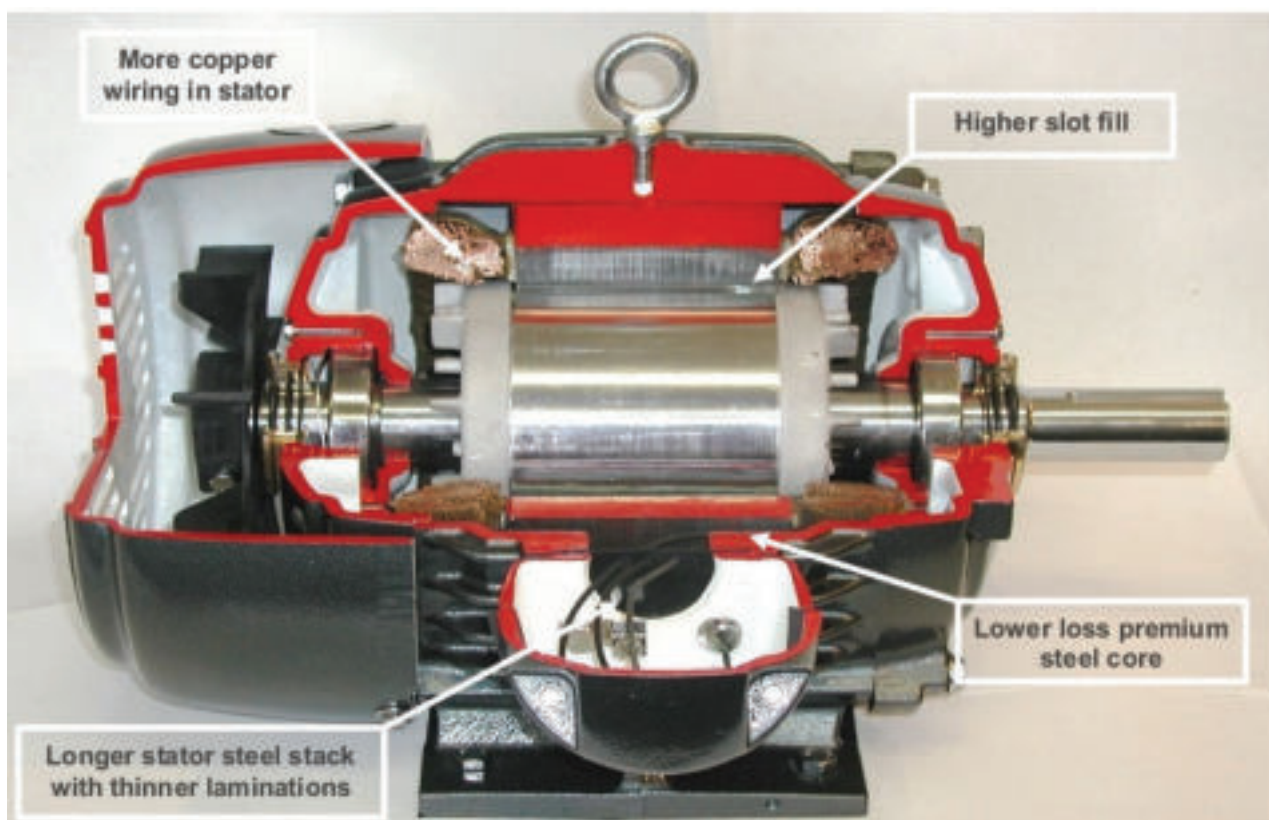


Figure 41: Energy Efficient Motors

Replacement of the existing standard efficiency motors by energy efficient motors will result in significant saving of electricity consumption in agitator motors.

Cost Benefit Analysis

The expected energy savings to be achieved by installing energy efficient motors is 1,964 kWh annually. The annual monetary saving for this project is INR 0.13 Lakh, with an investment of INR 0.50 Lakh and a payback period of 47 month.

Table 56: Cost Benefit analysis – Energy efficient motors in agitation system

Parameter	Values	Units
Motor capacity	3	hp
Agitator quantity	4	Nos
Existing Efficiency (Old motor)	80.00	%
EE motors Energy Efficiency(IE ₃)	86.70	%
Operational days	330	Days
Present power consumption in agitator	25,410	kWh/annum
Power saving	1,964	kWh/annum
Annual monetary savings	0.13	INR Lakh/annum



Raw Material Dosage



Body Preparation



Mould Preparation



Drying



Glazing



Printing



Firing



Final Output

Parameter	Values	Units
Investment	0.50	INR Lakh
Simple payback period	48	Months

Energy & GHG Savings



Replication Potential

This method can be adopted in all other units. Also, all new units & green field projects can implement this project.

