MANUAL ON ENERGY CONSERVATION MEASURES IN CERAMIC CLUSTER MORBI

Bureau of Energy Efficiency (BEE)

Ministry of Power, Government of India

Prepared By

SEE - Tech Solutions Pvt. Ltd.

MANUAL ON ENERGY CONSERVATION MEASURES IN CERAMIC INDUSTRY

Based on findings of BEE's SME Program for Morbi Ceramic Cluster

Sponsored by

Bureau of Energy Efficiency (BEE),
Ministry of Power, Government of India, New Delhi
www.bee.nic.in

Executing Agency

SEE – Tech Solutions Pvt. Ltd

11/5, MIDC, Infotech Park, Near VRCE Telephone Exchange,
South Ambazari Road, Nagpur – 440022
Website: www.letsconserve.org

April, 2010

BEE

The mission of Bureau of Energy Efficiency (BEE) is to develop policy and strategies with a thrust on self-regulation and market principles, within the overall framework of the Energy Conservation Act (EC Act), 2001 with the primary objective of reducing energy intensity of the Indian economy. This will be achieved with active participation of all stakeholders, resulting in accelerated and sustained adoption of energy efficiency in all sectors. The setting up of Bureau of Energy Efficiency (BEE) provides a legal framework for energy efficiency initiatives in the country.

Bureau of Energy Efficiency (BEE) is implementing a program (BEE's SME Program) to improve the energy performance in 25 selected SME clusters. The objective of the program is to accelerate the adoption of EE technologies and practices in the chosen SME clusters through knowledge sharing, capacity building and development of innovative financing mechanisms. Further information is available at www.bee-india.nic.in

SEE-Tech Solutions Pvt. Ltd.

SEE-Tech Solutions is a consulting & performance contracting firm for energy cost minimization. Its mission statement is "*Conserve our essential companion – Energy & Environment*", serving since 1993, it has completed more than 500 energy conservation assignments. It has contributed uniquely to the field by developing and implementing knowledge based software solutions: *See-UtiSave* & *See-ThermiSave,* which are being used by many Energy Auditors & Energy Managers. SEE-Tech Solutions is currently developing REEC (Regional Energy Efficiency Centre) with assistance from USAID in its ECO-III project, where in 150 energy conservation measures will be demonstrated for hands on capacity building in Energy Efficiency & Renewable Energy in industries & buildings. In this REEC, requirements of SMEs are duly addressed. Further information is available at www.letsconserve.org

SEE-Tech Solutions is Executing Agency for BEE's SME project in Morbi Ceramic Cluster.

DISCLAIMER

This manual has been developed by SEE-Tech Solutions for BEE on the terms of engagement as Executing Agency. Contents in this report are based on observations made during the field studies at Morbi, data and information provided by the units and based on information generally available to the public from sources believed to be reliable. No representation is made that it is timely accurate or complete. SEE-Tech Solutions has taken due care in compilation of data and information, however SEE-Tech Solutions does not guarantee the accuracy adequacy or completeness of any information and it is not responsible for errors or omissions or for the results obtained from the use of such information and specially states that it has no financial liability to what so ever to the users of this manual. This manual is published with the understanding that SEE-Tech Solutions is supplying information but is not attempting to render detail engineering services, if such services are required the assistance of an appropriate professional organization (Technology suppliers & LSPs) should be sought.

Foreword & Acknowledgement

SMEs have played a very significant role in Indian Economy, be it % of GDP, export or employment. However on technology and production cost front there is substantial potential for improvement through energy cost reduction and corresponding GHG emission reduction.

In BEE's SME Program 25 SME clusters have been identified for implementation of the program. Morbi Ceramic Cluster is one of them. There are more than 450 units and 50 more are coming up. Ceramic manufacturing is highly energy intensive, about 25% to 30% of the production cost is energy cost. It was interesting to find that Morbi SME cluster consumes 40 to 45 x 10^9 MJ of total energy, which is one of the highest in various SME cluster in India. Total energy consumption in Morbi ceramic cluster is about 1% of India's energy consumption. Such high energy consumption is also attributed to the fact that more than 70% of tile manufacturing in India is from Morbi.

Under this program total 75 Energy Audits are carried out in various ceramic units in Morbi which include Vitrified Tiles, Wall Tiles, Floor Tiles, Sanitary wares & others. The study has focused on identifying technology gaps and techno-economically feasible projects to reduce energy cost as well as corresponding GHG emissions. The study has also identified application of renewable energy in Ceramic manufacturing. For implementing the technologies, appropriate vendors/suppliers have been identified and pursued to serve Morbi Cluster. Local Service Providers (LSPs) have also been identified and developed.

This manual serves as a reference document for the units in Morbi cluster covering brief information on BEE's SME Program, Cluster level scenario at Morbi, Summery of Energy Audit findings and Technology assessment, Environmental benefits from identified technologies, Details of energy saving technologies, their saving potential, List of Technology providers, List of LSPs and several other related information so that the SME units can use this manual to understand process wise energy cost in ceramic manufacturing, compare their energy consumption with the benchmark and identify suitable technologies and their suppliers to reduce their energy consumption and thereby energy cost.

The next steps in the project involve developing DPRs (Detail Project Reports) for the identified technologies which will be used by the units for availing finance. SIDBI already has scheme for financing Energy Efficiency projects in SMEs. These DPRs will increase number of projects financed by banks. CDM PINs are also being developed to facilitate CDM projects arising from these identified technologies.

We urge SME units in Morbi Cluster to take advantage of this project, refer to the manual, interact with LSPs, Technology suppliers and forth coming DPRs in detail and implement the projects to reduce the energy cost.

We thank industrial associations at Morbi, Ceramic units, LSPs, Technology suppliers, local banks and all those who took keen interest in the project and development of this manual. We also thank BEE and TERI for their timely advice and support in executing the project.

Milind Chittawar, CEO & MD
SEE-Tech Solutions Pvt. Ltd

Table of Contents

List of Tables

List of Figures

List of Annexure

1.0 ABOUT BEE'S SME PROGRAM

1.1 Project Objectives

Bureau of Energy Efficiency (BEE) is implementing a program (BEE's SME Program) to improve the energy performance in 25 selected SME clusters. Morbi Ceramic Cluster is one of them. Objective of the program is to accelerate the adoption of energy efficient technologies and practices in the chosen SME clusters through technology gap studies, energy audits, benchmarking, knowledge sharing, capacity building at local level and development of readily usable DPRs to facilitate financing of energy efficient projects.

1.2 Expected Project Outcome

Under this BEE SME Program, following outcome is envisaged for Morbi Cluster:

Activity 1: Energy Use and Technology Analysis

This activity has developed information based on the status of Morbi Ceramic Cluster, identification and detailing of all possible energy efficiency measures, their techno-economic feasibility, overall potential to impact energy and environmental scenario. Energy use and status of adaptation of technology in order to improve energy performance of the units in the cluster has been studied and analyzed. 15 technologies/energy conservation measures have been identified preparation of DPR (Detail Project Report). This stage has been completed and findings have been presented in this manual.

Activity 2: Capacity Building of LSPs and SMEs

This activity has been started, LSPs have been identified and capacity creation among local service providers/technology providers in Morbi SME cluster has also been started which is helping the LSPs to undertake implementation of the identified energy efficiency measures.

Activity 3: Implementation of energy Efficiency Measures

Scope of this activity is to facilitate the implementation of energy efficiency measures in Morbi cluster through development of ready to use DPRs to facilitate bank financing. Development of 15 DPRs is in progress.

Activity 4: Facilitation of Innovative Financing Mechanism

As the objective of this activity is to facilitate the uptake of energy efficiency measures through innovative financing mechanisms without creating market distortion, efforts are in progress to develop such mechanisms.

1.3 Project Duration

Complete project duration is about 2.5 years. Project has started in March 2009. Most of the activities will be completed by December 2010. This project will be completed latest by June 2011.

1.4 Identified Clusters under the Program

There are 25 clusters identified under the BEE SME Program, these are as follows:

Table No. 1: List of Identified Clusters under BEE SME Program

Sr.	Name of Cluster/Sector	Product	Number of Units
1	Jamnagar (Brass)	Brass	846
2	Warangal (Rice Milling)	Rice Milling	115
3	Surat (Textiles)	Textiles	415
4	Pali (Textiles)	Textiles	357
5	Morbi (Ceramics)	Ceramics	442
6	Ahmedabad (Chemical Industries)	Process Industries	395
7	Solapur (Textiles)	Textiles	175
8	Alwar	Oil Milling	65
9	Bangalore	Machine Tools	54
10	Batala, Jalandhar & Ludhiana	Foundry	431
11	Bhimavarm	Ice Making	28
12	Bhubaneshwar	Brass	33
13	E & W Godavari	Refractories	44
14	Ganjam	Rice Milling	205
15	Gujarat	Dairy	22
16	Howrah	Galvanizing	57
17	Jagadhri	Brass & Aluminium	91
18	Jodhpur	Limestone	78
19	Jorhat	Tea	60
20	Kochi	Sea Food Processing	35
21	Muzaffarnagar	Paper	18
22	Orissa	Sponge Iron	45
23	Vapi	Chemicals & Dyes	180
24	Varanasi	Brick	122
25	Vellore	Rice Milling	49

2.0 CLUSTER SCENARIO

2.1 Overview of SME Cluster

2.1.1 Cluster Background

Morbi SME Cluster is mainly famous for Ceramic Tiles production and manufacturing over 70% of India's total ceramic tiles production. The nearest airport is at Rajkot, which is 67 Km from Morbi by road. From Ahmedabad, Morbi could be reached by Railway as well as by Road; the distance is about 184 KM. Taxis are available from Rajkot as well as Ahmedabad to reach Morbi.

There are approximately 479 ceramic units in this cluster which are engaged in manufacturing of Wall Tiles, Vitrified Tiles, Floor Tiles, Sanitary wares, Roofing Tiles and others. There are around 50 more ceramic units coming up in Morbi.

2.1.2 Products Manufactured

Different types of ceramic products manufactured in Morbi SME cluster are as follows:

Table No. 2: Ceramic Industrial Units at Morbi & their % share

Sr.	Type of Industry	Units	%
1	Wall Tiles	178	37 %
2	Vitrified Tiles	36	8 %
3	Floor Tiles	52	11%
4	Sanitary Wares	43	9%
5	Spray Dryer Mud Manufacturing Units	40	8%
6	Roofing Tiles (seasonal operation)	120	25%
7	Third Firing Manufacturing (Producing pictures on tiles)	10	2%
	Total	**479**	**100%**

2.1.3 Classification of Units

The ceramic units can be categorized based on the basis of type of product and the production capacity of the plant, viz.

1. Wall Tiles
2. Floor Tiles
3. Vitrified Tiles
4. Sanitary Wares

Table No. 3: Ceramic Units at Morbi, Production Wise Breakup

Type of product	No. of Units.				Production (Boxes/day)			
Scale of Unit	Small	Medium	Large	Total	Small	Medium	Large	Total
Wall Tiles	43	100	35	178	2,500	3,500	7,500	13,500

Type of product	No. of Units.				Production (Boxes/day)			
Scale of Unit	**Small**	**Medium**	**Large**	**Total**	**Small**	**Medium**	**Large**	**Total**
Floor Tiles	8	38	6	52	3,000	4,000	7,000	14,000
Vitrified Tiles		22	4	26*		4,000	8,000	12,000
Sanitary Wares	10	24	9	43	300	600	1,000	1,900

* - in case of vitrified tiles during our audit, 10 vitrified tiles units are proposed units. Therefore, we not able to consider the proposed vitrified units category wise. Presently the vitrified units are 26 but within 1.5 year this 10 vitrified units will be in operation.

Table No. 4: Morbi Ceramic Cluster Total Production, Turnover and Employees

Sr.	Data	Value
1	Total Cluster Production (KT/Yr)	4,749
2	Total Cluster Turnover (Crore Rs./Yr)	3,529
3	Total no. of employees	67,750

2.1.4 Production Capacity (In Tonnes or Pieces per Year) Detail

Average annual production in a typical ceramic unit for different types of product category is as follows:

Table No. 5: Annual Production of Ceramic Products in a Typical Ceramic Industry

Sr.	Type of Industry	Production in a Typical Unit*
1	Vitrified Tiles	7,55,879 to 13,76,289 Boxes/year
2	Wall Tiles	6,33,053 to 38,09,931 Boxes/year
3	Floor Tiles	14,93,322 to 42,76,309 Boxes/year
4	Sanitary Wares	5,23,496 to 7,74,389 Pieces/year

* Details:
In Vitrified Tiles, one box contains 4 tiles (size 600 mm x 600 mm),
In Wall and Floor tiles one box contains 84 tile (size 4 inch x 4 inch), 44 tiles (size 6 inch x 6 inch), 90 tiles (size 8 inch x 3 inch) , 25 tiles (size 8 inch x 8 inch), 15 tiles (size 8 inch x 12 inch), 13 tiles (size 10 inch x 10 inch), 10 tiles (size 10 inch x 13 inch), 8 tiles (size 10 inch x 16 inch), 5 tiles (size 13 inch x 24 inch), 10 tiles (size 12 inch x 12 inch), 7 tiles (size 12 inch x 18 inch), 6 tiles (size 16 inch x 16 inch).

2.1.5 Raw Materials Used

The raw Material used is clay which is supplied from Rajasthan and Gujarat, various additives are also used such as feldspar, silica etc.

2.2 Energy Situation in the cluster

2.2.1 Types of Fuels Used and Prices

Details of different types of fuels used in Morbi ceramic cluster along with their price and calorific value is as follows:

Table No. 6: Types of Fuel Used and Prices*

Sr.	Type of Energy	Price of Fuel, Energy	Calorific Value
1	Electricity	Rs. 4.92 to Rs. 5.84 per kWh	-
2	Natural Gas**	Rs. 14 to 17 per SCM	8,800 Kcal/SCM
3	Charcoal	Rs. 8 per Kg	6,500 Kcal/Kg
4	Lignite	Rs. 1.5 per Kg	3,500 Kcal/Kg
5	Saw Dust	Rs. 1.5 per Kg	4,801 Kcal/Kg
6	Indonesian Coal	Rs. 2.7 per Kg	5,500 Kcal/Kg
7	Biomass based Briquette	Rs. 3.5 per Kg	4,000 Kcal/Kg
8	HSD	Rs. 35 per lit	11,000 Kcal/Kg

* Reference period is July 2009 to December 2009

** It has been observed that Natural Gas price has reducing in past few years. The reduction has been observed from 23 Rs/SCM to 15 Rs/SCM.

2.2.2 Fuels and Electricity Consumption in a Typical Unit

Average thermal fuel and electricity consumption in a typical ceramic unit considering the minimum and maximum capacity ceramic units are as given below

Table No. 6: Fuel and Electricity Consumption in a Typical Unit

Type of Energy	Electricity (KWh/day)			Natural gas (SCM/day)			Solid Fuel (in terms of lignite), Kg/day		
Scale of Unit	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Wall Tiles	3,000	5,000	8,000	2,500	3,500	7,500	8000	9600	12000
Floor Tiles	3,000	5,000	8,000	3,000	4,000	7,000	12000	14000	16000
Vitrified Tiles	*NA	20,000	40,000	NA	9,000	20,000		20000	30000
Sanitary Wares	800	1,500	3,000	400	800	1,400	NA	NA	NA
Application	To drive all motive loads & lighting			Fuel for Kiln, Spray Drier, Drier			Fuel for Spray Drier, Drier & Kiln through direct combustion or gasifier		

* NA - Not Applicable

2.2.3 Specific Energy Consumption (In Appropriate Unit)

Based on the data provided by the units in the cluster Specific Energy Consumption for thermal and electrical energy has been calculated, which is as follows. Here in if solid fuels are also use then their equivalent NG consumption is calculated and provided below.

Table No. 7: Specific Energy Consumption Range in Ceramic Units in Morbi

Sr.	Type of Industry	Electrical Energy Consumption		Thermal Energy (Natural Gas)	
		Value	Unit	Value	Unit
1	Vitrified Tiles	3.71 to 5.01	kWh/m2	1.51 – 2.11	SCM/m^2
2	Wall & Floor Tiles	1.51 - 1.92	kWh/m^2	1.28 - 1.8	SCM/m^2
3	Sanitary Wares	57- 128	kWh/MT	81.48 - 110	SCM/MT

2.3 Manufacturing process/technology overview in a typical unit

2.3.1 Process Technology

Manufacturing process and technologies that are in use in Morbi Ceramic Cluster are as follows. The technologies that are used elsewhere in the world in ceramic manufacturing but not used in Morbi (or that are less popular in Morbi) are also covered.

Production Process of Wall/Floor/Vitrified tiles:

Process flow diagram for Wall, Floor & Vitrified tiles is shown in item 2.3.2.

Wet Grinding

Raw materials such as clay, feldspar, quartz, calcite etc. are mixed with water in a proper proportion and are grinded in a ball mill to make a homogeneous mixture. Ball Mill is a batch type of process. After completion of one batch of ball mill, slurry is taken in to the underground tanks fitted with agitator motor in each tank to maintain the uniformity of mixture (i.e. avoiding settling of solid particles). Ball mills and blungers are used for grinding.

Continuous wet grinding process/technology also exists but it is not in use in Morbi. Dry grinding technology is also available but it is also not in use in Morbi. This is mostly due to non suitability of raw material in Morbi for dry grinding process.

Spray Drying

After preparation of the slurry of required density, it is stored in underground tanks, which are continuously agitated to maintain uniformity of the slurry. Slurry is then pumped through a hydraulic pump into the spray dryer where the slurry is sprayed through nozzles. Material is dried in spray dryer, thus the moisture which is added during the grinding process in the ball mill is removed in the spray drier. Input moisture to spray drier is 35 to 40%, which is dried to 5 to 6 %. Product from the spray dryer is then stored in silos. Hot flue gases at a temperature of about 550 to 600 ^oC is used as heating source;

hot gases are generated by combustion of variety of fuels such as lignite, Indonesian coal, saw dust, briquette, natural gas through direct combustion as well as through gasifier.

As of date, Co-generation technology is not in use in Morbi Ceramic units. However with increase in exposure on gas turbine technology some of the units in Morbi are seriously considering co-generation. Specifically tile manufacturing units have good potential of co-generation, which in principle means, at the operating cost level co-generation technology can generate electricity almost at the utility (PGVCL) cost and can make spray drying energy cost almost free as the hot exhaust of the gas turbine is sufficient for spray drying. In case of Morbi natural gas price is reducing while electricity tariff has increased in past few years.

Pressing

The product from the spray dryer is then sent to the hydraulic press where the required sizes of biscuit tiles are formed and sent to dryer through conveyer.

In press, advanced technology is available which enables 3 step pressing to single step pressing, which improves productivity.

Drying

After press, biscuits containing about 5% to 6% moisture are sent to drier and dried to about 2% to 3% moisture level in case of vitrified tiles. In case of wall and floor tiles, biscuits are directly baked to a temperature of about 1100 to 1150 ^{o}C and after glazing, it is baked again. In some ceramic units, hot air from kiln cooling zone exhaust is used in dryers which saves energy consumption in driers.

Glazing

After drying, biscuit tiles are sent for glazing on the glaze line. Glaze is prepared in ball mills. Glazing is required for designing on tiles.

Firing and Baking

After glazing, the biscuit tiles are sent for final firing in the kiln. The glazed tiles are fired at a temperature of 1100 to 1150 ^{o}C in the kiln. Natural gas as well as producer gas from gasifier is used as fuel in the kiln.

Sizing

Tiles coming out of the kiln are sent for sizing and calibration in case of wall and Floor Tiles. The tiles are cut to proper sizes so that all tiles have same dimensions. After sizing finished product is sent for dispatch.

Polishing

Polishing is required for Vitrified Tiles. Polishing utilizes 40% to 45% of total electricity consumption in case vitrified units. After kiln the vitrified tiles are passed through polishing line. Polishing line consist of sizing, calibration and polishing machines.

Production Process of manufacturing of Sanitary Wares

Difference between manufacturing process of tiles and sanitary wares is the moulding process. In case of sanitary wares, manual moulding is carried out whereas in case of tiles hydraulic press is used to form the biscuits. The general process flow diagram for Sanitary Wares is shown in item 2.3.2.