Technology Supplier Details

Table 57: Technology Supplier details for on-off controller system

Description	Details
	Supplier – 1
Supplier Name	Rotomotive Drives
Contact Person	Mr Gagendra
Designation	Manager
Contact	+91 9377511911
Address	223, Napa Talpad, Gana Borsad Road, Taluka Borsad, Anand, Gujarat - 388560
	Supplier – 2
Supplier Name	Siemens
Contact Person	Mr Vedavyas Nayak
Designation	Cluster head - Drives
Contact	+919632077220
Address	Birla Aurora, Level 21, Plot No. 1080, Dr. Annie Besant Road, Worli, Mumbai – 400030



4.4. Case studies in renewable energy

4.4.1. Solar rooftop system

Baseline Scenario

Electricity cost constitutes 15 to 20% of total energy cost in a ceramic unit. As the ceramic units are spread across a large land area with broad sheds having significant roof areas, there is significant potential for the units to generate solar power for in-house applications through rooftop solar photo-voltaic (PV) systems. Renewable energy is deemed to be the best substitute for conventional fossil fuel. The ceramic unit has enough rooftop area which can be utilized to install solar PV for self-generation of electricity rather than purchasing from grid. A few ceramic units in Thangadh cluster have installed rooftop solar systems up to 50 kWp and are operating successfully.

The electricity generation potential at a specific location depends on the solar radiation received. The solar radiation received during each month throughout a year at Thangadh is given below:

Table 58: Site Specification – For Solar PV

Parameters	
Location	Latitude: - 22.58, Longitude: - 71.2
Direct Normal Irradiance	5 kWh/m ² /day
Wind	4.1 m/sec
Humidity	49%

The following graphs highlights solar irradiance:

Thangadh, Gujarat 363530, India

Latitude : 22.55 Longitude : 71.25

Annual Average : 5.97 kWh/m²/day

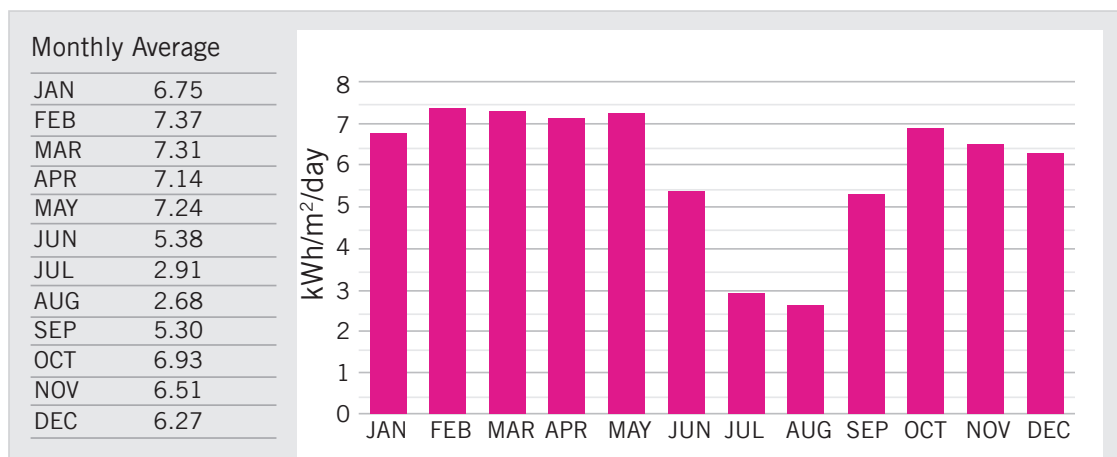


Figure 42: Solar Irradiance



Proposed System

The ceramic units in Thangadh have a significant potential for installing solar rooftop system. A typical 50 kWp solar rooftop system can generate around 0.80 Lakh units of electricity annually. The proposed system will be a grid-tied solar PV power unit consisting solar PV array, module mounting structure, power conditioning unit (PCU) consisting of maximum power point tracker (MPPT), inverter and controls & protections, interconnect cables, junction boxes, distribution boxes and switches. PV Array is mounted on a suitable structure. Grid-tied solar PV system is without battery and should be designed with necessary features to supplement the grid power during daytime. In grid-connected rooftop or small solar PV system, the DC power generated from solar PV panel is converted to AC power using power converter and is fed to the grid either of 33 kV/11 kV three phase lines or of 440V/220V three/single phase line, depending on the local technical and legal requirements.

These systems generate power during the daytime, which is utilized by powering captive loads and feeding excess power to the grid. In case the power generated is not sufficient, the captive loads are served by drawing power from the grid.

Net Metering Business Model – The net metering-based rooftop solar projects facilitate the self-consumption of electricity generated by the rooftop project and allow for feeding the surplus into the grid network of the distribution by the licensee. The type of ownership structure for installation of such net metering-based rooftop solar systems becomes an important parameter for defining the different rooftop solar models. In a grid-connected rooftop photovoltaic power station, the generated electricity can sometimes be sold to the servicing electric utility for use elsewhere in the grid. This arrangement provides payback on the investment of the installer. Many consumers from across the world are switching to this mechanism owing to the revenue yield.