Wet Grinding

The raw material is mixed with water in a ball mill where wet grinding is carried out in order to increase the fineness of the material. The slip/slurry, that is formed, is kept agitated in agitator tanks to homogenize the solution.

Moulding

The slip (slurry) is poured into the moulds by a hand held hose. The slip is pumped through a hydraulic pump into the mould.

Drying

The cast wares are then dried in natural environment with the help of ceiling fans.

Glazing

The dried wares are then glazed in spray glazing booths, where compressed air is used for spray glazing.

Firing

The glazed wares are then fired in the kilns up to a temperature of 1200 ^{o}C where the natural gas is used as a fuel. The output from the kiln is inspected before packaging and dispatch.

2.3.2 Process Flow Diagram

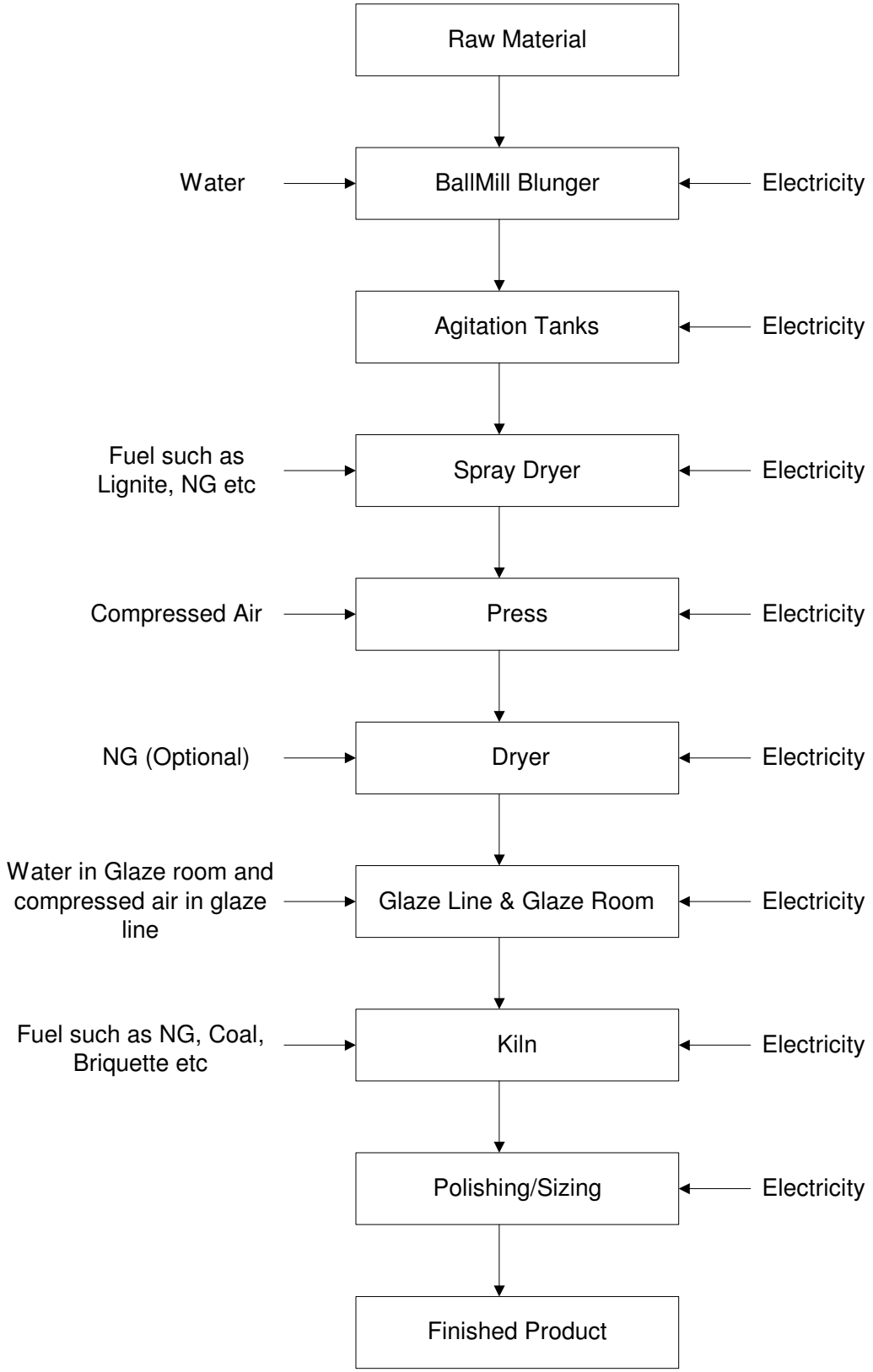

Figure No. 1: Process Flow Diagram of Wall/Floor/Vitrified Tiles

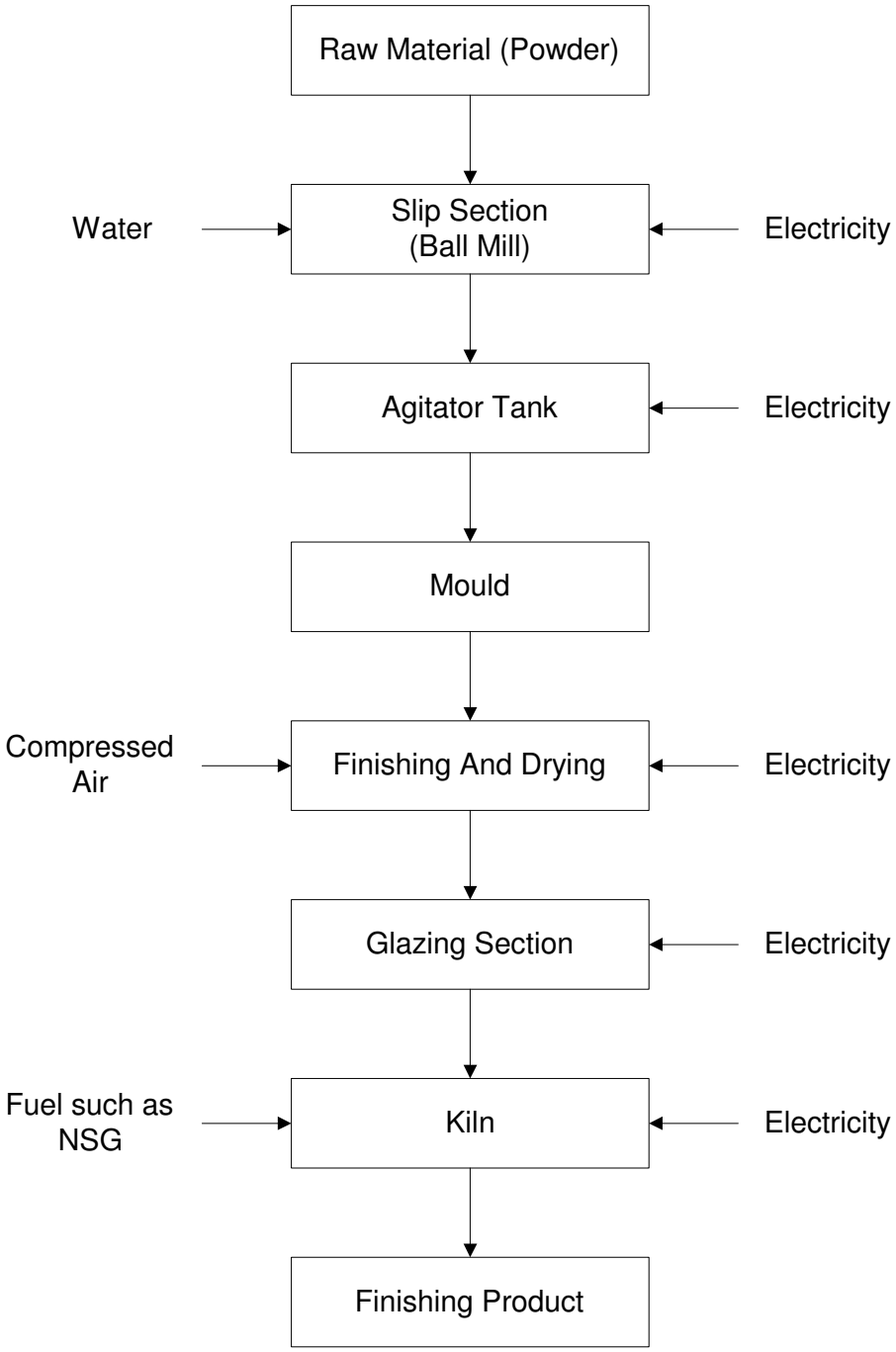

Figure No. 2: Process Flow Diagram of Sanitary Wares

2.4 Current Policies and Initiatives of Local Bodies

Table No. 8: Details of Associations of Morbi Ceramic Cluster

Sr.	Name of Association	Contact Details	Activities performed
1.	Gujarat Ceramic Floor Tiles Manufacturers' Association **Address:**8 - A, National Highway, 2 - Bhagwati Chamber, Morbi-363642	Mr. Becharbhai Patel - 09825230692	♦ Work for arranging various seminars, ♦ Arrange workshops, ♦ Inviting various agencies etc. apart from representing the cluster to various government organizations and business forums
2.	Morbi Sanitary Wares Manufacturers Association **Address:**8 - A, National Highway, 2 - Bhagwati Chamber, Morbi-363642	Mr. Vijaybhai Patel 02822 - 240053, 240968	♦ Work for arranging various seminars, ♦ Arrange workshops, ♦ Inviting various agencies etc. apart from representing the cluster to various government organizations and business forums
3.	Morbi Dhuva Glaze Tiles Association **Address:**8 - A, National Highway, 2 - Bhagwati Chamber, Morbi-363642	Mr. Becharbhai Patel - 09825230692	♦ Work for arranging various seminars, ♦ Arrange workshops, ♦ Inviting various agencies etc. apart from representing the cluster to various government organizations and business forums
4.	Gujarat Granito Manufacturing Association **Address:**8 - A, National Highway, 2 - Bhagwati Chamber, Morbi-363642	Mr. Becharbhai Patel - 09825230692	♦ Work for arranging various seminars, ♦ Arrange workshops, ♦ Inviting various agencies etc. apart from representing the cluster to various government organizations and business forums
5.	Morbi Roofing Tiles Manufacturing Association **Address:** Savsar Plot Main Road, Near old bus stand, P.O.No. 130, Morbi	Mr. Jayantilal Patel - 09825224900, 02822 – 240100	♦ Arrange seminars, ♦ Arrange workshops for awareness against the availability of financial funding

2.5 Issues Related To Energy Usage and Conservation and Barrier in Technology Up-Gradation

2.5.1 Energy Availability

There is no problem about availability of electrical and thermal energy at Morbi. Weekly electrical load-shedding is there. Thermal fuels are easily available. Natural gas is supplied by GSPC (Gujarat State Petroleum Corporation). There is good network for natural gas supply in Morbi. Most of the units are having their own DG sets to generate electricity in absence of grid power. Gujarat Mineral Development Corporation provides monthly quota for coal procurement to the units. Various forms of biomass are also used as a source for thermal energy. Various forms of biomass such as briquette, saw dust, wood etc. are also used as a source for thermal energy.

Though there is good potential for co-generation, but no plant has yet commissioned gas turbine or gas engine based co-generation. Interest in gas turbine based co-generation has started picking up in the cluster and within a few months (in 2010) it is expected that co-generation plants will be commissioned and put in use.

The cluster started with kerosene as thermal fuel in early 90s, then in mid 90s shifted to LPG. After 2000, as the cost of the energy from LPG was higher as compared to that from coal based gasification, units shifted to producer gas (generated by partial combustion of solid fuel through Gasifier). However in past few years, when the natural gas reached Morbi, many units started using Natural Gas for the kiln. Gasifier (producing producer gas) and potrifier (equipment using fluidized bed coal combustion to deliver hot flue gas) still remained as most chosen source of energy for spray dryer. With passage of time and quality related issues, some of the units took initiative and shifted their spray dryer operations on Natural Gas. Now those who have opted for Natural Gas based drying are seriously considering co-generation. Over a period of time, Natural Gas prices have reduced while grid electricity prices are going up thus making a stronger case for co-generation.

2.5.2 Technological Issues

In Morbi cluster, overall technical understanding on ceramic manufacturing is good and rapidly increasing. Important equipments like kiln, polishing machine etc are bought from Italy (Sacmi) and China (Modena), which are leading suppliers of these equipments world over. Many of the unit owners are frequently visiting international ceramic fairs and ceramic process equipment suppliers, thus keeping them informed. In past few years variable frequency drives have been adopted widely. It has been observed that at cluster level there is committed interested for leadership and following up is quick. In general, there is readiness to adopt provided delivery, outcome and results are demonstrated.

However the first change is still a challenge, upon success, later on duplication and adaptation is extremely prevalent in the cluster. The technologies need to be demonstrated within the cluster. While carrying out the audits and presenting the Energy Audit reports to the units, in the discussion with the plant owners & other personnel, many of them agreed with many of the identified energy saving measures and technologies but they demanded demonstration of the energy saving technologies in any plant and thereafter they have readiness to follow.

2.5.3 Financial Issues

Availing finance is not the major issue. Among the SMEs, the larger units, if convinced, are capable of either financing it themselves or get the finance from their banks. The smaller units will require competitive loan and other support to raise the loan. However as most of them have been able to expand their setup and grow, there is readiness to spend for energy efficiency technologies which have good returns. Energy Efficiency Financing Schemes such as SIDBI's, if focused on the cluster, will play a catalytic role in implementation of identified energy conservation projects & technologies.

The cluster has significant potential of co-generation through gas turbine, which can free over 100 MW from the grid in coming 3 years. However though there are good returns, this project is highly capital intensive and requires support of policy as well as innovative financial mechanisms. Initiative has already been taken by some of the units to install gas turbine based co-generation. Reputed Gas Turbine manufacturers have also started giving due focus to the cluster for adaptation of co-generation. CDM needs to be duly applied to generate additional cash flow to further improve the returns from the project.

2.5.4 Manpower Related Issues

At Morbi ceramic cluster, availability of skilled manpower is one of the limitations. Number of ceramic units has grown fast as compared to the availability of skilled manpower. One local technical person available at Morbi takes care of about 5 to 10 ceramic units. For major equipments like Kiln, Polishing Machine etc. maintenance or the repair work of these equipments is taken care by the equipment suppliers themselves. Even international suppliers like Sacmi, KEDA, Modena depute at least one of their representative at Morbi for the maintenance work. For other issues, Local technical persons at Morbi take care of most of the matters.

Specialized and focused training of the local service providers on better operation and maintenance of the equipments, importance of the energy and its use and energy conservation measures will improve awareness among the unit owners and workforce. Original equipment suppliers should also participate in these programs.

2.5.5 Technology & Service Providers Related issues

Many of the new technology provider's (especially some foreign technology leaders) have not shown keen interest in implementation of their new innovative technologies. This appears to be because of fear of duplication.

3.0 ENERGY AUDIT AND TECHNOLOGY ASSESSMENT

3.1 Methodology Adopted For

3.1.1 Energy Use and Technical Study

3.1.1.1 Pre-Energy Audit Activities

Methodology adopted for pre - energy audit activities has been as follows:

1. Based on the situation analysis data provided by BEE on Morbi ceramic cluster, the activities were evolved and planed accordingly. Three ceramic units were visited and observed in detail to get deeper understanding of the energy issues in the industry before starting the work.
2. Visited the associations and met with the officials of the associations, taken their feedback and views.
3. Based on the visit, identified high energy consuming equipments and analyzed ongoing technologies and started identifying gaps at the cluster level.
4. Prepared the data collection and equipment measurement format for the energy audit and its field measurements
5. Prepared a list of 75 units to be audited taking care that all types and sizes are covered.
6. Depending on visit to the 3 units, started identifying possible energy conservation areas.
7. Finally classified the units to be studied as:

    - Wall Tiles
    - Floor tiles
    - Vitrified Tiles
    - Sanitary Wares

Allocation of one person (who can also speak local language) from our team to work full time to convince the plant owners/persons to get ready for conducting the energy audit

Used local maps, books and information provided by association to get further details on the cluster

3.1.1.2 Preliminary Energy Study

Number of preliminary energy audit studies was done in 52 ceramic units

Methodology adopted for Preliminary Energy Audit study has been as follows:

1. Collection of the past one year electrical and thermal energy consumption data
2. Establishment of the energy consumption scenario at the plant
3. Establishment of the benchmarks of specific energy consumption of typical equipments wherever possible
4. Study of major energy consuming equipments at the plant
5. Identification of major energy consuming sections and further work on identification of energy conservation opportunities
6. Detailing of no cost and low cost saving measures at the plant.
7. Identification of the areas for detailed study and listing the measurements required
8. Modified previous formats for data collection and measurements and finalized them for detail energy audit study

3.1.1.3 Detailed Energy Study

Number of detailed energy audit studies was done in 23 ceramic units

Methodology adopted for Detail Energy Audit study has been as follows:

1. Detail observations on the equipments in terms of their functions, energy requirements
2. Electrical measurements on the electrical equipments by Load Analyzer which includes the measurement of Voltage, Current, kW, PF on the equipments such as transformer, motors, capacitors, air compressors, blowers etc.
3. Thermal measurements which include the temperature measurement by thermocouple and thermal imager, %CO2 in flue gas measurement by orsat apparatus which are crosschecked by Oxygen analyzer, air velocity measurement by anemometer etc on equipments such as kiln, dryer, spray dryer etc.
4. Arriving at energy balance and Specific Energy Consumption at plant level and process level
5. Carried out all the required measurements to quantify specific energy consumption at each of the major process steps for electrical energy consumption - i.e. kWh/MT or kWh/m^2 & Rs./MT or Rs/m^2 at Ball Mill, Agitation, Spray Dryer, Press, Kiln and Polishing Section and for thermal energy consumption – i.e. NG in SCM/m2 or SCM/MT at Spray Drier, Drier & Kiln
6. Developed process benchmarks by identifying ongoing best practices so as to promote their repetition in the cluster
7. Identification of alternative lower energy consumption or lower energy cost option to deliver same process function
8. Analyzed saving potential and investment required accordingly prioritized the measures and identified 15 technologies for preparation of DPR

Technical audit involves the following:

- In technical audit the technologies and processes used and equipment details have been studied.
- Compare the specific energy consumption of equipments of ceramic plants
- The capacity utilization to the total capacity installed has been studied
- Study of present technologies used in different types of ceramic industries used at Morbi
- Study the availability of new technologies and local service providers at Morbi
- Discuss with the clients on the constraints of adopting the energy efficient technologies such as energy efficient motors etc in their plants.

3.2 Observations Made During the Energy Use and Technology Studies Carried Out In the Cluster

3.2.1 Manufacturing Process and Technology/Equipments Employed

The manufacturing processes followed in all types of industries are same as covered in item 2.3.1 List of the major equipments employed is as follows:

a. Ball Mill/ Blunger
b. Agitators
c. Spray Dryer

d. Press
e. Vertical or Horizontal Dryer
f. Glaze Ball Mill and Glaze Line
g. Kiln
h. Sizing or Polishing in case of vitrified tiles Machine

3.2.2 Energy Consumption Profile & Availability

At the cluster level, Energy consumption profile & availability of various energy sources is as follows:

Table No. 9: Energy Consumption Scenario at Morbi Ceramic Cluster

Sr.	Type of Fuel	Quantity used/ annum	Unit	GJ/ annum	%	Availability
1	Electricity	1,200,000,000	Kwh/annum	4,317,888	8.23%	Available in required quantity
2	Natural Gas	660,000,000	M3/ annum	24,300,672	46.32%	Available in required quantity
3	Charcoal	165,000,000	Kg/ annum	4,487,340	8.55%	Available in required quantity
4	Lignite	1,320,000,000	Kg/ annum	19,330,080	36.84%	Available in required quantity
5	Diesel	800,000	lit/ annum	31,296	0.06%	Available in required quantity
	Total	**3,345,800,000**		**52,467,276**	**100.00%**	

3.2.3 Capacity Utilization Factor

Capacity utilization factor at the plant level and at the equipment level is described below:

Plant Level:

1. Wall and Floor tiles units operate on almost full capacity throughout the year. Units are shuts down for only 10 to 20 days in a year. Major maintenance is carried out in this period
2. Vitrified tiles units operate on almost full capacity throughout the year. Units are shuts down for only 10 to 15 days in a year. Major maintenance is carried out in this period.
3. Sanitary wares units operate on partial load depending upon the demand.
4. Roofing tiles units operate for about 5 to 6 months in a year and are highly seasonal.

Equipment Level:

1. Ball Mill/Blunger is a batch process and operates on a full capacity
2. Spray dryer operates for about 15 to 20 days in a month because of need of maintenance or requirement of cleaning. Therefore, spray dryer of higher capacity is installed.
3. Press operates on its full load capacity
4. Loading on kiln is almost on its full capacity utilization
5. In vitrified tiles units, Polishing machine operates only 18 to 20 days in a month.

3.2.4 Housekeeping Practices

During the energy use and technology study in the units, housekeeping and operational practices that can make significant impact on overall energy consumption of the plant are observed as follows:

1. Avoiding wastage while unloading from trucks/lorries: control spillages and contamination in the stock yard – can save 1 to 2 % of raw material
2. Water addition in ball mill/Blunger during the grinding process is through a drum or bucket – higher water addition can increase spray dryer energy consumption significantly (1% to 3%)
3. Moisture content in the product of the spray dryer is very important and needs to be regularly monitored – affects preparation of biscuit in the press, wastage of biscuit and energy consumption in dryer and kiln
4. Temperature & Pressure in the kiln is properly monitored on the control panel – affects overall quality of the tiles & sanitary ware
5. Speed of the blowers is controlled through variable frequency drives which are monitored by the pressure in the kiln – affects air flow and thus thermal energy consumption and also electrical energy consumption
6. In most of the ceramic industries small laboratory is provided to check the quality of the received raw material and also to monitor various process parameters at different stages during the production

Following points helps to develop best house keeping practices

1. Proper training and programs should be conducted on the benefits get by adopting the housekeeping practices
2. Development of proper team in the unit itself taking care of all these house keeping practices
3. Development of policies to maintain the same adopted in future also.

3.2.5 Availability of Data and Information

Energy consumption data for electricity and fuel are available however annual production data is partially available.

3.2.6 Any Other Relevant Aspect

Implementation of energy saving technologies in ceramic industries at Morbi is possible only through demonstration based approach. For example, initially in one or two units installation of variable frequency drive (VFD) on kiln blowers was carried out due to initiatives of VFD vendors and a few unit owners however as the success story spread, within a very short time (almost less than a year), this technology is implemented in almost all the ceramic units in Morbi.

3.3 Technology Gap Analysis and Implementation of Small Group Activities

This step was started with gathering specific energy consumption data and technologies available and prevalent world wide in ceramic industry. Specific Energy Consumption has been found to be as follows:

Table No. 10: Specific Energy Consumption in Ceramic Manufacturing

Sr.	Country	Electrical Specific Energy Consumption (kWh/Ton)*	Thermal Specific Energy Consumption (MKcal/Ton)*
1.	India	210	1.34
2.	China	259	1.05
3.	Italy	139	1.16
4.	Morbi	210	1.07

* **Source of data -** For China, Italy and India data, source is SIDBI booklet on Ceramic Industries and that for Morbi from the Energy Audit study.

3.3.1 Technology Gap Analysis and Process Up-Gradation

Latest technologies available and the best practices that should be followed in ceramic units to reduce the energy consumption are as follows:

A. Raw Material Processing

1. Purchase the right materials, it will save the energy and costs that would otherwise have to be incurred to treat them in the unit
2. Raw material is transported to the processing areas by conveyers: do not let the conveyor ON when there is no material to be transported.
3. Fit timer switches on all the grinding machines so that they automatically switch off after processing of the raw material

B. Blunger/Ball Mill

It is the most important part of the entire tile manufacturing. The composition and grinding of the raw material determines the quality of the final product. The grinding of raw material is carried out by ball mills or blungers. In this process, in the ball mill as the later on rotational speed of the mill can be brought down there is scope for installing VFD. A few of the units have implemented this measure.

Dry Vs. Wet Grinding Process

In case of dry grinding process, there is no requirement of water addition during grinding so the cost of fuel requirement for moisture removal in spray dryer is eliminated. But in case of some of the raw materials or process, there is requirement of water for additive mixing and proper grinding; therefore dry grinding process has not been applied in Morbi. However in future, if dry grinding process is evolved by cluster focused research & development it can bring in a revolution for the cluster.

Continuous Multistage Ball Mill versus Batch Ball Mill

In case of batch ball mill, once the raw material is fed, the grinding process starts in a batch by rotating the ball mill at a constant speed for about 5 to 6 hours whereas in case of continuous multistage ball mill, there are different stages and the speed of each stage is adjusted according to the grinding requirement. However, the specific energy consumption (kWh/MT) in case of ball mills at Morbi is found to be lesser than the data available for Continuous Multistage Ball Mill.

Installation of VFD on ball mills or blungers

As the loading on ball mill or blunger varies with time, reducing the speed of the motor through VFD in the later on period of the batch can result in reduction in electricity consumption by 15% to 20%.

Ball Mill

Variable Frequency Drive (VFD)

Some of the tips to reduce the energy consumption in Ball Mill:

1. Always operate the ball mill at its critical loading point. The material loading of the ball mill is a critical parameter in determining the energy consumption. Specific Energy Consumption will increase if the ball mill is loaded below/above the critical loading point.
2. Use grinding media (pebbles) in three different sizes for better and efficient grinding of raw material.
3. Check the mesh size of the slurry - when it reaches the required value, switch off ball mill/blunger. Regularly monitor batch time.
4. Don't blend the clay two or three days in advance.

C. Spray Dryer

In a spray dryer, slurry containing moisture around 33% to 35 % (on weight basis) is dried to form powder which contains moisture of 5% to 6%. Most of the ceramic units use lignite as a fuel (in potrifier) to supply hot flue gases to spray dryer. A few of the units use natural gas for spray drying.

Cogeneration Technology through Gas Turbine

Use of Gas Turbine for power generation and utilization of waste heat of turbine in spray dryer reduces plant's total energy cost. In India, in many of the ceramic plants outside Morbi cluster, this cogeneration technology is already in practice and offers very good potential for reducing overall energy cost for units in Morbi. Some of the units in Morbi has started considering this option for their units. Gas turbine suppliers are also started focusing on Morbi ceramic cluster.

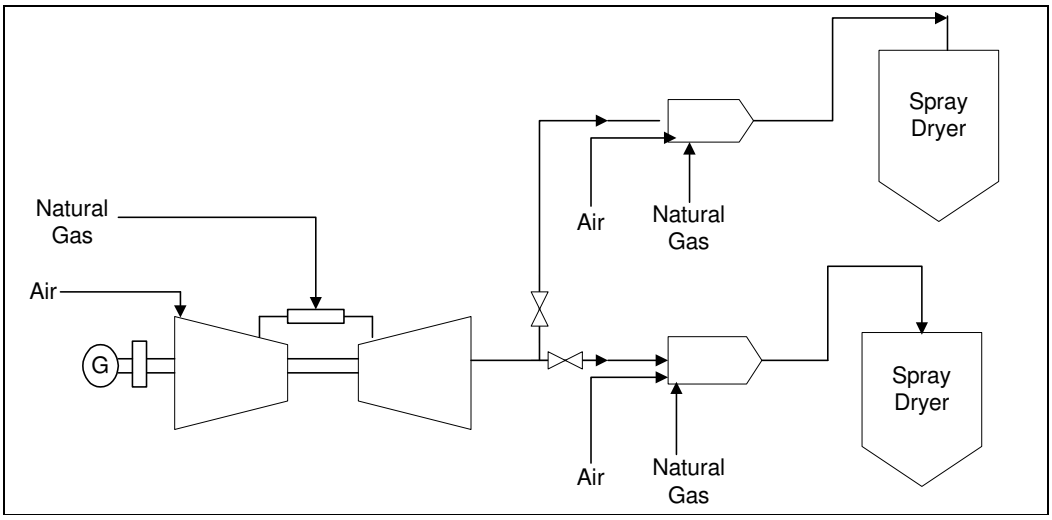

Figure No. 3: Cogeneration through Gas Turbine

Cogeneration Technology through Gas Engine

Use of Gas Engine for power generation and utilization of waste heat of engine in spray dryer is another option for co-generation. In Gujrat use of NG based engine has spread very fast for co-generation. In case of NG based engines waste heat is released in two ways (through exhaust gases at 350 to 400 deg C and through engine cooling heat exchanger at 75 to 80 deg C) therefore in order to fully utilize both of these streams it is required to use the hot water of engine for spray dryer slurry preheating through a heat exchanger and use exhaust of Engine in spray dryer.

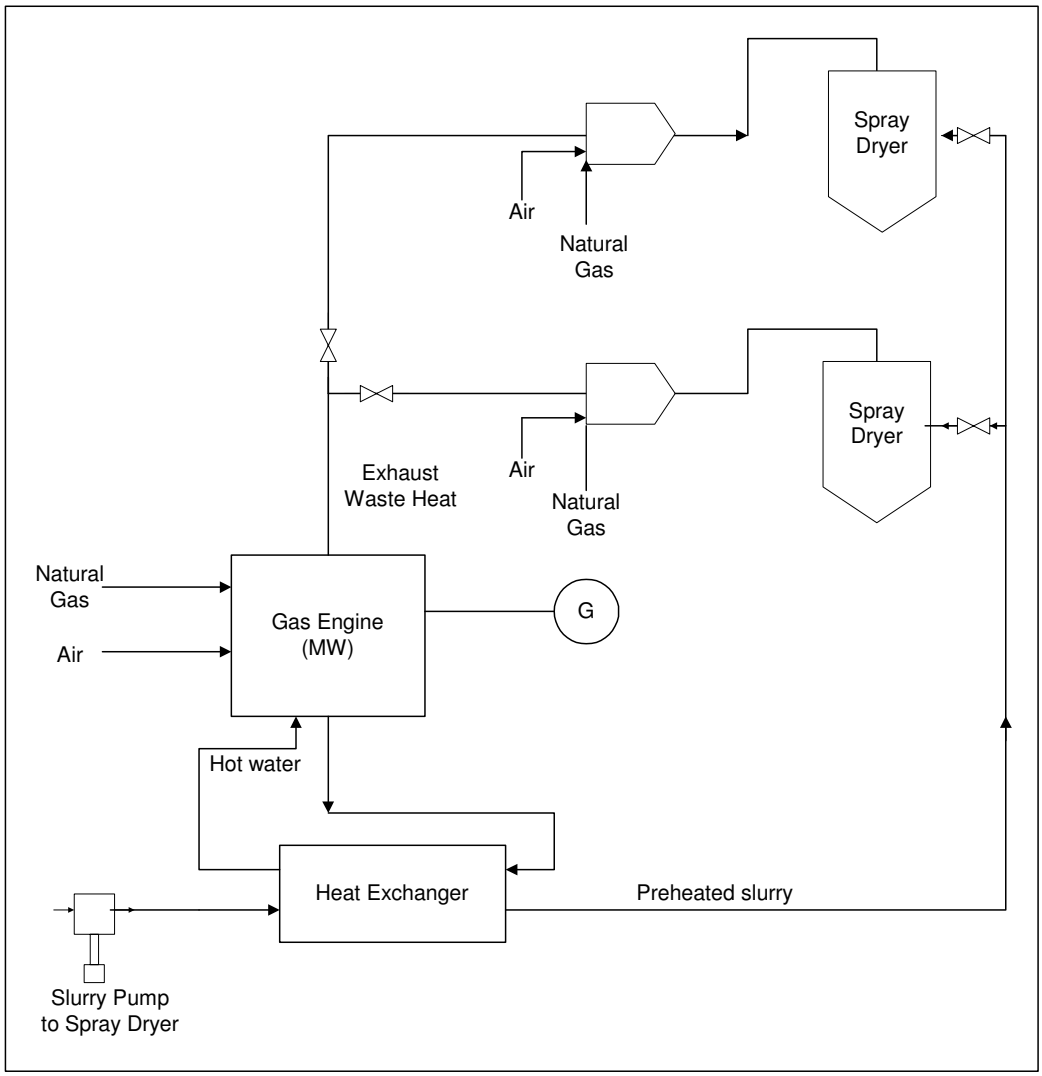

Figure No. 4: Cogeneration through Gas Engine

Overall savings on energy cost will be more in case of Gas Turbine as compared to that of Gas Engine but the project cost is comparatively lesser with Gas engines.

Use of solar heating system for spray dryer input slurry preheating

Utilization of solar energy for preheating of slurry input to spray dryer up to 60 ^{o}C to 65 ^{o}C can result in significant saving in fuel consumption in the spray dryer. Hot water at a temperature of about 80 ^{o}C to 85 ^{o}C can be generated through solar energy with the help of flat plate solar collectors. Slurry going to the spray dryer can be preheated in a specially designed heat exchanger. Availability of solar energy is very good in the region.

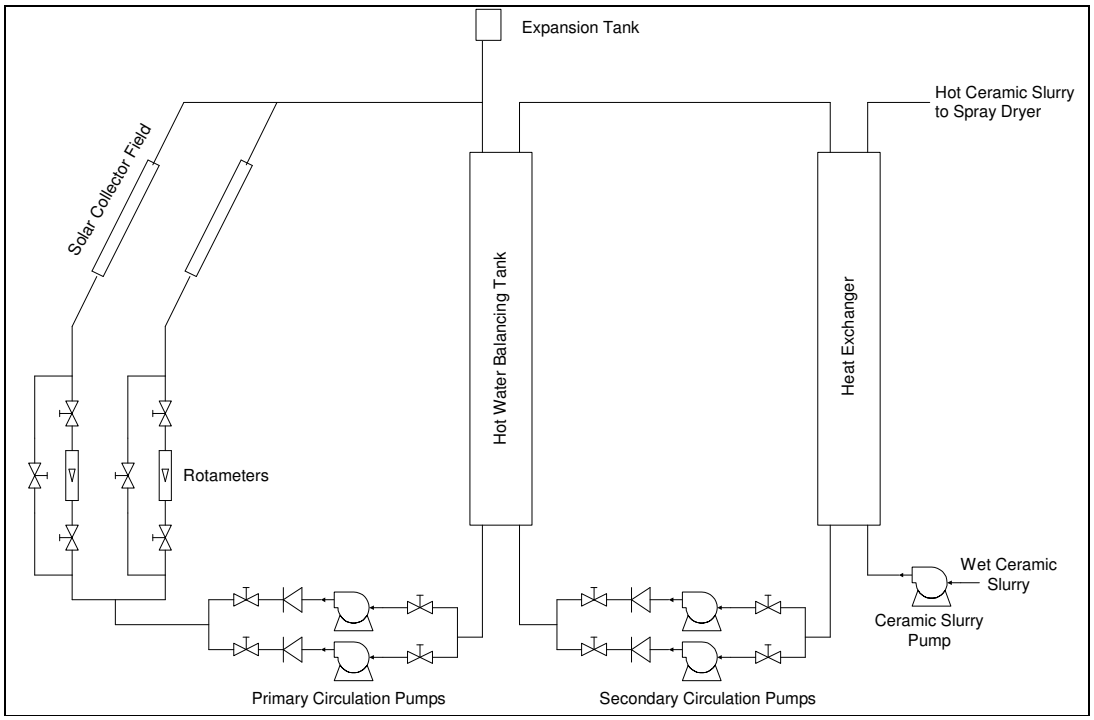

Figure No. 5: Preheating of Slurry Input of Spray Dryer through Solar Energy

Some of the Tips to Reduce the Energy Consumption

1. The particle size of the pulverized coal should be optimized and should be checked regularly.
2. Optimal excess air should be maintained in the combustion chamber for proper combustion.
3. Check and clean the nozzles regularly.
4. VFD should be installed on the ID fan and provide the senor with respect to the temperature of flue gas and the pressure in the spray dryer.

D. Press

1. Maintain suitable pressure settings in the press machine. The amount of pressure to be applied depends upon the type of product bring manufactured.
2. Installation of VFD on press hydraulic motor can saves electricity consumption in the press.
3. Installation of vacuum dust collector avoids the wastage of the raw material and also the energy required for reprocessing it.
4. If possible, operate press machine in off peak hours to benefit from time of use tariff.
5. Maintain the moisture content at the required level in the powdered raw material for proper processing from the press.
6. Inspect the output from the press. This will ensure that defective material is not dried or fired in the kiln.

E. Dryer

1. In this equipment, moisture is removed from the biscuit tiles surface by evaporation. The rate at which drying takes place depends on humidity, temperature of the air and the moisture content in the biscuit.
2. Avoid use of smoke air of kiln in dryer as its contribution in drying is negligible.
3. The dryer should be insulated with heat insulation brick and ceramic wool to prevent structural heat losses.

F. Glaze and Biscuit Preparation

1. Ball mills are used for preparation of Glaze material.
2. Installation of VFD on Glaze ball mill to reduce the electricity consumption needs to be evaluated and applied case to case basis.
3. Glaze storage tanks should be covered to avoid dust falling on them.
4. After glazing on the biscuit tiles, biscuits should be carried safely to avoid breakage.
5. Inspect the biscuit tiles and do not send defective ones for the second firing. This will save energy.

G. Roller Kiln

In the kiln, raw biscuit is converted to the finished product. Kiln consumes most of the thermal energy in ceramic industry. Already many measures are provided in the kiln being used in Morbi for waste heat recovery; however following measures/technologies can further improve kiln performance:

Use of hot air of cooling zone of kiln directly as a combustion air

Hot air from cooling zone of kiln has a temperature of about 250 ^{o}C to 300 ^{o}C. Use of this hot air directly for combustion of fuel (NG or PG) can result in significant savings in fuel consumption in the kiln.

Use of Smoke air (flue gas) of kiln for combustion air preheating

Smoke air of kiln is discharged into the atmosphere at a temperature of as high as 250 ^{o}C in some of the units. Ceramic units are not utilizing the exhaust smoke air (flue gas) of kiln for combustion air preheating because of the sulphur (SOx) content in it, which corrodes waste heat recovery systems. This sulfur comes from the additives mixed in raw materials in the tile production. To avoid this problem of corrosion during utilization of the smoke air of kiln for preheating the combustion air through recuperator, material of construction of recuperator can be changed to stainless steel based alloys which can bear corrosive effect of sulphur in smoke air in a better way thus providing more life to the recuperator. As the cost of the recuperator is not high and its payback period is within 1 year, these recuperators can easily be replaced after 4 to 5 years by a new one.

Use of energy efficient & high preheated air temperature burners

Use of high velocity energy efficient burner's and high preheated air temperature burners further improves kiln efficiency. Observed maximum preheated air temperature in the kiln in Morbi cluster is 250 ^{0}C, where as current burner technology accepts air preheat temperature upto 600 ^{0}C. This offers good opportunity for high temperature waste heat

recovery. Higher the combustion air temperature, lower will be the fuel consumption in the kiln.

Use of Briquette Fired Hot Air Generator

Use of solid fuel (lignite/coal/indonasian coal/biomass) is cheaper as compare to use of gaseous (Natural Gas, LPG) or liquid fuel (Kerosene/LDO/LPG). Therefore using these solid fuels for generation of hot air at about 300 ^{o}C and used it as a combustion air in kiln, dryer and spray dryer can result in reduction in energy cost. If biomass is used then it reduces GHG emissions also.

Installation of VFD on Blowers of Kiln

Installation of VFD on all blowers of kiln has already helped many units in Morbi to save electricity consumption in the blowers. However there are some units which have not implemented this measure, they can implement it and get benefited. Here role of VFD is to adjust speed of the blowers according to the requirement so as to maintain the required temperature and pressure in the kiln.

Even if the VFDs are installed, it is necessary to optimize operating speed of the blowers by standardizing the frequency and checking on regular basis that the VFDs are operating at these set frequencies.

Maintain the required air to fuel ratio for proper combustion of fuel

Use of theoretical air required for combustion of fuel along with the recommended excess air for that fuel results in saving in fuel consumption in the kiln. In the cluster, there is no practice to measure the excess air (by measurement of $\%CO_2$ in flue gas or by measurement of $\%O_2$ in the flue gas). It is important to start this practice.