A commission usually sets the rate that the utility pays for this electricity, which could be at the retail rate or the lower wholesale rate, greatly affecting solar power payback and installation demand. The features/ requirements for grid-connected rooftop solar PV system are as follows:

Table 59: Features/requirements for Grid Connected Solar PV Systems (Rooftop)

S. No.	Features / Requirements	Values
1	Shadow free roof area required	10 sq. m or 100 sq. ft. per kWp
2	Roof suitable for Solar PV system	Concrete/ GI/ tin shed (Asbestos may not be suitable)
3	Orientation of the roof	South facing roof is most suitable. Installation may not be feasible beyond 5 deg slope.
4	Module installation	Modules are installed facing South. Inclination of modules should be equal closer to the latitude of the location for maximum energy generation.



S. No.	Features / Requirements	Values
5	Cost of the rooftop solar PV system	<p>MNRE issues benchmark cost for GCRT SPV system and the cost for general category states for 2019-20 are as follows. This includes cost of the equipment, installation and O&M services for a period of 5 years.</p> <p>Above 1 kWp and up to 10 kWp: INR 54,000/ kWp Above 10 kWp and up to 100 kWp: INR 48,000/ kWp Above 100 kWp and up to 500 kWp: /INR 45,000/ kWp</p> <p>Based on discussions with a few project developers, average cost of the system (as per market conditions) is as follows: For 10 kWp system, INR 49,000/ kWp For 50 kWp system, INR 42,500/ kWp For 100 kWp system, INR 37,000/ kWp</p>
6	Useful life of the system	25 years
7	Annual energy generation from Rooftop Solar PV system	<p>18% CUF in 1st year, i.e., 1,578 kWh/ kWp / year 0.7% degradation every year for the useful life of the system. On an average, 1,452 kWh/ kWp/ year would be generated over the useful life.</p>

Merits

- ❖ PV panels provide clean & green energy. During electricity generation with PV panels, there is no harmful greenhouse gas emissions.
- ❖ Technology development in solar power industry is constantly advancing, which can result in lower installation costs in the future.
- ❖ PV panels have no mechanically moving parts, except in cases of sun-tracking mechanical bases; consequently, they have far less breakages or require less maintenance than other renewable energy systems (e.g. wind turbines).

Limitations

- ❖ The initial cost of purchasing a solar PV system is high, which includes paying for solar panels, inverter, batteries and wiring and for the installation.
- ❖ Although solar energy can be still collected during cloudy and rainy days, the efficiency of the system drops, which results in lower generation of energy.
- ❖ Installing a large PV system takes up a lot of space.



Cost Benefit Analysis

The expected savings by installation of 50 kWp solar rooftop is 0.80 Lakh kWh annually. The annual monetary saving for this project is INR 5.60 Lakh, with an investment of INR 18.50 Lakh and a payback period of 40 months.

Table 6o: Cost Benefit Analysis – Solar PV Systems

Parameters	Value	UOM
Proposed roof top solar installation	50	kW
Annual unit generation	1,600	kWh per kW/annum
Total energy generation per annum	80,000	kWh/annum
Electricity cost	7	INR/kWh
Cost savings	5.60	INR Lakh/annum
Investment	18.50	INR Lakh
Simple payback period	40	Months

Energy & GHG Savings



Technology Supplier Details

Table 61: Technology Supplier Details for Solar Rooftop System

Description	Details
	Supplier - 1
Supplier Name	Raijin Solar Energy
Contact Person	Mr Jaydip Agrawat
Designation	Managing Director
Contact	+919574511117
Address	909 to 911, Anand Mangal-3, Behind Kalyan Jewellers, Ambawadi, Ahmedabad, Gujarat 380006
	Supplier - 2
Supplier Name	Mysun Solar
Contact Person	Mr Pravin
Designation	Manager
Contact	+919890285988
Address	Unit No 816, 817 & 818, 8th Floor, Tower-1 Assotech Business Cresterra Plot No 22, Sector 135, Noida, Uttar Pradesh- 201301



4.5. New & innovative technologies

4.5.1. Solar-wind hybrid system

Baseline Scenario

Renewable energy is deemed to be the best substitute for conventional fossil fuel. Implementation of renewable energy posts various challenges, such as capital cost and consistency of power output, of which the latter can be solved by the installation of a Solar – Wind hybrid system. The ceramic units has enough rooftop area which can be utilized to install a solar-wind hybrid system that can harness solar energy and wind energy to generate electricity.

Proposed System

The Solar-wind hybrid system is also known as solar mill. The solar mill generates:

- ❖ Daytime energy from the sun and wind.
- ❖ Day & night energy from the wind energy.
- ❖ Energy even on cloudy days.
- ❖ More energy on hot sunny days due to cooling effect on solar panels by wind.



Figure 43: Solar wind hybrid system

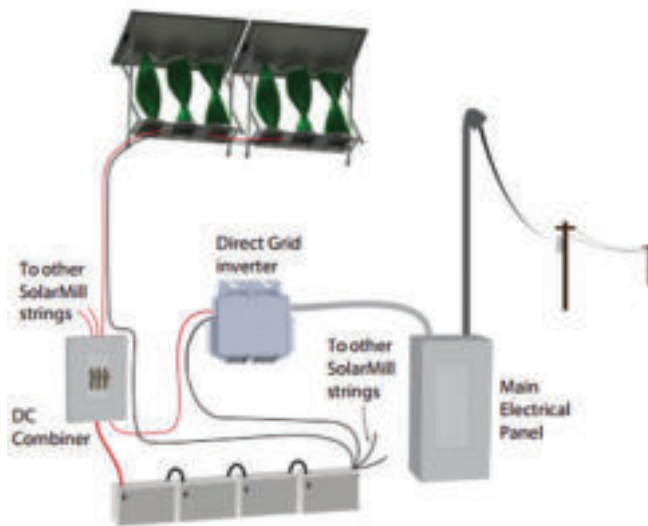


Figure 44: Hybrid mill connected to supply

It consists of three vertical axis wind turbines coupled to three permanent magnet generators. Automatic mechanical braking is provided once the wind speed goes beyond the cut-off speed. On-board smart electronics include dynamic Maximum Power Point Tracking (MPPT). It uses wind and solar resources on a 24/7/365 basis, allowing access to energy and very little interruption of services. The design life of solar mill is 25 years.

Specifications

The increase of renewable power per square foot of roof is obtained by combining two power sources. For a rooftop installation, combining solar and wind power is a complementary combination. For example, many locations are less windy in the middle of the day when the sun is at its peak and the wind picks up after dusk. Other advantages are solar module providing protection for the wind portions of the mechanism from direct rain and hail and assisting with the direction of air into the turbines.

Since this compact installation is designed for rooftops and urban atmosphere, savonous type of wind turbine is chosen for its low running speed and relative insensitivity to turbulence. Power generation begins at a wind speed of 5 kmph. Independent MPPT for both wind and solar is calibrated. Maximum power point tracking (MPPT) is an algorithm included in charge controllers used for extracting maximum available power. The power from both wind and solar generation is routed into a common 48V DC bus which has built-in charge control for a lead acid battery bank.

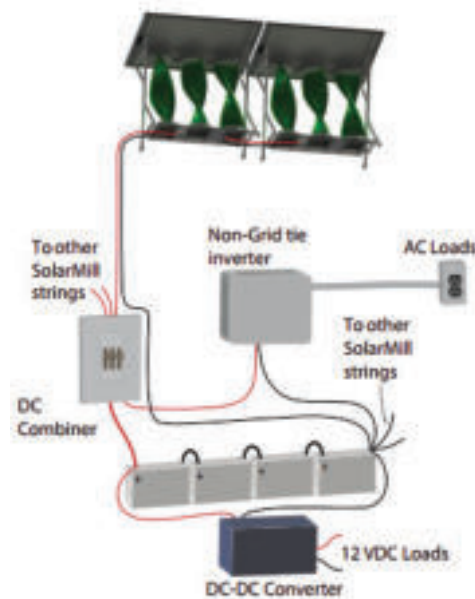


Figure 45: Hybrid mill connected to loads

Modes of Use

In grid-tied system, the bank of batteries is connected to one or more Direct Grid micro-inverters, which connect to the user's electrical panel. The inverters push power back to the

grid efficiently when the batteries become fully charged.

In off-grid storage, the batteries can be used to supply power to electrical devices in off grid settings. This electrical energy can power DC powered devices through a voltage converter, or can power AC devices through an inverter.

Merits

- ❖ Power generation during daytime as well as night-time.
- ❖ Reliable power generation even on cloudy days.
- ❖ A compact hybrid solar mill to meet a portion of the unit's load after detailed study with vendors.
- ❖ Power generation starts at 2-5 m/s and mechanical braking occur beyond 18 m/s.
- ❖ The power generation can be monitored online.

Limitations

- ❖ Higher investment.

Cost Benefit Analysis

The expected savings in electrical energy to be achieved by installation of a 50 kWp Solar - Wind hybrid system is 1.09 Lakh kWh units annually. The annual monetary saving for this project is INR 7.11 Lakh, with an investment of INR 50.00 Lakh and a payback period of 84 months.