Table No. 11: Theoretical Air Required and the Recommended Excess Air for Proper Combustion of Fuels

Fuel	Theoretical Kg of Air/kg of Fuel	Recommended Excess Air, %
Coal	10.8	30 % to 40%
Lignite	8.4	35 % to 40 %
Wood	5.8	20 % to 25 %
Furnace oil	13.9	12 % to 15 %
Natural Gas	17.34	5 % to 7 %

Insulation Improvement of Kiln Reduces The Fuel Consumption

Proper insulation of kiln reduces the fuel consumption in the kiln thereby reduces heat loss through the kiln surface. Ideally surface temperatures should be maintained less than 60 deg C. However it has been found that the temperature levels are high and there is scope for improving the insulation in most of the units. Units need to keep thermocouple based instrument & infra read gun type portable temperature measuring devices and check it themselves on status of the insulation. Both of these instruments are extremely cost effective. it is further recommended that at least once in a year, the units must go for a thermograph based survey of the insulation. Left had side is photograph where as the right picture is its thermograph clearly identifies the hot spots where insulation needs to be improved. Once the insulation work is carried out again thermograph needs to be taken

to check the quality of insulation repair. Such a holistic approach is required for insulation improvement.

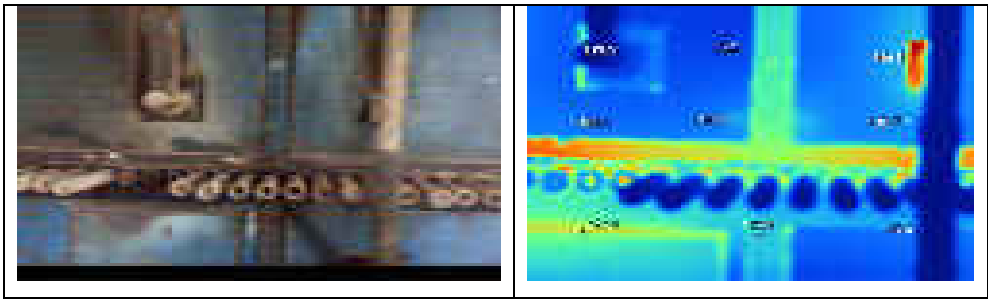

Figure No. 6: Thermal Image Showing the Surface Temperature of Kiln

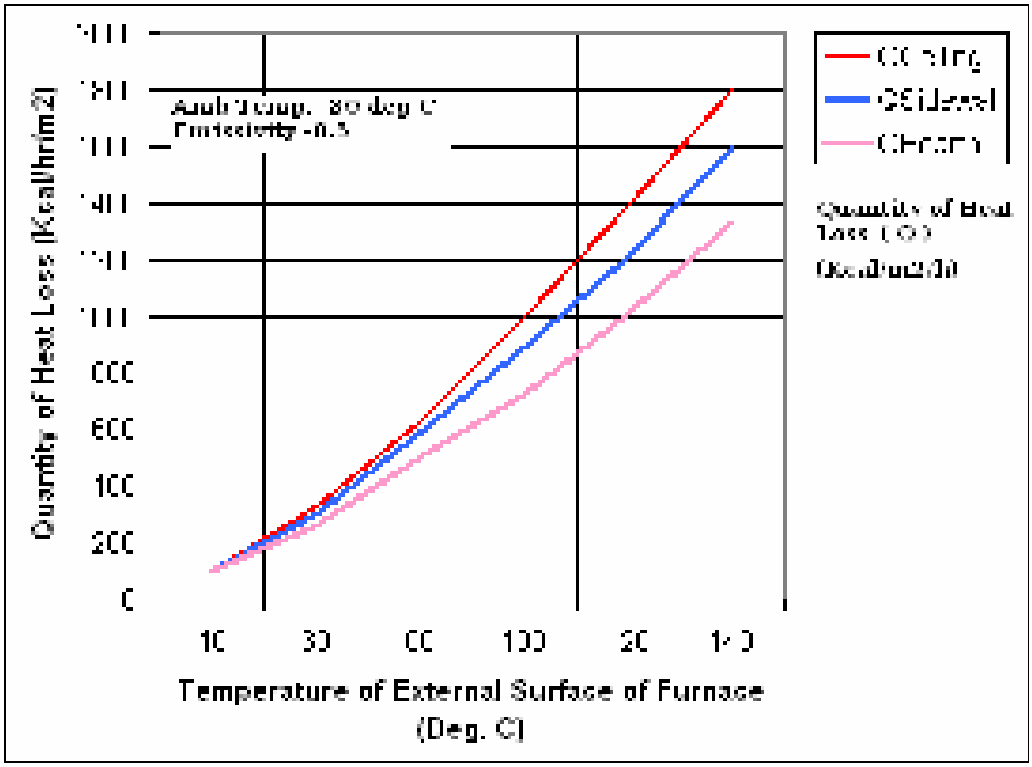

Figure No. 7: Graph Showing the Quantification of Heat Loss through Kiln Surface

Some of the tips to reduce the energy consumption in the kiln by improving operating practices is as follows:

1. 1% reduction of residual oxygen in the flue gas reduces the fuel consumption by 1%.
2. Every 20 ^{o}C rise in combustion air temperature will raise the thermal efficiency of the kiln by 1%.
3. A 22 ^{o}C reduction in the flue gas temperature can reduce the fuel consumption by 1 %.

H. Tunnel Kiln

In sanitary wares, tunnel kiln is used. Cars containing the raw sanitary products are baked in the tunnel kiln for about 14 to 18 hours. The technologies that can reduce energy consumption in the kiln are as follows:

Saving in fuel consumption in tunnel kiln by preheating the combustion air by smoke air through recuperator

Smoke air of tunnel kiln is not utilized and its heat is wasted in to the atmosphere through exhaust flue gases. However like ceramic tiles, smoke air of sanitary wares tunnel kiln does not have any sulphur content in it as its raw material and additives are sulphur free. Therefore, smoke air of tunnel kiln can be easily utilized to preheat the combustion air through use of recuperator.

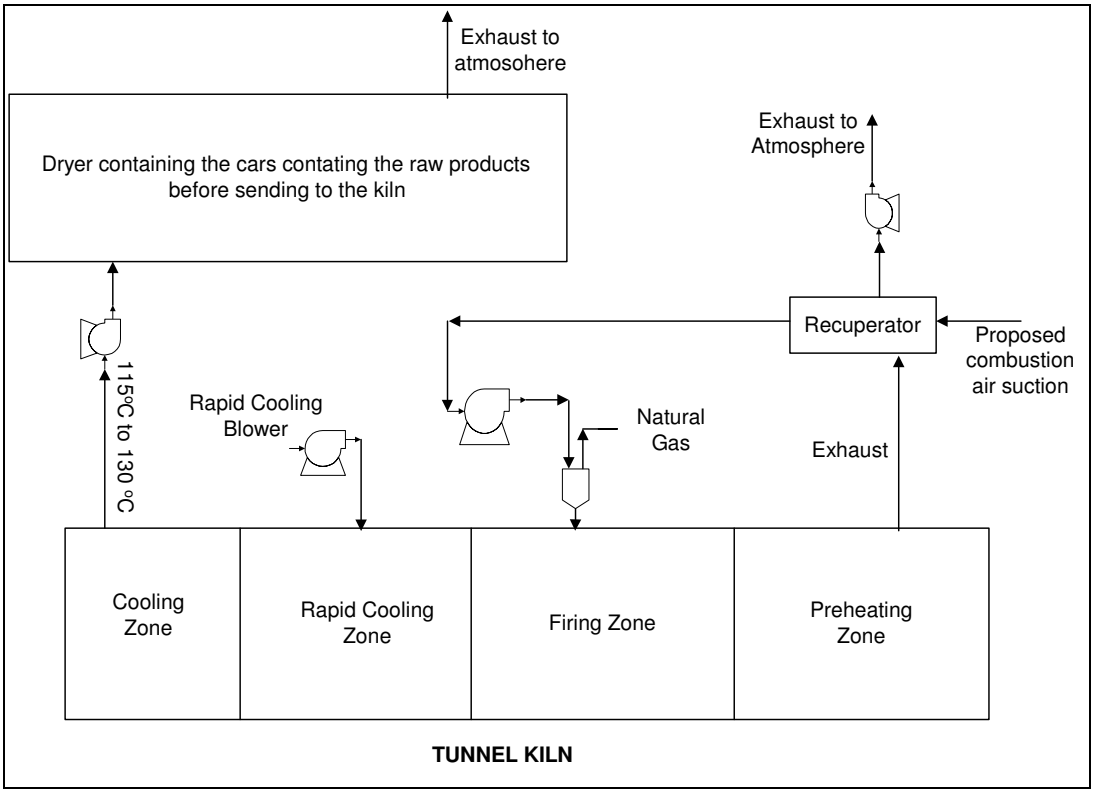

Figure No. 8: Preheating Of Combustion Air by Smoke Air through Recuperator

Use of low thermal mass car in tunnel kiln in case of sanitary wares

Higher the weight of the car (which carries green ceramic sanitary wares), higher will be the fuel consumption; therefore replacement of high mass refractory car by low thermal mass car can reduce the weight of car by about 23% to 24% which will reduce fuel consumption in the kiln significantly.

Use of hot air directly as a combustion air in tunnel kiln

In tunnel kiln of sanitary wares, direct use of hot air from final cooling zone of kiln as combustion air can results in significant savings in fuel consumption of kiln. This can be carried out by connecting the suction of the existing combustion air blower from the final

cooling zone of kiln. Both of the blowers need to be balanced, which can be carried out by installing VFDs.

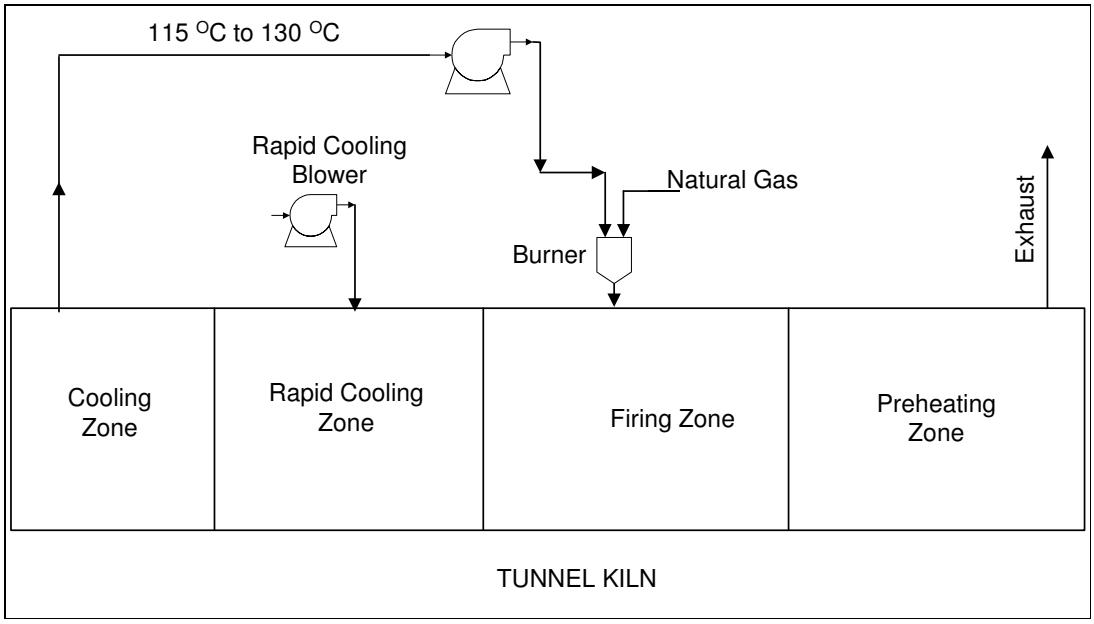

Figure No. 9: Use of Hot Air Directly As a Combustion Air in Tunnel Kiln

Use of hot air from cooling zone of tunnel kiln for input material preheating

Temperature of hot air from cooling zone of tunnel kiln is found to be 115 to 130 ^{o}C, which is exhausted in to atmosphere. Heat of this hot air can be recovered by preheating the input material to the kiln. This will save fuel consumption in the kiln.

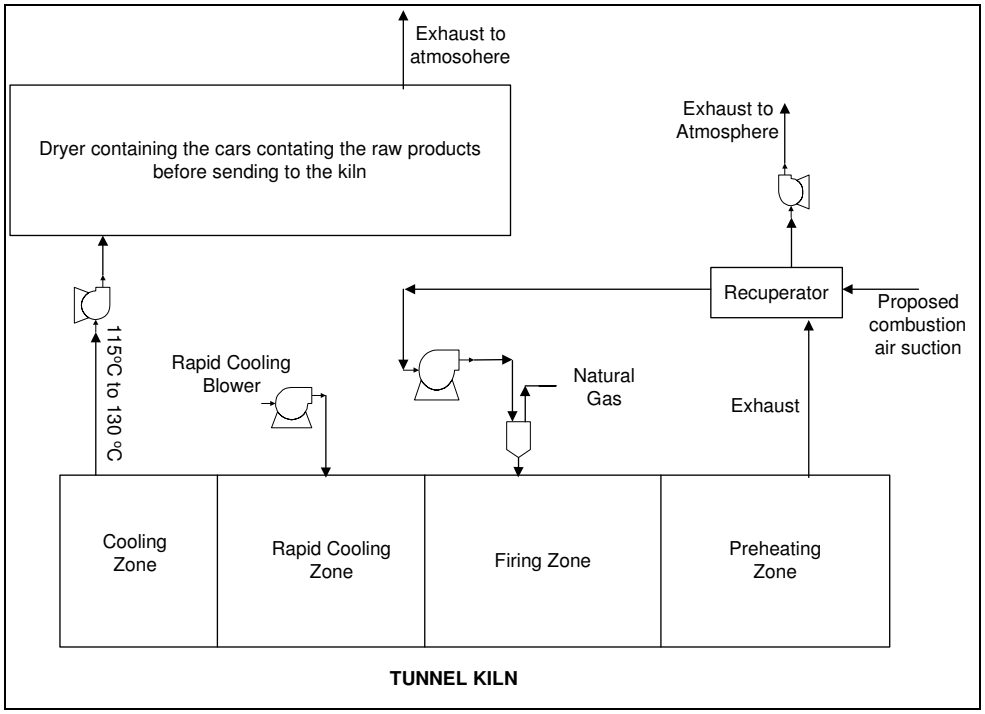

Figure No. 10: Utilization of Hot Air for Input Material Preheating

I. Polishing Machines

Polishing machines are used in case of vitrified tiles only, however they consume about 40 to 50 % of total electricity of vitrified tile plant thus polishing machines are maximum electricity consuming equipments in vitrified tiles units. Polishing machines operate for 18 to 20 days a month.

Some of the Tips to reduce the Energy Consumption in Polishing Machines:

1. Replacement of existing motors by energy efficient motors can save electricity consumption significantly. The savings will occur because of two reasons first by difference in design efficiency of standard efficiency motors and energy efficient motors, which will be 1.5% to 2% but secondly due to low loading of existing standard efficiency motors of polishing machines. Here due to flat nature of efficiency curve of energy efficient motor savings could be 3% to 4% thus total savings by installing energy efficient motors could be 4.5% to 6%.
2. Running the polishing machines in off peak hours, so that lower tariff of TOD (Time of Day) saves the energy cost. Difference between maximum tariff and minimum tariff is Rs. per kWh. As the capacity of polishing machines in most of the units is 25 to 30% more, the polishing machines are not continuously utilized. Therefore staggering of operation of polishing machines can be carried out based on Time of Day tariff, which means more use of electricity during 10 PM to 6 AM and less use during peak hours of 7 AM to 11 AM and 6 PM to 10 PM. As switching ON & OFF will increase, it is suggested to implement staggered operations along with installation of Maximum Demand Controller, so that MD does not increase un-necessarily. This project will also help the grid to reduce the load during peak hours.

J. Electrical distribution System

Electrical distribution system is an integral part of the ceramic industry. An efficient electrical distribution system, proper utilization of electricity tariff benefits and proper electrical demand management can reduce electrical energy cost significantly.

Electricity Tariff of PGVCL (Paschim Gujarat Vitran Company Limited):

At Morbi, there is high tension (HTP - I) supply in case of wall, floor and vitrified tiles whereas in the sanitary wares they are using low tension (LTP - I or LTP - III) supply.

HTP - I (HT Tariff):

This tariff will be applicable for supply of electricity to HT consumers contracted for 100 kVA and above for regular power supply.

Demand Charges:

1. For billing demand upto contract demand.

(a)	For first 500 kVA of billing demand	Rs. 98/per kVA per month
(b)	For next 500 kVA of billing demand	Rs. 139/per kVA per month
(c)	For next 1500 kVA of billing demand	Rs. 208/per kVA per month
(d)	For billing demand in excess of 2500 kVA	Rs. 237/per kVA per month

PLUS

2. Energy Charges for all HTPI consumers.

	For entire consumption during the month	
(a)	Upto 1000 kVA contract demand	385 Paise per Unit
(b)	For 1001 kVA to 2500 kVA contract demand	405 Paise per Unit
(c)	Above 2500 kVA contract demand	415 Paise per Unit

Note: Wherever actual demand exceeds the contract demand, the actual demand shall be considered for determining the applicable slab of energy charges.

PLUS

Time of Use Charges: These charges shall be levied on all HT consumers:

For energy consumption during the two peak periods, viz., 07:00 Hrs to 11:00 Hrs and 18:00 Hrs to 22:00 Hrs	75 Paise per Unit

Billing Demand: The billing demand shall be the highest of the following:

(a) Actual maximum demand established during the month
(b) Eighty-five percent of the contract demand
(c) One hundred kVA

Minimum Bills:

Payment of "demand charges" based on kVA of billing demand.

Lighting and NonIndustrial Loads:

The consumption of lights and fans and other nonindustrial loads of the factory building as also the consumption of creche, laboratory, stores, time keeper's office, yards, watch and ward, first aid centres, and dispensaries during a month registered at the main meter on HT side shall be charged at the energy charges specified above.

Power Factor:

Power Factor Adjustment Charges:

(a) The power factor adjustment charges shall be levied at the rate of 1% on the total amount of electricity bills for the month under the head "Demand Charges" and "Energy Charges" for every 1% drop or part thereof in the average power factor during the month below 90% upto 85%.

(b) In addition to the above clause, for every 1% drop or part thereof in average power factor during the month below 85% at the rate of 2% on the total amount of electricity bill for that month under the head "Demand Charges" and "Energy Charges", will be charged.

Power Factor Rebate:

If the average Power factor of the consumer's installation in any month is above 95% the consumer will be entitled to a rebate at the rate of 0.5% (half percent) in excess of 95% power factor on the total amount of electricity bill for that month under the head "Demand charges" and "Energy charges" for every 1% rise or part thereof in the average power factor during the month above 95%.

Meter Charges:

The meter charges per month are chargeable as prescribed under 'GERC (Licensee's Power to Recover Expenditure incurred in providing supply and other Miscellaneous Charges) Regulations, 2005 as in force from time to time.

Electricity Duty and Tax on Sale of Electricity:

Electricity Duty and tax on sales of electricity will be collected in accordance with the rates prescribed by the Government from time to time. The consumer shall make separate metering arrangement for segregation of energy consumption wherever necessary for the purpose of levying electricity duty at different rate.

Maximum Demand and its Measurement:

The maximum demand in kW or kVA, as the case may be, shall mean an average KW/KVA supplied during consecutive 15 or 30 minutes (as the case may be) period of maximum use where such meter reading directly the maximum demand in KW/KVA have been provided.

Contract Demand:

The contract demand shall mean the maximum KW/KVA for the supply, of which the supplier undertakes to provide facilities from time to time.

Rebate for Supply at EHV:

On Energy charges:		Rebate @
(a)	If supply is availed at 33/66 kV	0.5%
(b)	If supply is availed at 132 kV and above	1.0%

Concession for Use of Electricity during Night Hours:

For the consumer eligible for using supply at any time during 24 hours, entire consumption shall be billed at the energy charges specified above. However, the energy consumed during night hours of 10.00 PM to 06.00 AM next morning as is in excess of one third of the total energy consumed during the month, shall be eligible for concession at the rate of 75 Paise per unit. Appropriate meter (and time switch, if required) shall be procured and installed by the consumer at his cost and sealed by the Distribution Licensee.

Delayed Payment Charges:

No delayed payment charges if the bill is paid within ten days from the date of billing (excluding the date of billing).