Table 62: Cost Benefit Analysis – Solar Wind Hybrid Systems

Parameters	Value	UOM
Installed capacity of solar wind mill	50	kWp
Average generation per day per kWp	6.0	kWh
Area required	60	m ²
Annual operating days	365	Days
Electricity tariff	6.5	INR/kWh
Average annual energy saving on conservative basis	1,09,500	kWh
Annual cost savings	7.11	INR Lakh/annum
Investment	50	INR Lakh
Simple payback period	84	Months



Energy & GHG Savings



Technology Supplier Details

Table 63: Technology Supplier Details – Solar-Wind Hybrid Systems

Description	Details
Supplier Name	Windstream Technologies
Contact Person	Mr. Bhaskar Sriram
Phone No	+91 99599 18782
Address	G2-SSH Pride, Plot 273, Road No-78, Jubilee Hills, Hyderabad 500096



4.5.2. Hydroxy gas combustion in kiln firing in kiln

Baseline Scenario

Ceramic tiles industries are high energy consuming industries mainly thermal energy. More than 35-40% of total cost is energy cost in ceramic tiles industries. Most energy consuming process is the firing process or kiln process. The primary energy use in ceramic manufacturing is for kiln. Natural gas is used for most drying and firing operations. Nearly 30% of the energy consumed is used for drying and over 60% of the energy consumed is used for firing.

Kiln performance is directly related to the temperature maintained & thermal efficiency at various zones of kilns. Hydroxy Gas Generator (HHO) can be used to save 10–15% of fossil fuel consumption without altering the existing system.

Implementation Details

Hydroxy gas is the combination of hydrogen and oxygen gas produced from the electrolysis of water. HHO system is composed of HHO gas unit and hydroxy system combustion system (boiler, furnace etc.). The water fuelization system converts the water into hydroxy gas and makes thermal energy. From the Hydroxy gas, the heat generation device will convert into water energy which has calorific value of 2.56 kCal/Litre.



The ceramic unit can have hydroxy mixed combustion system (min 5% of total energy) to mix with Natural gas in kiln firing and burn Hydroxy Gas with conventional fuel to achieve fuel savings. Hydroxy Gas Generator unit supplies Hydroxy Gas 24 hours into the combustion chamber of existing facility. The Hydroxy Gas is mixed with conventional fuel and burned together. This can result in saving of 5-10% in fuel consumption.

Figure 46: HHO Gas Generator

Cost Benefit Analysis

The expected energy savings to be achieved by installing HHO system is 10,334 Lakh kCal annually. The annual monetary saving for this project is INR 33.51 Lakh, with an investment of INR 80 Lakh and a payback period of 28 months.

Table 64: Cost benefit analysis – Hydroxy gas generator

Parameter	Value	UOM
Natural gas consumption before intervention	8,500	SCM/Day
Operational hours	24	Hours /Day
Operational days	350	Days/annum
Natural gas consumption after implementation of intervention	8,160	SCM/day
Annual gas savings due to implementation of measure	1,11,720	SCM/annum
Cost of natural gas	30	INR/SCM
Total thermal energy cost savings per annum	33.51	INR Lakh/annum
Total investment required to implement this measure	80.00	INR Lakh
Simple payback period	28	Months

Energy & GHG Savings



Replication Potential

This method can be adopted in all other units. Also, all new units & green field projects can implement this project.

Technology Supplier Details

Table 65: Technology supplier – Hydroxy gas generator

Description	Details
Supplier Name	Kankyo Group
Contact number	+91-9150001111
Address	No.11, Ayyavu Street, Ayyavu colony, Amminijikarai, Chennai



4.5.3. Installation of Energy Efficient burners in place of existing old conventional burners in kiln firing

Baseline details

In ceramic unit, kilns are the major source of fuel consumption. Natural gas is used mainly in kiln firing operations. Kiln performance is directly related to the temperature maintained & thermal efficiency at various zones in the kilns. In most of the ceramic units, conventional burners are used for fuel firing in kiln and there is no proper air flow control mechanism for maintaining proper combustion of fuel. The thermal efficiency of the kiln can be improved using high velocity burners. High velocity burners are better for tunnel and shuttle kiln wherein temperature uniformity is important.

About the technology

High velocity burners:

High velocity burners find application where the temperature uniformity within the job is very important for their quality and to have re-circulation of combustion gases.

Energy efficient high velocity burner is characterised with uniform and high flame length. Ceramic product requires temperature uniformly in entire job. High velocity burner with excess air control system can provide the uniform heat transfer for entire job, thereby increasing the quality of ware and efficiency of kiln.

In a kiln, the re-circulation of products of combustion can substantially contribute to the speed of heating and temperature uniformity. For low temperature ovens and dryers, suitable re-circulating fans are generally provided to achieve temperature uniformity. However, fans are not practical for high temperature furnaces and kilns.



Figure 47: High velocity burner



Figure 48: High Velocity Burner with Flame

Excess air can help in re-circulation, but this will result in wastage of fuel. 30% excess air for a 1,100°C kiln will require an additional 24% fuel than stoichiometric firing. In comparison, high velocity gases entrain and re-circulate more than seven times of its own volume will eliminate the need for fans or excess air.

Features of high velocity burners

- ❖ 300 to 1,650°C operating temperatures
- ❖ Inherently low emissions
- ❖ 18,000 to 5,00,000 kCal/hr capacity range
- ❖ 300°C preheated air
- ❖ Wide air/fuel ratio flexibility



Figure 49: Perfect combustion with correct air fuel to ratio



Figure 50: Improper air to fuel ratio

It is recommended to install the high velocity burner with precise control system for air to fuel ratio resulting in increasing the combustion efficiency and utilizing the heat uniformly through entire raw ware. 3-7% of fuel savings can be achieved.

Results:

- ❖ Reduced specific energy consumption in kiln
- ❖ Increased thermal efficiency
- ❖ Reduced fuel (natural gas) costs by 3-7%.

Cost Benefit Analysis

The expected energy savings to be achieved by using high velocity burners in kiln is 1,827 Lakh kCal annually. The annual monetary saving for this project is INR 6.10 Lakh, with an investment of INR 15.00 Lakh and a payback period of 30 months.

Table 66: Cost benefit analysis – Energy efficient burner

Parameter	Value	UOM
Production	14	Tonne/day
Natural gas consumption before intervention	1,540	SCM/Day
Operational hours	24	Hours/Day
Operational days	330	Days/annum
Natural gas consumption after implementation of intervention	1,478	SCM/day
Annual gas savings due to implementation of measure	20,328	SCM/annum
Cost of natural gas	30	INR/SCM
Annual monetary saving	6.09	INR Lakh/annum
Investment	15.00	INR Lakh
Simple payback period	30	Months

Energy & GHG Savings



Technology Supplier Detail

Table 67: Technology supplier details – Energy Efficient Burner

Description	Details
Name of Company	Wesman Thermal Engineering
Contact Person	Mr Tushar Shah
Designation	General Manager
Contact	+91 9879206992
Address	A-442, Sakar-VII Nehru Bridge Corner, Ashram Road, Ahmedabad 380009 T: +91 (79) 40070474

4.5.4. Optimization of water consumption by installation of water softener unit

Baseline details

Water is used for slurry preparation and in tile polishing section in ceramic units. Batch timing and resource consumption (water, electricity and fuel) depends on the water quality. Poor quality of water increases the batch timing and resource consumption. In Thangadh cluster TDS of bore well water is very high. Use of high TDS water for slurry preparation results in higher consumption of water & power per batch of slurry. As the moisture content in slurry increases, due to more TDS, it requires more time and higher coal consumption for drying in spray dryer in tiles manufacturing units. The high TDS of water can be controlled by installing softener unit, which will enable resource savings.

Bore well water is having TDS level of 1,200 to 1,500 ppm which can be improved by installing softener unit which may reduce TDS reduce level by or to less than 500 ppm.

About the technology

Industrial water softener:

The correct balance of minerals of incoming water to industrial systems is essential to the proper operation and maintenance of expensive equipment. It is also imperative to provide a consistent finished product. Industrial water softeners remove excess minerals, such as calcium and magnesium, to a specified and monitored level to continue the industrial process. The process of industrial water purification and softening, takes water that is unfit for industrial use, and turns it into water that is free of sediment and contaminants, with the correct pH balance.



Figure 51: Water softener unit

The system of water softening for industrial purposes requires the incoming water to travel through a porous resin bed. This resin has the appearance and consistency of tiny plastic beads. These fine beads have been constructed and treated so that each tiny bead is exceptionally porous. The surface area is also permanently chemically altered to be highly attractive to the offending minerals. The surface sites of the resin have an affinity for minerals that have an electron charge of positive two and higher, such as calcium and magnesium. Other minerals with a similar valence may also be removed. A complete analysis of the incoming water is essential to the proper operation of the water softening system.

Incoming water enters the water softener vessel that is filled with the resin bed. The velocity of the water slows, spreading over the wider surface area of the bed, and travels through

the millions of tiny beads. During this process, the minerals in the water are attracted to the resin surface areas. The water then exits the resin bed – freed of the laden minerals with little significant hydraulic head pressure drop. The resin bed captures the hardness minerals in the water. However, as the surface area of each bed in the resin is occupied by minerals, the effectiveness of the water softener gradually declines. A complete industrial water softening system has to include equipment to regenerate these resin beds. Usually, there is a duplicate resin bed that can be engaged, so that the initial resin bed has time to refresh. After water is diverted to the second bed, the regeneration of the first bed can be commenced.

The alternative is to shut off the outflowing water during the regeneration process. This may be possible if softened water demand is limited to one or two shifts only.

The resin has a much higher affinity for calcium and magnesium ions, but it will ‘give up’ those when rinsed with water containing a very high concentration of sodium ions (i.e., very ‘salty’ water) and the sodium ions replace calcium and magnesium ions on the resin. Finally, the resin bed is flushed with water to remove excess salt before the bed is placed back into service.