Delayed payment charges will be levied at the rate of 1.5% per month (upto the time of permanent disconnection of supply) in case of all HT consumers except Agricultural category and for the period from the date of permanent disconnection, the delayed payment charges will be levied at the rate of 1.25%. Delayed payment charges will be levied at the rate of 1% per month or part thereof for the Agriculture consumers from the date of billing till the date of payment if the bill is paid after ten days from the date of billing.

For Government dues, the delayed payment charges will be levied at the rate provided under the relevant Electricity Duty Act.

RATE LTP - I

This tariff is applicable for aggregate motive power load not exceeding 125 BHP and other than those specified in LFDII.

Fixed charges per month:

For an installation having the contracted load upto 10 BHP	Rs. 22/per BHP
For installation having contracted load exceeding 10 BHP:	

(i) For first 10 BHP of contracted load	Rs. 22/per BHP
(ii) For next 40 BHP of contracted load	Rs. 40/per BHP
(iii) For next 25 BHP of contracted load	Rs. 65/per BHP
(iv) For next 25 BHP of contracted load	Rs. 100/per BHP
(v) Balance BHP of contracted load	Rs. 155/per BHP
(vi) For the actual load in excess of the contracted load	Rs. 300/per BHP

PLUS
Energy Charges:

(a)	For installation having contracted load upto and including 10 BHP: For entire consumption during the month	360 Paise per Unit
(b)	For installation having contracted load exceeding 10 BHP: For entire consumption during the month	385 Paise per Unit

PLUS

Reactive Energy Charges:

For installation having contracted load over 20 BHP for all reactive units (KVRAH) drawn during the month	10 paise per KVARH

Minimum bill per installation per month for consumers other than Seasonal Consumers:

a)	When contracted load is upto 75 BHP	Rs. 105/- per BHP
b)	When contracted load exceeds 75 BHP	Rs. 180/- per BHP

RATE LTP - III

This tariff shall be applicable to consumers using electricity for motive power services for minimum contract demand of 15 kW and up to 100 kW at low voltage.

Fixed charges:

(a)	For billing demand upto the contract demand	
	(i) For first 15 to 40 kW of billing demand	Rs. 65/per kW per month
	(ii) Next 20 kW of billing demand	Rs. 100/per kW per month
	(iii) Above 60 kW of billing demand	Rs. 165/per kW per month

(b)	For billing demand in excess of the contract demand	Rs. 210/per kW

PLUS

Energy charges:

For the entire consumption during the month	40 paise per unit

PLUS

Reactive Energy Charges:

For all the reactive units (KVARH) drawn during the month	10 paise per KVARH

Billing Demand:

The billing demand shall be highest of the following, rounded to the next full kW:

(a) Eighty -five percent of the contract demand
(b) Actual maximum demand registered during the month
(c) 15 kW

Minimum Bill Payment of demand charges every month based on the billing demand.

Benefits from Electrical Tariff

1. Running of loads like press, polishing machines wherever possible in off peak hours; Most of the units in Morbi have not fully utilized this opportunity.
2. Improvement of power factor (PF) near to unity resulting in availing maximum 2.5% incentives on total of demand and energy charges, During the field studies it was observed that most of the units are availing 1% to 1.5% of this rebate, very few of them were more than this. This benefit must be utilized to 2.5% or nearing to it. Power factor improvement also reduces system losses. Power factor is improved by installing the capacitors in fixed as well as in APFC mode (Automatic Power Factor Controller Mode).
3. Utility measures PF at HT and transformer also contribute to some inductive load while sensors of APFC are installed at LT therefore transformer's inductive load always remains uncompensated. This inductive load needs to be taken care of by installing required capacitors.

Table No. 12: kVAr required for Power Factor Correction

Original Power Factor	Desired Power Factor															
	0.85	**0.86**	**0.87**	**0.88**	**0.89**	**0.90**	**0.91**	**0.92**	**0.93**	**0.94**	**0.95**	**0.96**	**0.97**	**0.98**	**0.99**	**1.00**
0.85	0.00	0.03	0.05	0.08	0.11	0.14	0.16	0.19	0.23	0.26	0.29	0.33	0.37	0.42	0.48	0.62
0.86		0.00	0.26	0.53	0.08	0.11	0.34	0.17	0.20	0.23	0.26	0.30	0.34	0.39	0.45	0.59
0.87			0.00	0.03	0.06	0.08	0.11	0.34	0.17	0.20	0.24	0.28	0.32	0.36	0.42	0.57
0.88				0.00	0.03	0.06	0.08	0.11	0.15	0.18	0.21	0.25	0.29	0.34	0.40	0.54
0.89					0.00	0.03	0.06	0.09	0.12	0.15	0.18	0.22	0.26	0.31	0.37	0.51
0.9						0.00	0.03	0.06	0.09	0.12	0.16	0.17	0.23	0.28	0.34	0.48
0.91							0.00	0.03	0.06	0.09	0.13	0.16	0.21	0.25	0.31	0.46
0.92								0.00	0.03	0.06	0.10	0.13	0.18	0.22	0.28	0.43
0.93									0.00	0.03	0.07	0.10	0.14	0.17	0.25	0.40
0.94										0.00	0.04	0.07	0.11	0.16	0.22	0.36
0.95											0.00	0.03	0.08	0.13	0.19	0.33
0.96												0.00	0.04	0.09	0.15	0.29
0.97													0.00	0.05	0.11	0.25
0.98														0.00	0.06	0.20
0.99															0.00	0.14
1																0.00

Following points can be helpful for energy savings in transformer:

1. Transformers can be switched off on holidays or periods of no load, if there is separate lighting transformer.
2. Transformers should be always loaded to optimum level (20% to 60%). Transformers should not be oversized or undersized.
3. Improvement of P.F. on LT side would reduce current and hence reduce copper losses in transformer.
4. Amorphous core distribution transformers are more energy efficient than transformers made with silicon iron cores. However these transformers are yet to become commercially popular.

K. Electrical Utilities - Motors and DG Sets

Motors

Electrical energy consumption through motors is maximum in most of the industries therefore ensuring that the motors are operating at maximum possible efficiency is important.

Replacement with energy efficient motors to improve efficiency as well as reduce under-loading

Replacing old re-winded motors with higher efficiency modern design motors will be a good idea particularly after 3 to 4 re-windings. With every re-winding drop in motor efficiency is expected. Following diagram explains standard & energy efficient motor's efficiency. Here it can be seen that at lower loads efficiency of energy efficient motor does not drop as much as that of standard motor efficiency. Therefore at lower and fluctuating load gain in efficiency is much higher than that at full load.

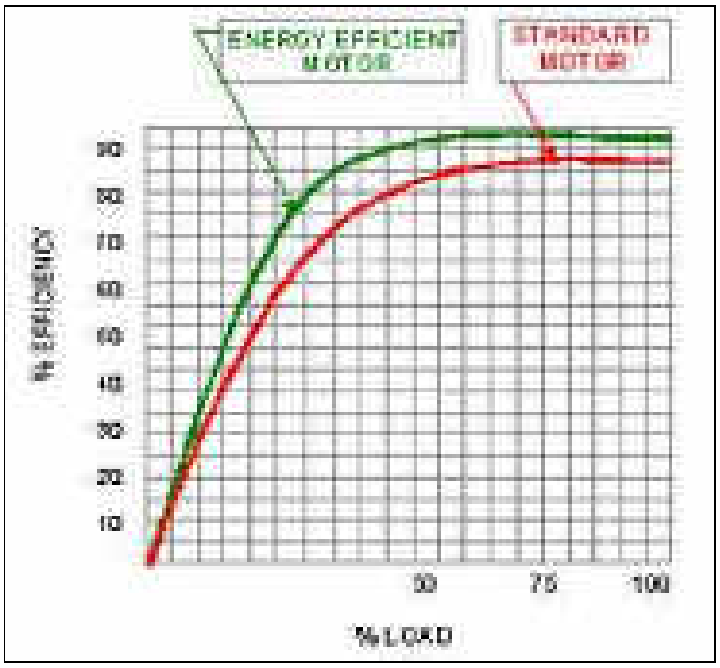

Figure No. 10: Standard Motor Vs Energy Efficient Motor

Installation of Variable Speed Drive

Incorporation of electronic speed controls for AC motors driving pumps/fans/compressors requiring variation in throughput on a continuous basis or requiring throughput significantly less than the design value, electronic adjustable speed drives or variable frequency drives (VFDs) can typically save significant amount of energy. These drives have already been applied in kiln blowers, however in other electrical loads such as hydraulic press, compressor, agitator motors, pumps and other electrical motive load there is potential for installation of VFDs to deliver energy savings.

Replacement of V belts by Energy Efficient Flat belts

Replacement of V-belts with flat belts or grooved V-belts can typically save 4% to 6% of the transmitted energy. There is potential for these savings in ball mills & agitators.

Improved Maintenance Practices

It is important to develop preventive maintenance schedule and implement it systematically. Improved maintenance practice ranges from the simplest task of using clean hands during lubrication, and to the more complex task of replacing windings in a manner, which results in no loss in efficiency. Therefore it is always paying to invest in proper maintenance practices.

Replacement of Oversized Motors by Appropriate Size Motor

Many a times oversized motors are chosen and when installed they operate at lower % loading and thus at lower efficiency. Therefore right sizing of motors is very important. If existing motor is found to be oversized, it is required to evaluate its replacement by right sized motor or possibilities of converting the motor from delta operation to star operation as covered below. This conversion does not involve any capital investment. For replacing

the motor by right sized motor it is required to calculate the savings & pay back period and if found suitable then only it should be changed.

Delta to star conversion of motors (with less than 50% loading)

If the motor is continuously running below 50% of its designed load, it is better to reconfigure the motor from delta to star connection or install an auto delta star converter. However this is to be carried out with full precaution by ensuring that the starting torque requirement is not high and over load current settings are duly reduced otherwise motor may burn. This measure can result into savings up to 5 to 8%.

Use of Motor Energy Savers / Soft starters

There are different types of Motor Energy Savers available in the market. However their suitability and applicability for specific motor application in ceramic manufacturing needs to be evaluated application by application. Only upon detail demonstration and monitoring, if savings are achieved then only these equipments should be applied. To avoid jerks while starting the motors, soft-starters are used which provide smooth start operation. However Soft starters are not primarily meant for energy saving. Some of the soft starters come with features of VFD; these may provide some savings also apart from soft start.

Switch Off Motors When Not Required

This is most common sense based energy saving measure. Some times it is observed that motors and its driven load keep running at no load, this is particularly observed in start and close of batch operations. Such practices need to be avoided.

DG Sets

1. Diesel generator set are installed in almost all of the ceramic units for electrical power backup. Tips to improve the performance of DG sets are highlighted below
2. Provide a energy (kWh) meter and keep a record of kWh generation and diesel consumption for the period for which the DG operates or keep a daily record. DG performance must be monitored in terms of kWh/Liter of Diesel. A good condition DG and properly loaded DG is expected to deliver 3.5 kWh per liter of HSD consumption.
3. Do not operate DGs too under loaded as oil consumption is more dependent on hours of operation than their % loading. Therefore right DG sizing is equally important.
4. At present electricity availability is better, however if it worsen then converting existing engine to NG based operation or opting for a NG based engine must be considered. The cost of electricity generation on NG will be very less as compared to HSD.

Operation of DG Sets:

1. The operating temperature of engine should be kept within normal limits. Oil temperature should not exceed 60-70 deg.C
2. Engines and alternator should be mounted and aligned properly to ensure minimum vibration.
3. Prolonged overload should always be avoided

4. Unbalanced loads should be limited so that rated current is not exceeded in any case.
5. Engine speed should be kept at the normal speed. Engine breathers should be kept clean to ensure sufficient intake of air.
6. Check for leaks in the lubrication system and attend to them promptly
7. Change oil on condition basis and not on the thumb rule basis

L. Air Compressors

Air compressors are used in ceramic units to supply the compressed air to operate pneumatic equipments From the below figure, it is clear that only 10% to 30% of input energy to the compressor reaches to the point of end use and the balance 70% to 90% of input energy gets wasted in the form of friction and noise.

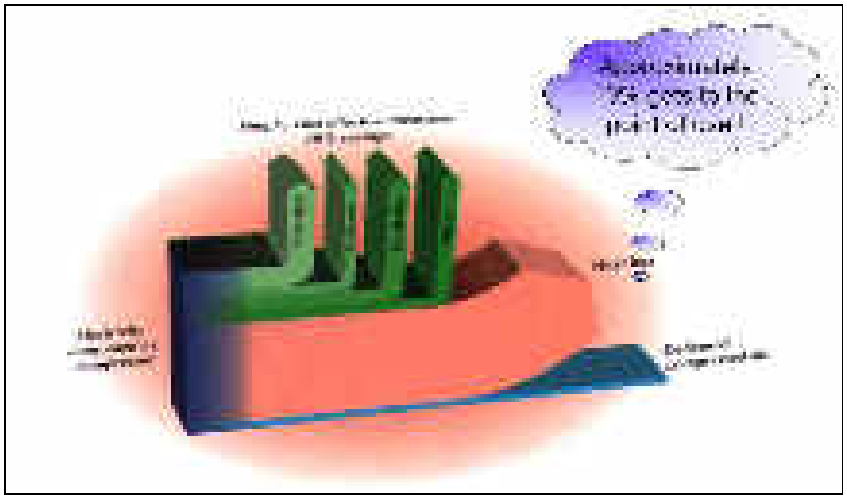

Figure No. 11: Sankey Diagram for Energy Utilization in Compressors

Table No. 13: General Selection Criteria for Compressors

Type of Compressor	Capacity (m^3/hr)		Pressure (bar)	
	From	To	From	To
Root blower compressor single stage	100	30,000	0.1	1
Reciprocating				
-Single / Two stage	100	12,000	0.8	12
-Multi stage	100	12,000	12.0	700
Screw				
-Single	100	2,400	0.8	13
-Two stage	100	2,200	0.8	24
Centrifugal	600	300,000	0.1	450

Minimize Unload Power Consumption by Correctly Sizing the Compressor

If the installed compressor capacity is higher than the compressed air requirement in the plant, the compressor often goes in unloading mode, where in it keeps consuming about 25% to 35% of loaded condition motor input power. However it does not deliver any compressed air in this mode, so this energy is totally wasted. The compressor remains in

unload mode till the system pressure drops to load pressure. In case of reciprocating compressors, unload power consumption is about 15% to 20% and in case of screw compressor unload power consumption is about 30 to 35% of load power consumption. Therefore energy saving can be achieved by minimizing the unload power consumption which can be achieved by right sizing of the compressor while purchasing the compressor or using VFD to de-rate the compressor. Thus even if a higher capacity compressor is purchased by installing VFD it can be de-rated to deliver smaller capacity. Thus apart from compressor efficiency, total energy consumption of the compressed air system also depends on correct type & size of compressors.

Table No. 14: Specific Power Consumption for Reciprocating Compressor

Pressure (Bar)	No. of Stages	Specific power kW/170 m^3/hr (kW/100CFM)
1	1	6.29
2	1	9.64
3	1	13.04
4	2	14.57
7	2	18.34
8	2	19.16
10	2	21.74
15	2	26.22

Minimize Compressed Air Leakages

Quantity of air losses through small holes, cracks, leaky couplings, joints etc, can add up to a very large value. With proper installation and maintenance, leakage losses should not exceed 5% of the total capacity of the compressor.

Reduction in suction air temperature

As the suction air temperature goes up, power required to by the compressor to compress the air goes up. Compressor inefficiency is dissipated in form of heat so if there is no proper insulation the temperature in the compressed air room goes up and thus suction temperature goes up further. This results in lower volumetric efficiency and higher power consumption for the compressor. For an appropriate 4 ^oC rise in suction air temperature, the power consumption increases by 1% for the same output. Hence it is recommended to provide a separate suction duct from outside (open atmosphere) to the compressor directly.

Table No. 15: Effect of Intake Air Temperature on Energy Consumption

Inlet temp. (^oC)	Relative air delivery (%) as Suction Air Temperature Rises	Increase in Power Consumption with rise in Suction Air Temperature with respect to 15.5 Deg C Suction Air Temperature (%)
15.5	100	Nil
21.1	98.1	1.3
26.6	96.3	2.5
32.2	94.1	4.0
37.7	92.8	5.0
43.3	91.2	5.8

Install Screw Compressors With In- Built Variable Frequency Drives for Fluctuating Loads

1. Variable speed drives can be installed for all types of air compressors. However, it is best suited for screw type air compressors. The advantages of installing VFD for screw compressors are:
2. The compressors does not operate in load/unload mode, it always this saves the unload power consumption.
3. As compressor does not go load/unload effective operating pressure is also reduced, so the energy consumption also reduces.
4. Increase in frequency clearly indicates increase in compressed air consumption.

Install Trans-Vector Nozzles for Cleaning Hoses

The use of compressed air for cleaning applications is common in the industry. However if proper nozzles are not used, compressed air consumption increases significantly. Here use of transvector nozzles results in the atmospheric air getting sucked through the circumferential holes provided thereby resulting in 30 to 40% of the atmospheric air is utilization thus reducing the compressed air consumption by 30 to 40% in cleaning.

Install Electrical Equipments in Place of Pneumatic Equipments

Replace pneumatically operated equipments with suitable electrical operated equipments as electrical equipments are more energy efficient and thus less power consuming as compared to pneumatic tools. Compressor output is generally in the range of 30% (means only 30% of electrical gets converted into compressed air rest all is wasted). Further the efficiency of pneumatic tools is about 70%. Hence total efficiency of compressed system becomes 21% (0.3 x 0.7 = 0.21 =21%). This efficiency is lower than efficiency of electrical tools i.e. maximum overall efficiency of pneumatic system is 20% to 25%. If pneumatic tools could be replaced with electrical tools operating efficiency of 70% to 80% can be achieved which means very high savings in electrical energy. Over past few years many compressed air driven equipments have been replaced by electrical machines.

Some Of The Best Practices Leading to Energy Savings In Ceramic Units With No Or Low Investments:

1. Installation of water monitoring system on ball mill/Blunger for monitoring of water addition in raw material and also to measure the moisture of output product of the spray dryer help in reduction in fuel consumption in spray dryer.
2. Install kWh meters section wise/equipment wise to measure the electricity consumption on daily basis. This activity helps to identify the major energy consuming areas and focus on them for energy saving. It also helps to monitor the specific energy consumption equipment & process wise. Benchmarks get developed and daily specific energy consumption gets monitored against these benchmarks. If there is increased energy consumption in some of the areas, it gets noticed quickly and therefore corrective action can be taken fast. Putting such a system in place also helps in measuring and quantification of the savings achieved if any saving measure is implemented in a particular section or equipment.
3. Install variable frequency drive (VFD) on screw type air compressors to save the no load power consumption.