Benefit

Expected benefits of using low TDS water for slurry preparation:

- ❖ Water saving – 5 to 10%
- ❖ Power saving – 2 to 3%
- ❖ Fuel saving – 15 to 20% (in spray dryer)
- ❖ Chemicals saving – 15 to 20%

Technology Supplier Details

Table 68: Supplier details – Industrial water softener

Description	Details
Name of Company	Aqua Filsep Inc
Email	inquiry@aquafilsep.com
Contact	Tel :+91 79 26580047 Mobile : +91 98250 48142
Address	A1/I, Chinubhai Tower, Ashram Road, Ahmedabad – 380 009



4.5.5. Installation of Energy Management System

Baseline details

The energy cost in a ceramic unit accounts for 25-30% of total production cost. In ceramic unit, kilns are the major source of fuel consumption. Natural gas is used mainly in kiln firing operations. Electrical energy is used for the operation of ball mills, compressor, agitators, cast section & kiln auxiliaries. Monitoring the energy use at various equipment will provide feedback and measurement of energy consumption, patterns, trends and will help in identifying opportunity areas in order to reduce energy usage and costs.

Hence for monitoring the consumption of natural gas and electrical energy, ceramic units can install an energy management system and can optimize the energy cost.

About the technology

Energy management system provides the means to controlling and reducing the energy consumption. Installation of energy management system at unit level will monitor the energy consumed by various machines. From this, the benchmark energy consumption can be set with respect to production for the machines. If an increase in energy consumption is noticed for any machine, then the reasons for the increased consumption can be diagnosed and proper remedial actions can be taken.

The energy management system involves metering, data collection, data analysis and interpretation of energy consumption. For measurement of electrical energy multiple energy meters to be installed at various sections like ball mill, slip preparation, cast house and compressor room. Online gas flow can be installed in kiln for measurement of natural gas consumption in the kiln. Energy management system communicates with multiple energy meters and online gas flow meter installed at site location.

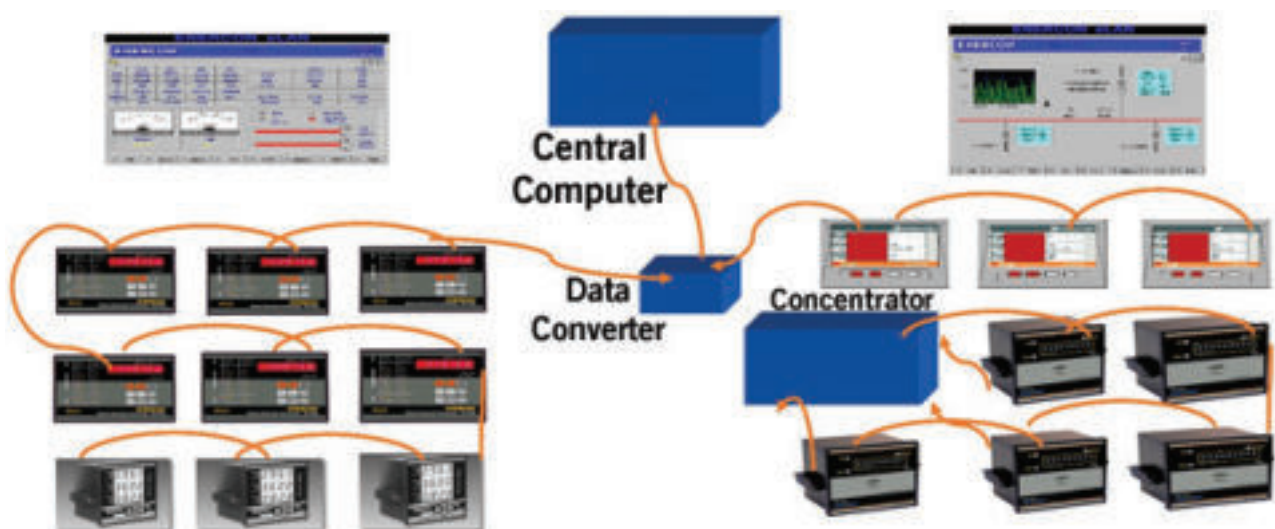


Figure 52: Components of Energy Management System

Implementation of Energy Management System provides the following benefits:

- ❖ Identification and assessment of application and consumption and prioritizing in those areas identified as high consumers.
- ❖ Identification and prioritization of savings opportunities by comparison of economic variables such as initial investment required and the payback period.
- ❖ Defining the baseline energy consumption by comparing the energy performance of the unit before and after initiating the energy management system.
- ❖ Analyzing the trend of energy consumption using the system data and, analyze the performance of the unit in achieving the energy objectives and also establish future energy goals and programs

Results:

- ❖ Reduced specific energy consumption in unit
- ❖ Reduced energy cost by 2- 3% from present levels

Cost Benefit Analysis

The expected energy savings to be achieved by installing the energy management system is 1,030 Lakh kCal and 3,072 kWh annually. The annual monetary saving for this project is INR 3.60 Lakh, with an investment of INR 3.00 Lakh and a payback period of 10 months.