4. Install variable frequency drive on FD and SFD blowers of spray dryer and open the throttle fully; this results in saving in electricity consumption in the blowers.
5. Install vacuum dust collector in press to reduce the raw material wastage and thus avoid repetitive use of energy for processing of same raw material.
6. Periodical current measurements of the capacitors help in identification of the de-rated capacitors; accordingly replacement of the de-rated capacitors by new ones helps in maintaining power factor of plant at unity. Amount of PF rebate can vary from Rs. 20,000 to Rs. 2,50,000 per month depending on the CD and actual PF, therefore maintaining PF to unity must be achieved. This is in addition to reduction in MD charges.
7. Proper insulation of kiln, spray dryer and hot air pipelines reduce the heat loss which correspondingly reduces the fuel consumption.
8. The following are different ways to conserve the energy in pumping system:
    - When actual operating conditions are widely different (head or flow variation by more than 25% to 30%) than design conditions, replacements by appropriately sized pumps must be considered
    - Replacement with High Efficiency Pumps
    - By improving the piping design to reduce Frictional Head Loss
    - By reducing number of bends and valves in the piping system
    - By avoiding throttling process to reduce the flow requirement
    - By Trimming or replacing the impellers when capacity requirement is low
    - By using Variable Speed Drives
    - By using Energy Efficient Motors

Energy Efficient Technology Providers: Energy Efficient Technology Providers are as follows:

Table No. 16: Energy Efficient Technology Providers

Sr.	Energy Efficient Technology Provider	Technologies	Website
1.	Sacmi	Ball Mill, Spray Dryer, Press, Kiln	www.sacmi.com
2.	Modena Machinery Co. Ltd	Ball Mill, Spray Dryer, Kiln	www.modena.com.cn
3.	KEDA Industrial Co. Ltd.	Polishing Machine	www.kedagroup.com
4.	Foshan Henglitai Machinery Co. Ltd	Press	www.en.hlt.cc
5.	Green Power International Pvt. Ltd.,	Cogeneration through Gas Engine	www.greenpowerinternational.com
6.	Turbo Mach Pvt. Ltd.	Cogeneration through Gas Turbine	www.mysolar.cat.com
7.	NRG Technologists Pvt. Ltd.	Solar system for preheating spray dryer input slurry	www.nrgtechnologists.com
8.	ABB, Siemens, Bharat Bijli, Kirloskar and	Energy efficient motors	www.elmomachines.com

Sr.	Energy Efficient Technology Provider	Technologies	Website
	National Electrical Industry		
9.	Crystal Controls	Variable frequency drives and controls	-
10.	Shiwkon Digitek Pvt. Limited	Moisture measuring instrument, Power meter, ON - OFF system for agitation motors, Flue gas analyzer	www.shiwkon.com
11.	Wesman Thermal Engg. Processes Pvt. Ltd	High velocity energy efficient burners	www.wesman.com
12.	Yajna Fuel Services	Briquette fired hot air generator	www.yajnafuelindia.com
13.	Chemequip	Recuperator	-
14.	Poonam Refractories	Kiln Insulation	-

3.3.2 Implementation of Small Group Activities

Why is Small Group Activities important?

Small Group Activities (SGA) are activities by group of employees at operator level. They aim to solve problems that occur at the place taken care of by each employee and put emphasis on participation and team work. Factories can apply small group activities to many kinds of work along with normal work or other measures that are already underway. The burden on employees will not increase because of small group activities. They not only bring benefits to factories but also increase the knowledge and ability in performing jobs of employees, improve communication among employees, increase creativity, and make it possible to express their own proposal with less hesitation. As a result, employees will start to think "This is our problem." This SGA can be applied to Energy Conservation, too, with successful results, as shown in Figure 13.

How is Small Group Activities related to Energy Conservation?

An excellent example of organizational structure that promotes energy management emphasizing participation is that they form overlapping small groups as in figure 14. The feature of this structure is that a small group for energy management is distributed to various sections as in figure 15, which is a recipe for success of Total Energy Management (TEM) and makes various communications and management of activities more efficient and effective.

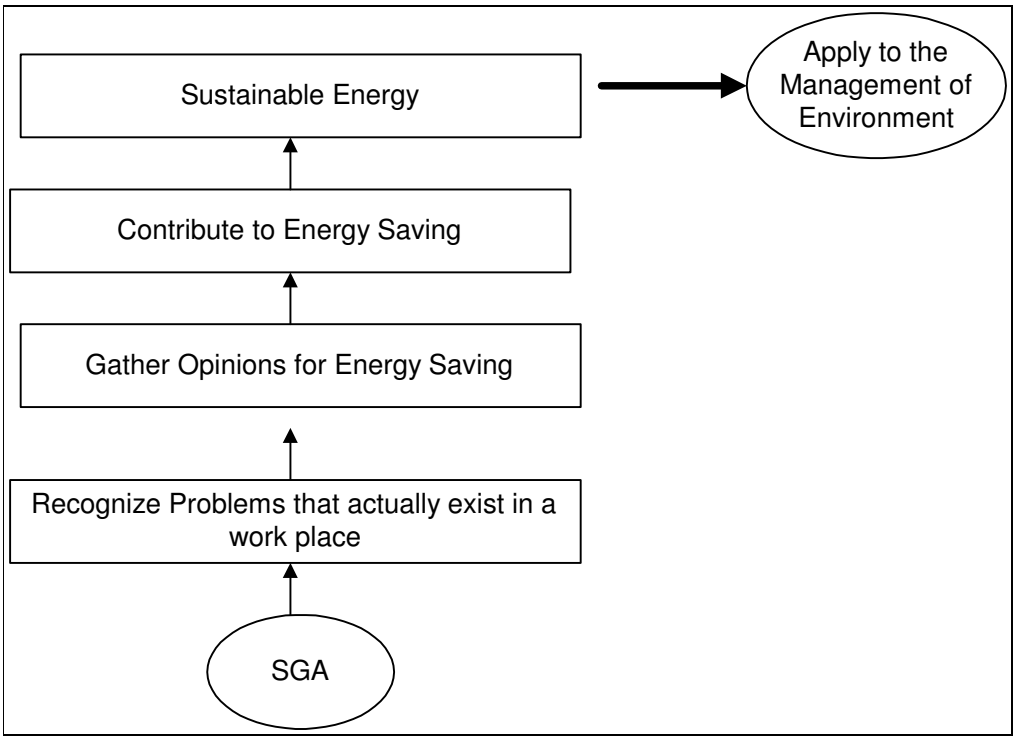

Figure No. 12: Relationship of SGA and energy saving

Small group activities for TEM are the activities in which employees of all levels in production or management, starting from the top to the bottom, participate in order to reduce loss related to their own job by improving their job. In order for the activities to succeed, management of all levels must provide support in necessary training and equipment, communication of policies, and the setting of problems to solve.

Small group activities for TEM can be divided into 4 or 5 levels depending on the scale of the organization. This division is in order to emphasize the fact that everyone must improve in their job under the responsibility to each other. It also enables us to make improvement without overlapping. The following example shows utilizing the existing job-related organization as much as possible, as already mentioned in Part 2, 2."Strategy for Improving the Efficiency of Energy Usage further", Step 2 Proper EC Organization including Assignment of Energy Manager (page 12).

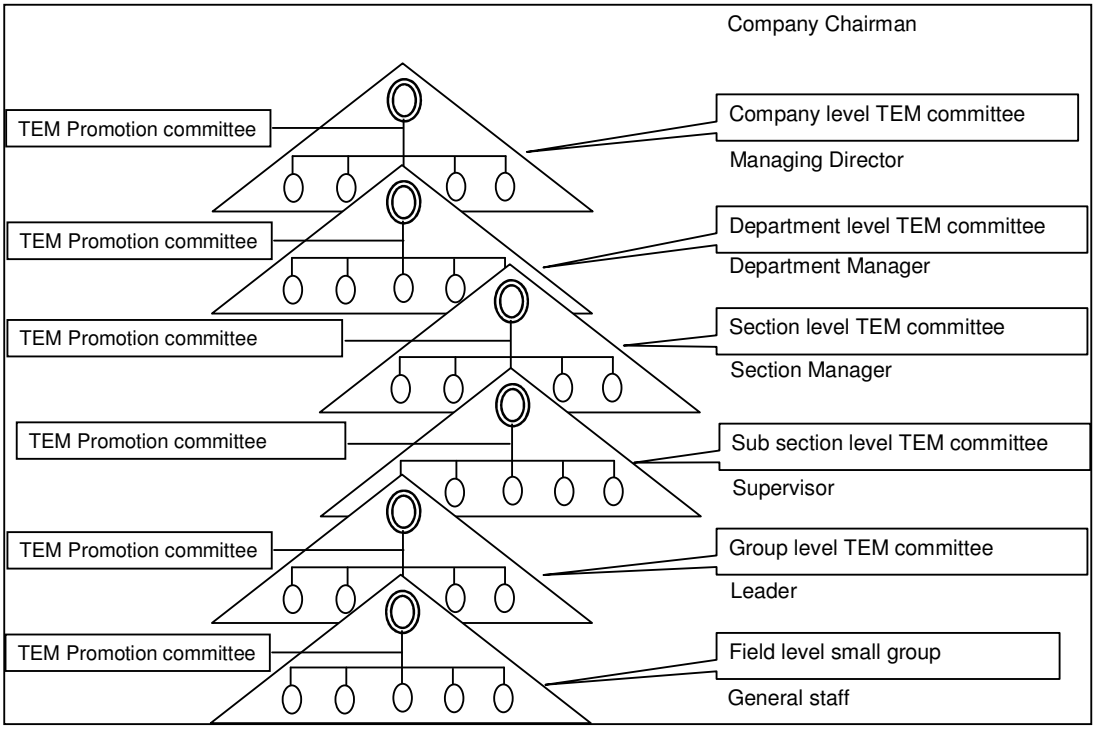

Figure No. 13: Example of Organizational Structure with Overlapping

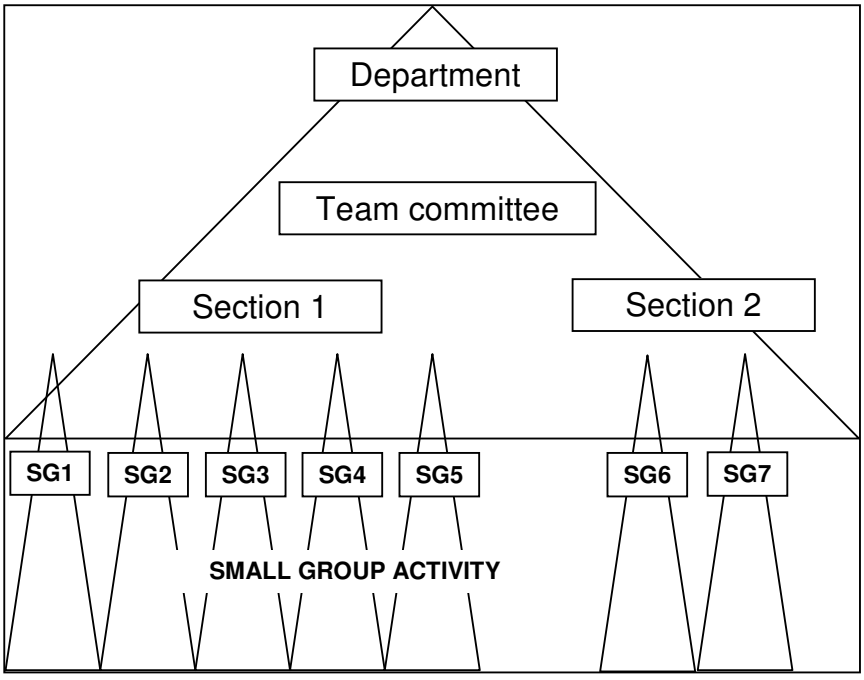

Figure No. 14: Positioning of SGA in Main Job Structure

(1) Executives level

- Define the policy and target for Total Energy Management
- Follow-up and manage activities to make sure that activities are implemented according to the policy

- Consider opinions and suggestions from the promotion office
- Consider reports from promotion committee from various levels

(2) Level of Total Energy Management promotion office

- Make sure that whole activities are done in the correct direction, without delay and smoothly
- Find a suitable method that makes it possible to implement activities continuously and without slowdown
- Listen to opinions and suggestions from small groups in order to use for improving
- Provide advice for Total Energy Management to various groups
- Persons in charge of the office must be those with good personal relationship, friendly, and with spirit of good service

(3) Medium level

- Define the policies of each department that are consistent with the policy of the Total Energy Management and the target of the company
- Define numerical targets to sub-groups apart from the target of the company as a whole
- Follow-up the progress in order to provide to sub-groups
- Report the progress along with suggestions and opinions to upper level committee periodically

(4) Workers/Operators level

- Implement small group activities with various themes and achieve target
- Report progress and problems encountered during implementation to upper level committee periodically
- Ask for support, suggestions, and opinions from upper level committee

(5) Responsibility of Energy Conservation committee

- Gather and analyze information on costs related to energy every month
- Analyze and solve problems related to energy
- Find a method for energy conservation
- Prepare energy conservation plan
- Follow-up the result of implementing the plan
- Perform activities such as public relationship for encouraging employees to participate
- Offer training to small group in each department

3. Steps of Small Group Activities for Energy Conservation

Small group activities for Energy Conservation can be done by using "10 Stages for Success", based on "PDCA Management Cycle", as shown below and also in Figure No. 15:

- Plan: Make an efficient plan in order to improve operation
- Do: Implement according to the plan
- Check: Check if implementation was according to the plan

- Act: Judge what to improve, what to learn and what to do from what we have checked

Please note that these stages are substantially the same as "Key Steps" explained earlier, but put more stress on utilization of SGA. So readers could read and use either methods up to their preference.

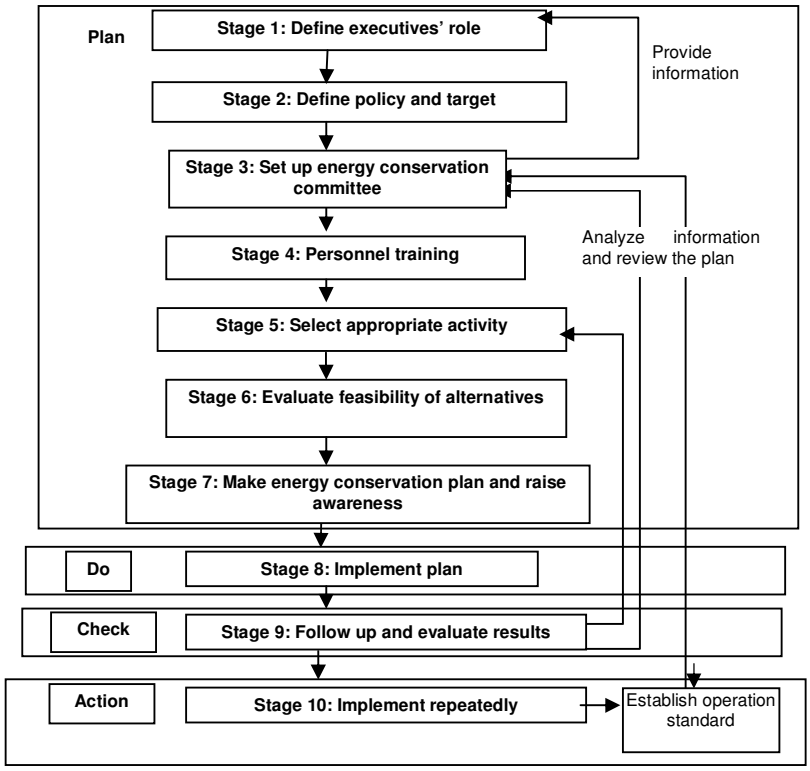

Figure No. 15: 10 Stages for Success

Stage 1: Define Executive's Role

In promoting small group activities, support must be provided such as basic environmental support. Therefore, executives must provide follow up support to employees of their companies.

- Establish a special unit that provides support to small group activities
- Prepare a system for managing small group activities in the company
- Prepare annual plan for small group activities
- Prepare a venue for meeting, consultation, advice or suggestion
- Establish a system for giving rewards to high achieving employees
- Establish a reporting system starting from informing what to do until reporting of the results
- Establish a fair system for evaluating results
- Establish a system for providing support and training to employees

Stage 2: Define Policy and Target

- Executives must announce a policy of supporting small group activities.
- Energy conservation committee must act as an advisor in order to set a numerical

target that is consistent with total energy management (TEM) policy and the target of the organization. Specific targets must be set for each group.

We can see that responsibilities in stages 1 and 2 are mainly those of executives and committee. Responsibility of employees will become clearer from stage 3 and afterwards.

Stage 3: Set up Energy Conservation Committee

The principle of small group activities (SGA) is to divide into groups based on the scope of responsibility. The size of the group will depend on the size of organization. However, size of the group should not be too large. Usually a size of 5 to 10 persons is considered appropriate. It is important to define responsibilities clearly so that every member of the group can have their responsibility and participate in the activities.

Stage 4: Personnel Training

This stage will help employees to have more knowledge and understanding, have new ideas, and have more belief in their own responsibility.

Stage 5: Select Appropriate Activity

In doing small group activities, each member must be able to think, express their own ideas, and make decisions based on reality and by investigating electrical equipment, machines, and office equipment that exist in the area of their responsibility. Items to consider include size, number, where to use, situation of usage, current situation, and the number of hours usage per day.

By this we can evaluate the current situation of energy usage. Also by judging if there are more machines than needed, we can choose suitable activities and real problems for the organization.

Stage 6: Evaluate feasibility of alternatives (Analyze problems and decide on the measures and activities in each point)

Each group will gather ideas on the reasons for the problems, obstacles, and how to solve problems in order to decide on the problems, measures, and importance of activities and thus evaluate on the feasibility of activities to do based on advice from department manager. Basically, the following activities are not suitable for small group activities.

- Highly technical issues
- Issues that require a long time or many people to implement

We have identified the following problems through small group activities.

- Issues on material quality or production that influence energy usage
- Behavior on energy usage
- Efficiency of machines or equipment that uses energy
- Awareness toward environment and energy usage
- Safety costs for energy conservation

Stage 7: Make Energy Conservation Plan and Raise Awareness

Each group must prepare its activity plan. Generally, implementation for small group activities takes 6 months to 1 year. Activities to be implemented should correspond to the

objectives of each group. Besides, it might help to listen to opinions of all organizations in order to receive support from all other organizations.

Stage 8: Implement Plan

Implement according to the plan of each group.

Stage 9: Follow Up and Evaluate Results

After implementing the plan, each member of small groups will follow up and evaluate the result by analyzing result, search for strong and weak points of activities, find a way to improve the activities and report on general achievement.

Stage 10: Implement Repeatedly

Energy conservation is an activity that must be implemented repeatedly. Therefore, it is necessary to implement each activity repeated and make improvement to each activity. If we are satisfied with the results, by achieving the objectives of activities, we should provide rewards in order to give motivation for continuing the small group activities and implement creative activities.

Dos and Don'ts in Energy Conservation

1. Don't Emphasize the mistakes in the past. It is better to talk about the present.
2. Don't Be worried about the theory or principles. Don't spend too much time in discussion or analysis of problems in meeting rooms.
3. Don't Think that an activity can be done perfectly from the beginning. It is necessary to do the job continuously by having experiences and judging by ourselves.
4. Do Start with an activity that requires small amount of investment.
5. Do Raise awareness so that all employees understand the necessity and importance of energy conservation and participate in it.
6. Do Start the activity now without postponing to tomorrow.

Tools that are Used Often for Small Group Activities for Energy Conservation

5S means 5 basic activities that are needed in order to keep order in working space by emphasizing increasing efficiency and improving working environment of the workers. It consists of Seiri (Arrangement), Seiton (Orderliness), Seiso (Cleaning), Seiketsu (Cleanness), and Shitsuke (Discipline).

QCC (Quality control circle) means controlling quality through group activities. For this, it is necessary to work hand in hand and achieve objective quality or customers' request. With this, we can find weak points, find the cause of problems, gather ideas for problem solving and systematically prepare quality and thus, solve problems such as material loss, production costs, working hours, or productivity. This is also a very useful tool to tackle with Energy Conservation problem. So many factories or institutions are encouraged to utilize this tool.

3.4 Energy Conservation Measures Identified

3.4.1 Proposals for Energy Conservation & Technology Up-Gradation

3.4.1.1 Proposal Description Including Technology/Product Specifications, Benefits of Implementation, Cost of Implementation, Monetary Savings, Simple Payback Period and Issues/Barrier in Implementation for Each Proposal

Based on the findings of technology gap analysis & energy audits various energy conservation measures are identified and grouped in following categories:

1. For vitrified tiles, wall tiles, floor tiles and sanitary wares
2. For vitrified tiles, wall tiles and floor tiles
3. For vitrified tiles
4. For Sanitary wares

1. For Vitrified Tiles, Wall Tiles, Floor Tiles And Sanitary Wares

A. Installation of Variable Frequency Drive (VFD) In Ball Mills and Blunger

Project Description and Benefits:

Ball mill/Blunger is a batch grinding process. As per the process requirement the motor should run at full speed during the start of batch, however after a particular time the ball mill or Blunger can be rotated at less speed (RPM). A few of the units have already implemented this project successfully; however most of the units are yet to implement this project. The speed of the motor can be reduced by installing variable frequency drive on Ball Mill/Blunger motor and operating speed can be programmed based on time. This will result in reduction in electricity consumption to the tune of 15% saving in electricity consumption in ball mills and blunger. This concept is applicable to glaze preparation ball mill in glaze section also.

Approximate One Time Investment: It varies from Rs.1,00,000 for small units to Rs. 50,00,000 for large units (per ceramic unit) depending upon their production capacity, numbers of ball mills, blungers and their installed motor capacity.

Annual Savings: Varies from Rs. 37,000 for small units to Rs. 10,00,000 for large units (per ceramic unit) depending upon their production capacity, numbers of ball mills, blungers and their installed motor capacity.

Simple payback period: Varies from 10 to 40 months.

$$\text{Payback period} = \frac{\text{Investment}}{\text{Savings}}$$

Note: One case study on saving calculation by implementation of this project is given in annexure - 1: Technology/ Equipment Assessment Summary (Point 1)

Status of Adaptation of This Technology: This technology is already in operation in a few of the units in Morbi, its mass scale adaptation is yet to happen.

Issues/Barrier in implementation: There are no technological barriers as variable frequency drives on kiln blowers and some other applications has already been implemented in most of the ceramic units. Benefit of variable frequency drive is already known to the users. However in case of ball mills the motor size is multiple times higher

than the blower motors, therefore investment is high and in comparison to blowers % saving is less. No. of ball mills or blungers are also more, all are not in operation simultaneously so the operating hours per ball mill is low. So return on investment is comparatively lower than that for blowers. It is expected that this measure will pickup in near future.

B. Installation of Variable Frequency Drive (VFD) in Motors of Agitation Section

Project Description and Benefit:

It is observed that the loading on agitator motors is in between 30% to 65%. Also the speed of the motors is higher than required for most of the time during agitation process. It is to be noted that agitation is a variable load process. Initially when the fresh charge comes from Ball Mill/Blunger, loading on motor is in between 65 % to 72%. However after some time as the raw material become uniform then the loading on motor decreases. For most of the time motor keeps on rotating at higher speed than the required. Installation of the variable frequency drive (VFD) on agitator motors can saves electricity consumption in agitation section by 15 %.

Approximate One Time Investment: Varies from Rs. 80,000 to Rs. 16,00,000 for a single ceramic unit depending upon the production capacity and size & number of agitator motors.

Annual Savings: Varies from Rs. 20,000 to Rs. 2,50,000 for a single ceramic unit depending upon the production capacity and size & number of agitator motors.

Simple payback period: Varies from 18 to 30 months.

Note: One case study on saving calculation by implementation of this project is given in annexure - 1: Technology/ Equipment Assessment Summary (Point 2a)

Status of Adaptation of This Technology: At present, this measure is at proof of concept level and being tried in a few of the units.

Issues/Barrier in implementation: Though this measure is techno-economically viable, but over all saving potential is low as % energy consumption for agitation process itself is low. There are no technological barriers as variable frequency drives on kiln blowers and some other applications has already been implemented in most of the ceramic units. Thus benefit of variable frequency drive is already known to the units. As the agitator motor size is small, investment is also low. It is expected that this measure will pickup in near future.

C. Replacement of Existing Standard Efficiency Motors by Energy Efficient Motors in Agitation Section

Project Description and Benefit:

In agitation section, loading on motors is adequate at the start of the batch i.e. just after addition of slurry in the agitation tank, however as the mixture becomes uniform, loading on motor decreases to less than 50%. This reduction in motor loading decreases the motor efficiency and thereby results in more electricity consumption. As the motors are standard efficiency motors, at reduced load drop in efficiency is very high, therefore replacement of the existing standard efficiency motors by energy efficient motors will result in significant saving in electricity consumption of agitator motors. It is to be noted that

while energy efficient motors have better efficiency (1.5% to 3%) at full load but at partial load (< 50%) this difference goes as high as 4% to 8% resulting in higher savings at low load situations.

Approximate One Time Investment: It varies from Rs. 50,000 to Rs. 8,00,000 for a single ceramic unit depending upon its production capacity and size & number of agitator motors.

Annual Savings: Varies from Rs. 10,000 to Rs. 3,00,000 for a single ceramic unit depending upon the production capacity and size & number of agitator motors.

Simple payback period: Varies from 6 to 40 months.

Note: One case study on saving calculation by implementation of this project is given in annexure - 1: Technology/ Equipment Assessment Summary (Point 2b)

Status of Adaptation of This Technology: This technology is yet to start in the cluster, as the awareness will improve through this project and more and more EE motor manufacturers start taking interest in the cluster its adaptation will increase. Few demonstrations are necessary so that units start accepting the technology. For new units, it will be easier to adopt the technology as for them the incremental payback period for additional investment in EE motor will have more attractive payback period. Therefore new units are urged to install EE motors right since beginning specifically on the equipments requiring motors of less than 50 HP (37kW) capacity.

Issues/Barrier in implementation: Awareness about the energy efficient motors need to be improved. Vendors for EE motors are to be brought to the cluster. More demonstrations (including demonstrations by third party) will certainly increase its adaptation. New units are likely to take more interest.

D. Implementation of ON - OFF Controller (10 minutes ON and 5 minutes OFF) for Agitation Motors

Project Description and Benefits:

In agitation section, agitators are provided in underground tanks to maintain the uniformity of the slurry. These motors operate for about 24 hours in a day. Installation of automatically ON - OFF system on the agitator motors do not effect the uniformity (quality) of slurry but gives saving in electricity consumption in agitator motors. This system automatically switches ON agitator motors for about 10 minutes and then switches OFF for about 5 minutes. This means that in one hour agitator motors operate for about 40 minutes and remain switch off for about 20 minutes. This could result in approximately 30% saving in electricity consumption of agitator motors.

Approximate One Time Investment: Varies from Rs. 5,000 for small units to Rs. 1,60,000 for large units for a single ceramic unit depending upon the production capacity and size of a particular ceramic unit.

Annual Savings: Varies from Rs. 17,000 to Rs. 2,00,000 for a single ceramic unit depending upon the production capacity and size of a particular ceramic industry.

Simple payback period: Varies from 3 to 13 months

Note: One case study on saving calculation by implementation of this project is given in annexure - 1: Technology/ Equipment Assessment Summary (Point 2c)

Status of Adaptation of This Technology: This technology is already implemented and working successfully in the cluster however mass scale adaptation is yet to happen.

Issues/Barrier in implementation: There are no issues as such. More awareness on such automatic controls, mass scale demonstration will increase its adaptation. There is some concern about its impact on the quality. Promotional approach by the LSPs can accelerate the adaptation.

E. Improvement in Kiln Insulation

Project Description and Benefits: One of the heat losses in the kiln is due to the radiation loss from the surface of the kiln which is minimized by improving the insulation in kiln, spray dryer, pipes, recuperators and other hot surfaces. This reduces the surface temperature and thereby reduces fuel consumption.

Approximate One Time Investment: Varies from Rs. 2,00,000 to Rs. 30,00,000 for a single ceramic unit depending upon the production capacity and size of a particular ceramic unit.

Annual Savings: Varies from Rs. 60,000 to Rs. 15,00,000 for a single ceramic unit depending upon the production capacity and size of a particular ceramic unit.

Simple payback period: Varies from 20 to 36 months

Note: One case study on saving calculation by implementation of this project is given in annexure - 1: Technology/ Equipment Assessment Summary (Point 3)

Status of Adaptation of This Technology: Kiln insulation improvement has already been taken in many ceramic units. Mostly this activity is carried out during annual plant shut down.

Issues/Barrier in implementation: Awareness about quantification of the ongoing losses due to poor insulation will increase the adaptation. This was observed during the field studies when the thermographs were shown to the units where detail energy audit has been carried. As the units observed hot spots, their readiness to improve the insulation increased. All these thermographs are also provided in the detail energy audit reports to specifically drive implementation of this measure.

F. Power factor improvement to unity through installation of capacitors

Note: Electricity tariff structure at Gujarat is already covered in point J - Electrical Distribution System under the heading of 3.3.1 - Technology Gap Analysis and Process Up gradation

Project Description and Benefits:

Gujarat state electricity board provides the incentives for good power factor (PF > 0.95) and penalty for bad PF (less than 0.9). For power factor maintained at unity, incentives of 2.5% on energy and demand charges are provided. Most of the units have scope for improving this incentive by 0.5% to 1.5%. Power factor is improved by the installation of capacitors and replacement of the de-rated existing capacitors.

Approximate One Time Investment: It varies from Rs. 5,000 to Rs. 5,49,000 for a single ceramic unit depending upon present PF and operating load.

Annual Savings: It varies from Rs. 3,000 to Rs. 3,40,000 for a single ceramic unit depending upon present PF, maximum demand & energy charges.

Simple payback period: Varies from 4 to 48 months

Note: One case study on saving calculation by implementation of this project is given in annexure - 1: Technology/ Equipment Assessment Summary (Point 4)

Status of Adaptation of This Technology: Automatic Power Factor Controller (APFC) technology is already implemented in many units, however understanding of its functioning and the concept of PF, its impact on the bill and understanding on testing of capacitors need to be improved. There is no monitoring of the results after the installation of APFC. This is also due to non-trained man-power on the shop floor for this matter.

Issues/Barrier in implementation: Most of the unit owners are financially aware of this tariff benefit however in many units there is no periodical checking of capacitors. More training at shop floor level is necessary. Proper approach for monitoring of PF must be developed and followed. This can be done by daily monitoring of PF and take corrective actions accordingly.

G. Preheating of combustion air by smoke air through recuperator in ceramic tiles industry

Project Description and Benefits:

It was observed that in ceramic kiln, exhaust smoke air (flue gas) of kiln having temperature between 150ºC to 250ºC is not utilized due to presence of sulphur in smoke air. Many of the ceramic units tried to utilize the smoke air heat but their experiments failed due to corrosion. To avoid this problem right material of construction (high grade stainless steel) for recuperator is necessary so that material has less impact due to the sulphur. Also these recuperators are to be procured from experienced suppliers only. Cost will be more but the equipment will survive for more periods (4 to 5 years). As the cost of the recuperator is paid back faster then its life it still makes economical sense to install such recuperators. Also one observation is that as spray dryer material sustains sulphur content in the material then the recuperator can also work, the only important issue is that one has to select proper material of construction to avoid corrosion.

Approximate One Time Investment: Varies from Rs. 2,50,000 to Rs. 24,00,000 for a single ceramic unit depending upon the production capacity and size of a particular ceramic unit.

Annual Savings: Varies from Rs. 2,00,000 to Rs. 40,00,000 for a single ceramic unit depending upon the production capacity and size of a particular ceramic unit.

Simple payback period: Varies from 5 to 30 months

Note: One case study on saving calculation by implementation of this project is given in annexure - 1: Technology/ Equipment Assessment Summary (Point 6)

Status of Adaptation of This Technology: It has been tried but has not worked in long run. Proper recuperator designer and manufacturer needs to take the initiative and demonstrate successful operation of this technology in at least one ceramic unit, others will follow accordingly.

Issues/Barrier in implementation: Fear of corrosion needs to be removed by demonstration.

2. For Vitrified Tiles, Wall Tiles And Floor Tiles

A. Preheating of input slurry of spray dryer through solar energy up to 60^{o}C

Project Description and Benefits:

Availability of sunlight is good in Morbi. Utilization of the solar energy for spray dryer slurry preheating up to 60 ^{o}C can saves fuel consumption in spray dryer significantly. Hot water at a temperature of about 80 ^{o}C is generated through solar energy with the help of solar flat plate collectors. Slurry going to the spray dryer is preheated through hot water up to 60 ^{o}C in a heat exchanger. This does not remove moisture content in slurry; it only preheats the slurry upto 60 ^{o}C. By preheating the slurry up to 60 ^{o}C will results in 2 to 3% saving in fuel consumption in the spray dryer.

Approximate One Time Investment: Varies from Rs. 7,00,000 to Rs. 65,00,000 for a single ceramic unit depending upon the production capacity, size of the unit, number and capacity of the spray dryers and layout related issues.

Annual Savings: Varies from Rs. 50,000 to Rs. 21,00,000 for a single ceramic unit.

Simple payback period: Varies from 4 to 7 years

Note: One case study on saving calculation by implementation of this project is given in annexure - 1: Technology/ Equipment Assessment Summary (Point 6)

Status of Adaptation of This Technology: At present this technology is not in use, however there is very good potential for this technology. Once if this technology runs successfully in one ceramic unit then will be definitely implemented in other units also.

Issues/Barrier in implementation: High investment, high payback period and no demonstration.

B. Installation of Biomass/Briquette Fired Hot Air Generator Which Supplies Hot Air for Kiln Firing, Dryer and Spray Dryer Firing

Project Description and Benefits: In case, where only natural gas is used in the plant and no solid fuel is used and the hot air from the kilns is fully utilized in the dryer, energy cost saving can be achieved by generation of hot air at about 300 ^{o}C from biomass/briquette fired hot air generator and utilization of this hot air as a combustion air in kiln and spray dryer. These energy cost saving are achieved only due to the price difference in the solid fuel and the natural gas. Rs/Kcal of solid fuel is more economical than natural gas.

Approximate One Time Investment: Rs. 10,00,000 to Rs. 30,00,000 for a single ceramic unit depending upon the plant capacity.

Annual Savings: Varies from Rs. 12,00,000 to 40,00,000 for a single ceramic unit depending upon the plant capacity.

Simple payback period: Varies from 10 to 12 months

Note: One case study on saving calculation by implementation of this project is given in annexure - 1: Technology/ Equipment Assessment Summary (Point 8)

Status of Adaptation of This Technology: Such approach is not in use in Morbi, however the hot air generator is proven technology.

Issues/Barrier in implementation: Awareness about the technology is first necessity. More experiments need to be carried out as a proof of concept for such a application.

3. For Vitrified Tiles

A. Installation of Natural Gas Turbine for Electricity Generation and Use of Exhaust Flue Gas of Turbine in Spray Dryer

Project Description and Benefit: In ceramic units, natural gas is used in spray dryer as a fuel and electricity is taken from the state grid. Gas Turbine based cogeneration technology generates electricity for the plant where as the hot exhaust of the gas turbine is used in spray dryer. Mostly there is no supplementary fuel requirement in the spray dryer. This saves total spray dryer fuel cost. Over all energy cost of plant in co-generation mode is lower than the present scenario. From total natural gas input to the gas turbine 20 % of the energy in natural gas is converted to electricity and remaining energy (80%) goes in flue gas which is supplied to the spray dryer as its complete source of energy. One unique observation about energy prices in Morbi – NG prices have come down over a period of time where as electricity prices have gone up. If this trend goes on for more period, feasibility for Gas Turbine will further improve.

Approximate One Time Investment: Rs.6,80,00,000 to Rs. 13,75,00,000 depending on the size of the co-generation plant required.

Annual Savings: Rs. 2,56,00,000 to Rs. 6,07,00,000

Simple payback period: Varies from 31 to 37 months

Note: One case study on saving calculation by implementation of this project is given in annexure - 1: Technology/ Equipment Assessment Summary (Point 9)

Status of Adaptation of This Technology: This technology is already implemented and running successfully in other ceramic units out of Morbi Cluster. One of the unit in Morbi is implementing this technology where as one more unit is also likely to start soon.

Issues/Barrier in implementation: High investment and high payback period. As the cluster will see NG based co-generation in Morbi Cluster further installations will automatically increase.

B. Installation of Natural Gas Engine for Electricity Generation and Use of Exhaust Flue Gas of Engine in Spray Dryer

Project Description and Benefits: Use of Gas Engine is another option for adopting cogeneration technology. About 40% of the input heat is utilized for electricity generation, 30% of input heat is available in the exhaust which can be used in the spray dryer and the remaining heat loss is from jacket cooling water which is to be utilized for preheating slurry or combustion air through installation of radiator. This technology reduces overall energy cost of plant.

Approximate Investment required: Rs. 4,60,00,000 to Rs. 8,00,00,000 depending on size of the unit

Annual Savings: Rs. 1,57,00,000 to Rs. 3,06,00,000 depending on the electricity requirement of the unit.

Simple payback period: Varies from 27 to 38 months

Note: One case study on saving calculation by implementation of this project is given in annexure - 1: Technology/ Equipment Assessment Summary (Point 10)

Status of Adaptation of This Technology: This technology has already been implemented in other units out of Morbi Cluster how ever in Morbi Cluster it is yet to start. In Morbi, one of the unit has taken proposal from the technology supplier.

Issues/Barrier in implementation: High investment and high payback period. The units want to see the demonstration first at Morbi cluster only.

C. Replacement of Standard Efficiency motors by Energy Efficient motors in polishing machine in case of vitrified tiles

Project Description and Benefits: Polishing section is the major electricity consuming section in vitrified tiles units. About 40 to 50 % of electricity out of total is consumed by the polishing section. It was observed that the loading of the machines of polishing section is less than 50 %. Efficiency of standard efficiency motors decreases significantly with the decrease in loading of the induction motors. It is observed that the motors installed on the polishing machines have rated efficiency of about 85% only. Therefore, there is more scope of saving in electricity consumption by replacement of the existing motors of the polishing machines by the energy efficient motors. New units can install energy efficient motors from beginning because payback period for incremental cost is usually small.

Approximate One Time Investment: Varies from Rs. 16,00,000 to Rs. 27,00,000 for a single ceramic unit depending upon the production capacity, size and number of motors.

Annual Savings: Varies from Rs. 8,00,000 to 20,00,000 for a single ceramic unit depending upon the production capacity, size and number of motors.

Simple payback period: Varies from 10 to 28 months

Note: One case study on saving calculation by implementation of this project is given in annexure - 1: Technology/ Equipment Assessment Summary (Point 11)

Status of Adaptation of This Technology: At present EE motors are not yet adopted in the cluster; however if the awareness is increased and results are properly demonstrated, more units will adopt EE motors.

Issues/Barrier in implementation: Unawareness about the energy efficient motors and their saving potential. Polishing machines are imported and motors come as a part of it. Many times the user is dependent on the equipment supplier for the kind of motors that come with the equipment. More demonstration cases will increase its implementation.

4. For Sanitary Wares

A. Installation of Low Thermal Mass Cars in Tunnel Kiln for Sanitary wares

Project Description and Benefit: It was observed that weight of the tunnel kiln car is more which results in extra fuel consumption as material of the kiln car is also heated to same product temperature. The kiln car consists of steel structure with wheels at the bottom. On the structure of kiln car, refractory bricks are provided to form the support structure for the sanitary wares. If replacement refractory bricks is carried out by porous blocks and ceramic fiber material and also with similar other measures, weight of the kiln car can be significantly reduced which will result in saving in fuel consumption. Weight of the kiln car can be reduced by 23 to 24 %.

Approximate One Time Investment: Varies from Rs. 16,00,000 to 20,00,000 for a single ceramic unit depending upon the production capacity and size of the tunnel kiln.

Annual Savings: Varies from Rs. 5,50,000 to 6,80,000 for a single ceramic unit.

Simple payback period: Varies from 7 to 32 months for a single ceramic unit

Note: One case study on saving calculation by implementation of this project is given in annexure - 1: Technology/ Equipment Assessment Summary (Point 12)

Status of Adaptation of This Technology: This technology is already in use in some of the units, whereas other units are following it and implementing this technology.

Issues/Barrier in implementation: Lack of awareness about the technology and resistance to adopt the change even if it is known. More of training, demonstration and sharing the results will enhance its adaptation.

B. Installation of recuperator in tunnel kiln thereby preheating combustion air through smoke air

Project Description and Benefit: Smoke air of tunnel kiln is not utilized and is exhausted in to the atmosphere. Like ceramic tiles, smoke air of sanitary wares tunnel kiln does not have sulphur content. Therefore, smoke air of tunnel kiln can be easily utilized to preheat the combustion air through recuperator.

Approximate One Time Investment: Varies from Rs. 89,000 to Rs. 5,30,000 for a single ceramic unit depending on size and layout of the kiln.

Annual Savings: Varies from Rs. 50,000 to Rs. 4,50,000

Simple payback period: Varies from 7 to 14 months

Note: One case study on saving calculation by implementation of this project is given in annexure - 1: Technology/ Equipment Assessment Summary (Point 13)

Status of Adaptation of This Technology: Presently this technology is not in use, once if this technology runs successfully in one of the units then it will be definitely implemented by other units also.

Issues/Barrier in implementation: Awareness among the units needs to be improved. Efforts from LSPs need to be increased to convince the units. Most of the units want to see the demonstration first and then there is willingness for implementation.