Table 69: Cost benefit analysis – Energy Management System

Parameter	Value	UOM
Production	14	Tonne/day
Natural gas consumption before intervention	1,540	SCM/day
Operational hours	24	Hours /day
Operational days	330	Days/annum
Natural gas consumption after implementation of intervention	1,505.35	SCM/day
Annual gas savings due to implementation of measure	11,435	SCM/annum
Cost of natural gas	30	INR/SCM
Electrical energy (kWh) before intervention	12,800	kWh/month
Electrical energy (kWh) after implementation	12,544	kWh/month
Annual electrical energy savings due to implementation of measure	3,072	kWh/annum
Annual monetary saving	3.60	INR Lakh/annum
Investment	3.00	INR Lakh
Simple payback period	10	Months



Energy & GHG Savings



Technology Supplier Detail

Table 70: Technology supplier details – Energy Management System

Description	Details
	Supplier – 1
Name of Company	Elmeasure India Pvt Ltd
Contact Person	Mr Akash
Designation	General Manager
Contact	Mobile: +918866098020
Address	Ahmedabad, Gujarat
	Supplier – 2
Name of Company	Smart Joules Pvt Ltd
Contact Person	Mr. Akshay Pandey
Designation	General Manager
Contact	Mobile: +919958768838
Address	B-98, Lower Ground Floor, Defence Colony, New Delhi, Delhi 110024



5. Conclusion

In a typical sanitaryware manufacturing unit, kiln firing and raw material blending operations are dominant energy users. Significant energy efficiency improvement opportunities in units exist in kiln firing and raw material blending via waste heat recovery, thermo ceramic coating to reduce the radiation losses in kiln, low thermal mass in kiln furniture, utilization of renewable energy, high alumina balls in glaze ball mill in the place natural stone/pebbles, high speed blunger in place of ball mill and increased automation. Through this compendium, some of the key technologies that are highly replicable in the cluster have been identified and for these technologies the case examples are included.

The identified technologies can be categorized into three heads, namely, Level 1, Level 2 and Level 3, based on the investment requirement and the payback, as follows:

Level 1: Low investment

- ❖ Waste heat recovery in tunnel kiln.
- ❖ Reduction in ball mill power by installation of VFD on ball mill drive
- ❖ Installation of VFD in screw compressor to avoid unloading.
- ❖ Retrofit energy efficient ceiling fans in place of conventional fans.
- ❖ Energy efficient pumps.
- ❖ Energy conservation in compressor by modifying airline system.
- ❖ Transvector nozzle for compressed air sanitaryware mould cleaning application.
- ❖ Maximum demand controller for avoiding excess contract demand penalty.
- ❖ Installation of VFD on agitator motor.
- ❖ Installation of on-off controller system in agitator motor.
- ❖ Installation of energy efficient motor in place of existing conventional motors in agitator system.

Level 2: Medium investment

- ❖ High alumina balls in glaze ball mill in the place natural stone/pebbles.
- ❖ Energy efficient coating to reduce the radiation losses in kiln and reduce fuel consumption.
- ❖ Installation of energy efficient motors in place of old rewinded motors.
- ❖ Improvement of kiln insulation to reduce radiation losses.



- ❖ Excess air control system to maintain optimum air to fuel ratio in kiln.
- ❖ Installation screw compressor with VFD in place of reciprocating compressor.
- ❖ Power factor correction & harmonic mitigation at main LT incomer.
- ❖ Low thermal mass for reduction of kiln car losses in sanitaryware units.
- ❖ Installation of Energy Management System.

Level 3: High investment

- ❖ Solar rooftop system.
- ❖ Solar-wind hybrid system.
- ❖ Hydroxy gas combustion in kiln firing in kiln.
- ❖ Installation of Energy Efficient burners in place of existing old conventional burners in kiln firing.
- ❖ Optimization of water consumption by installation of water softener plant.
- ❖ High speed blunger in place of ball mill for raw material grinding process.

The energy efficiency & renewable energy projects detailed in the case studies in this compendium indicate that there is a good potential for benefits in both low hanging and medium-to-high investment options. The ceramic units in Thangadh can implement the low hanging fruits (with smaller investments) faster, as with minimum or no investments, several savings can be achieved. However, for the high investment projects, a detailed review in the form of DPR can be prepared.

The Thangadh ceramic cluster should view this manual positively and utilize this opportunity to implement the best operating practices and energy saving ideas during design and operation stages and thus move towards achieving world class energy efficiency status.



For more details, please contact



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