C. Use of hot air of cooling zone of tunnel kiln directly as a combustion air.

Project Description and Benefits:

In tunnel kiln of sanitary wares, direct use of hot air from final cooling zone of the kiln as combustion air will result in saving in natural gas consumption in the tunnel kiln. This can be carried out by just extending the suction of the existing combustion air blower to the final cooling zone of kiln. It requires only the cost of the pipeline to extend the length and the insulation.

Approximate One Time Investment: Varies from Rs. 50,000 to 60,000 for a single ceramic unit depending upon size & layout of the kiln.

Annual Savings: Varies from Rs. 80,000 to 4,00,000 for a single ceramic unit depending upon size of the kiln.

Simple payback period: Varies from 2 to 12 months

Note: One case study on saving calculation by implementation of this project is given in annexure - 1: Technology/ Equipment Assessment Summary (Point 14)

Status of Adaptation of This Technology: This technology is already in operation in some of the units. However it is to be promoted to be used in other units.

Issues/Barrier in implementation: Awareness among the units needs to be improved. Efforts from LSPs need to be increased to convince the units. Most of the units want to see the demonstration first and then there is willingness for implementation.

D. Use of hot air of final cooling of tunnel kiln for preheating the input material

Project Description and Benefit:

If smoke air is utilized to preheat the combustion air in tunnel kiln then the hot air from the final cooling zone of tunnel kiln having temperature between 113ºC to 130ºC can be utilized to preheat the input material of kiln by constructing on small chamber and passing this hot air and material to be pre-heated in this chamber. This will result in saving in fuel consumption in the tunnel kiln.

Approximate One Time Investment: Varies from Rs. 3,50,000 to Rs. 6,50,000 for a single ceramic unit depending upon the production capacity and size of the tunnel kiln.

Annual Savings: Varies from Rs. 3,50,000 to Rs. 5,81,000 for a single ceramic unit

Simple payback period: Varies from 7 to 14 months

Note: One case study on saving calculation by implementation of this project is given in annexure - 1: Technology/ Equipment Assessment Summary (Point 15)

Status of Adaptation of This Technology: At present this technology is not in use however there is willingness to adopt this technology. Once this technology runs successfully in one unit then other units will adopt it fast

Issues/Barrier in implementation: Want to see first the demonstration and then there is readiness to implement the technology.

3.4.2 Availability of Technology in Local/National/International Market

Extensive survey has been carried out to identify availability of technology/ product in local/national /international market. Scenario and the opportunities are explained to them those who were not aware about the Morbi Cluster. Thereafter only those who have shown interest to serve Morbi Cluster are included in the following lists. Details of the international, national and local service providers are given in sections 3.3.1 and 3.4.3.

3.4.3 Availability of Local Service Providers Who Can Take Up the Proposals

LSPs who can take up above mentioned proposals are as follows:

Table No. 17: Details of the Vendors for Supplying the Identified Technologies

Sr.	Technology	Name of Service Provider	Address	Contact Person and No.
1.	Variable Frequency Drive for AC Motors and capacitors including APFC Panel for PF improvement	Crystal Controls	309, Abhishree complex, Opp. Star India Bazar, Nr. Jodhpur Char Rasta, satellite, Ahmedabad – 15	Mr. Dhanji Ghinaiya - 09714714192, 079 – 26923306
2.	Solar Heating System for pre-heating the slurry to spray dryer	NRG Technologists Pvt Ltd	989/6, GIDC Makarpura Vadodara - 390 010, Gujarat State	Mr. Chaitanya Yardi - 0265-2642094, 2656167
3.	Energy Efficient Motors	ABB/National Electrical Industry (NEI), Hindustan Motor	NEI - Vimla Complex, second Floor, Nr. Old Shardamandir Rly. Crossing, Ahmedabad - 06 ABB - Ahmedabad	National Electrical Industry - Mr. Anuj Patel - 09898084805 ABB- Mr. Dinesh Mistry - 0265 - 2642141/42
4.	Instrumentation such as moisture measuring instrument, ON - OFF system, Power meter etc.	Shiwkon Digitek Pvt. Limited	309 - Pushpam, Opp.Seema Hall, 100 Feet, Shyamal - Anand Nagar Road. Satellite, Ahmedabad - 380 015	Mr. Hardik Patel - 09825050706
5.	Briquette fired hot air generator	Yajna Fuel Services	B – 15, Dattaviahar Co – Operative Housing Society, Ground Floor, Shivaji Nagar, B – Cabin, Thane (W) – 400602	Mr. Mukund Gharpure - 09969410594, 022 - 25424983

Sr.	Technology	Name of Service Provider	Address	Contact Person and No.
6.	Gas Engine	1. Green Power International Pvt. Ltd.	E – 12/A, Sector – 63, Noida – 201 301 (U.P.), India	Mr. Ashish Trikha - 0120-4655 460 / 4655 455 / 458, 09717790676
		2. Wartsila India Limited	48, Neco Chambers, Sector 11, C B D Belapur, 400 614 Navi Mumbai	022 -2757 5361/71
		3. Cummins Inc		
7.	Gas Turbine	Turbo Mach India Pvt. Ltd.,	5 & 6, Papa Industrial Estate, Suren Road, Andheri (East), Mumbai – 400093	Mr. Pradeep Yadav - 09833491235
8.	Energy Efficient Burners, which can take combustion air having temperature 300 Deg C and above	Wesman Thermal Engg. Processes Pvt. Ltd	B/702, Sagar Tech Plaza, Andheri-Kurla Road, Saki Naka, Mumbai 400 070	Mr. Frederick C Pinto – 022-28509521/22, 09324384381
9.	Low thermal Mass car of tunnel kiln, other projects of sanitary ware tunnel kiln	Payal Allien Engineering	Morbi	Mr. Hasmukh Patel - 09427934644
10.	Recuperator	Chemequip Industries	451/2 GIDC Makarpura Industrial Estate Vadodara -390 010	Mr. Parthiv Adeshra - 09824209898
11.	Kiln insulation improvement	Poonam Refractories	Bazar Road, Post Box No. 2, Wankaner-363621 (Dist. Rajkot)	Mr. Ketan Mehta - 09825224640
12.	Ceramic fibre supplier for tunnel kiln car	Orient Refractory	220, Ambawadi, GIDC, Wadhwan city, Surendranagar	Mr. R.K.Jain - 09825355877

Table No. 18: Details of the Identified Technical Experts to Assist For Implementation of Above Identified Projects in Ceramic Industry

Sr.	Technology	Name of Service Provider	Address	Contact person and No.
1.	Technical Expert to provide the guidance or design for implementation of identified projects	Yajna Fuel Services	B – 15, Dattaviahar Co – OperativeHousing Society, Ground Floor, Shivaji Nagar, B – Cabin, Thane (W) – 400602	Mr. Mukund Gharpure - 09969410594, 022 - 25424983
2.	Roller Kiln Expert	Perfect Mechanical System	8 A - National Highway, Lakdhirpur Road, Morbi	Mr. Bakulbhai - 09825230692
3.	Tunnel Kiln Expert	Sharma Kiln Technology	Morbi	Mr. Adir Sharma - 09327039235
4.	Ceramic Plant Expert in operation and maintenance	Individual Consultant	Morbi	Mr. Omesh Gandhi - 09879417065

3.5 Identification of technologies/equipments for DPR preparation

3.5.1 Justification for Technologies Identified for DPR Preparation

Sr.	List of technologies for DPR Preparation	Justification for selection of technologies
1.	Installation of variable frequency drive (VFD) in Ball Mills and Blunger resulting in saving in electricity consumption in Ball Mills and Blungers	This technology is already implemented in a few units and savings have been achieved. Units in Morbi are fully aware of energy savings by installation of VFDs in kiln blower. Its mass adaptation has already happened in kiln blower case. Units have shown readiness for its implementation. Further procurement and implementation time is low.
2.	Saving in Electricity Consumption in agitation section by following 3 measures: Units must implement one of the technology, which ever is comfortable to them	
2a	Installation of variable frequency drive (VFD) in motors of agitation tanks resulting in saving in electricity consumption of agitation section.	Morbi Cluster is comfortable with VFDs and its operation therefore only savings through this measure needs to be convinced.
2b	Replacement of existing standard efficiency motors by energy efficient motors of agitation tank resulting in saving in electricity consumption in agitation section	The cluster has not yet tasted energy efficient (EE) motors and resulted energy savings. Therefore it is important to begin with EE motors. Here in agitators the motor size is small (<10 kW), loading is varying (35% to 70%), running time is 24 hours so all the conditions are perfectly suiting in favor of EE motors. Some of the Industrialists have indicated that they may not Implement this technology in existing plant as the investment has been already made but they will definitely

Sr.	List of technologies for DPR Preparation	Justification for selection of technologies
		consider implementation of EE motors in new plants. There are about 50 new plants coming up at Morbi. Incremental payback for installation of new EE motor is very less.
2c	Implementation of ON - OFF system (10 minutes ON and 5 minutes OFF) for agitation motors results in saving in electricity consumption of agitation section	This control is already in use in some of the ceramic industries. Cost for implementation of this technology is negligible as compared to the savings achieved; therefore this control mechanism could be picked up very fast for implementation in Morbi ceramic cluster.
3.	Improvement in kiln, spray dryer and other hot surface insulation resulting in saving in respective fuel consumption	As a routine maintenance insulation levels must be regularly checked. If timely corrective measure is not taken then the losses will go up over a period of time. So it is not an option. This measure can be implemented during annual shut down. For implementation of this measure, creating the awareness is required. Loss quantification due to poor insulation needs to be explained by the LSP to the unit owners then the unit owners will definitely be going to implement insulation improvement as a regular maintenance activity.
4.	Monitory saving in electricity bill due to increase in PF rebate and MD charges reduction by power factor improvement through installation of capacitors & APFC panel	This is the simplest and widely accepted measure for energy cost reduction in all the industries. Many of the units have installed capacitors and APFC panel however due to lack of technical understanding of PF, monitoring of PF is not adequate. Many of the unit owners did not know the amount of benefit by power factor improvement. They just knew that there is incentive provided by GEB but how much is not known. After increase in awareness, the understanding on PF is improving how ever this measure has to be taken as a specific measure till the results are not achieved on sustained basis. Periodical checking of the de-rated capacitors and their replacement is must. Its not that the APFC is installed and the job of PF management is fully done.
5.	Preheating of input slurry of spray dryer through solar energy resulting in saving in spray dryer fuel consumption	This is the most feasible renewable energy project for the cluster. Even though the cost of implementation of this technology is high but due to the subsidies available by MNRE for implementation and possible CDM benefits through POA or bundled CDM project, unit owners may think to implement this project.

Sr.	List of technologies for DPR Preparation	Justification for selection of technologies
6.	Use of exhaust smoke air of kiln to preheat the combustion air in kiln through recuperator thereby resulting in saving in fuel consumption in the kiln	Presently, unit owners do not think of using this technology due to sulphur content and moisture presence in flue gas as the recuperators get corroded. But if right grade of Stainless Steel is used for manufacturing the recuperator and instead of fabricating it if it is procured from the established and proven supplier life of the recuperator can definitely be increased. So the manner of implementing this project needs to be changed. After creating the awareness on how to implement this technology so that the life of the recuperator could be achieved for about 5 to 6 years and the vendor keeping the cost within reach do that lower payback period could be achieved – can be the right conditions for acceptance of the technology. After every 5 to 6 years the recuperator could be replaced.
7.	Installation of variable frequency drive on hydraulic press motors resulting in saving in electricity consumption in press section	This technology is already implemented in some of the ceramic units. If proper awareness is created increased adaptation will occur. As the savings are proved on the shop floor, more units will implement the project.
8.	Installation of briquette fired hot air generator which supplies hot air for kiln firing, dryer and spray dryer firing	This is an interesting concept in which savings will occur because of price difference in fuels. This is the reason why most of units are using solid fuel in spray dryer where as (because of product quality issue) most of units use NG in the kiln. Air which is required for combustion can be pre-heated in hot air generator by using solid fuel (as it is available at cheaper rate). If proper awareness is created on this concept the unit owners may find it interesting for implementation.
9.	Installation of Natural Gas Turbine for Electricity Generation and use of exhaust flue gas of turbine in spray dryer resulting in elimination of fuel in spray dryer and reducing overall energy cost	Implementation of this technology may take time as the investment is high also payback period is high but overall saving potential is very high. Units in Morbi have already started exploring this option. It is expected that a few installation of GT can occur in near future, looking at these installations others will follows soon.
10.	Installation of Natural Gas Engine for electricity generation and using the exhaust flue gas in spray dryer resulting saving in spray dryer fuel cost	This option has comparatively less capital cost. Many NG based cogeneration systems are already operating in Gujarat in variety of industries. Though technically GT suits more for ceramic industry but looking at cost and easier operational intricacies NG based co-

Sr.	List of technologies for DPR Preparation	Justification for selection of technologies
		generation is also recommended for the cluster. Any one or both picks up in the cluster its good for the cluster.
11.	Use of energy efficient motors for polishing line results in saving in electricity consumption in polishing section.	The cluster has not yet tasted energy efficient (EE) motors and resulted energy savings. Therefore it is important to begin with EE motors. Polishing motors in vitrified tile plants consume 40% to 45% of electricity. Therefore saving potential from this technology is very high. Here Some of the Industrialists have indicated that they may not be able to Implement this technology in their existing plants as the investment has been already made but they will definitely consider implementation of EE motors in new plants. There are about 50 new plants coming up at Morbi. Incremental payback for installation of new EE motor is very less.
12.	Installation of low thermal mass cars in tunnel kiln for sanitary wares resulting in saving in fuel consumption in kiln	As this concept is already in use in some of the sanitary wares units at Morbi itself, further improvement in awareness can enhance the adaptation. The unit owners are expected to implement this measure after knowing the savings and investment.
13.	Installation of recuperator in tunnel kiln thereby preheating combustion air through smoke air resulting in saving in fuel consumption in kiln	It's a proven measure, already in existence in ceramic units outside Morbi. Once this technology is implemented at one place or once a unit gets convinced about the savings achieved by this technology, its implementation will start, which will be followed by others as in this project investment is less.
14.	Use of hot air of cooling zone of tunnel kiln as combustion air resulting in saving in fuel consumption in kiln	This technology is already in use in some units. Also it requires very less investment and the savings achieved is large. Therefore, many of the sanitary ware units will implement this technology.
15.	Use of hot air of final cooling of tunnel kiln for preheating the input material resulting in saving in fuel consumption in kiln	This practice is already applied in some of the vitrified tiles units. The same needs to be brought to sanitary ware units. Once proper awareness is created, saving potential and investment required are understood, the units will definitely implement this project.

3.6 ENVIRONMENTAL BENEFITS

Sr.	List of technologies for DPR Preparation	Environmental Benefits (reduction in GHG emission TCO2/year)	Reduction in NOx, SOx,
1.	Installation of variable frequency drive (VFD) in Ball Mills and Blunger resulting in saving in electricity consumption in the ball mills and blungers	53,682	Nominal
2	Installation of variable frequency drive (VFD) in motors of agitation system resulting in saving in electricity consumption of agitation section	8,890	Nominal
3	Replacement of existing motors by Energy Efficient motors of agitation section resulting in saving in electricity consumption in agitation section	10,637	Nominal
4	Implementation of ON - OFF system (10 minutes ON and 5 minutes OFF) for agitation motors resulting in saving in electricity consumption in agitation section	17,443	Nominal
5	Improvement in kiln and other thermal insulation resulting in saving in fuel consumption in kiln	58,749	Nominal
6	Saving in Rs. in electricity bill by power factor improvement through installation of capacitors & APFC panel	-	NA
7	Preheating of input slurry of spray dryer through solar energy resulting in saving in spray dryer fuel consumption	75,940	Nominal
8	Use of exhaust smoke air of kiln to preheat the combustion air in ceramic tiles kiln through recuperator thereby resulting in saving in fuel consumption in kiln	189,539	Nominal
9	Installation of variable frequency drive on press hydraulic motors resulting in saving in electricity consumption in press section	67,069	Nominal
10	Installation of briquette fired hot air generator which supplies hot air for kiln firing, dryer, spray dryer firing	62,500	NA
11	Installation of Natural Gas Turbine for Electricity Generation and use of exhaust flue gas of turbine in spray dryer resulting in elimination of fuel in spray dryer	210,750	Nominal
12	Installation of Natural Gas Engine for Electricity Generation and use of exhaust	200,000	Nominal

Sr.	List of technologies for DPR Preparation	Environmental Benefits (reduction in GHG emission TCO2/year)	Reduction in NOx, SOx,
	flue gas of engine in spray dryer resulting in elimination of fuel in spray dryer		
13	Use of energy efficient motors for polishing line resulting in saving in electricity consumption in polishing section	7,367	Nominal
14	Installation of Low Thermal Mass Cars in Tunnel Kiln for Sanitary wares resulting in saving in fuel consumption in kiln	3,866	Nominal
15	Installation of recuperator in tunnel kiln thereby preheating combustion air through smoke air results in saving in fuel consumption in kiln	1,599	Nominal
16	Use of hot air of cooling zone of tunnel kiln as combustion air results in saving in fuel consumption in kiln	1,713	Equivalent amount in Sox reduction due to fuel saving
17	Use of hot air of final cooling of tunnel kiln for preheating the input material results in saving in fuel consumption in kiln	5,760	Equivalent amount in Sox reduction due to fuel saving

Note: These all technologies do not result into any reduction in waste generation.

4.0 CONCLUSION

4.1 Summary of Findings

4.1.1 All Energy Saving Proposals/Measures Identified For the Cluster

Sr.	Identified Saving Measures
For Vitrified Tiles, Wall tiles, Floor Tiles and Sanitary Wares	
1.	Installation of variable frequency drive (VFD) in Ball Mill and Blunger resulting in saving in electricity consumption of the ball mills and Blungers
2.	Installation of variable frequency drive (VFD) in motors of agitation tanks resulting in saving in electricity consumption of agitation section
3.	Replacement of existing conventional standard efficiency motors by energy efficient motors in agitation section resulting in saving in electricity consumption
4.	Implementation of ON - OFF system (10 minutes ON and 5 minutes OFF) for agitation motors resulting in saving in electricity consumption of agitation section
5.	Improvement in insulation in kiln, Spray Dryer resulting in saving in fuel consumption
6.	Monitory in electricity bill by power factor improvement through installation of capacitors & APFC Panel
7..	Preheating of combustion air by smoke air through recuperator in ceramic tiles industry resulting in saving in fuel consumption
For Vitrified Tiles, Wall tiles and Floor Tiles	
8.	Preheating of input slurry of spray dryer through solar energy resulting in saving in spray dryer fuel consumption
9.	Installation of briquette fired hot air generator which supplies hot air for kiln firing, dryer, spray dryer firing resulting in saving in energy cost as some of the heat load is shifted from NG to cheaper solid fuel
For Vitrified Tiles	
10.	Installation of Natural Gas Turbine for electricity generation and use of exhaust flue gas of turbine in spray dryer resulting in elimination of fuel in spray dryer and reducing overall energy cost
11.	Installation of Natural Gas Engine for electricity generation, use of exhaust flue gas of engine in spray dryer and jacket cooling water heat for pre-heating of slurry resulting in saving in spray dryer fuel consumption and also reducing overall energy cost
12.	Use of energy efficient motors for polishing line
For Sanitary Wares	
13.	Installation of low thermal mass cars in tunnel kiln for sanitary wares
14.	Installation of recuperator in tunnel kiln thereby preheating combustion air through smoke air
15.	Use of hot air of cooling zone of tunnel kiln as combustion air
16.	Use of hot air of final cooling of tunnel kiln for preheating the input material

4.1.2 Technology Gap Assessment for All Energy Saving Proposals/ Measures Identified For the Cluster

Sr.	Present practice/ technology	Improved practice/ technology
1	Ball Mill and Blunger without VFD	VFD installed on ball mills and Blunger
2	Heavy refractory brick cars in tunnel kiln	Installation of low thermal mass cars in tunnel kilns
3	Hot air from cooling zone of tunnel kiln is lost in atmosphere	Use of hot air as combustion air and for preheating input material
4	Cold air of cooling zone mixes with hot air of firing zone	Improving the partition between firing zone and cooling zone
5	Improper insulation of kiln, spray dryer and other hot surfaces	Improvement in insulation
6	Conventional standard efficiency agitator motors	Replacement of these motors with energy efficient motors in agitator section
7	Air compressor without VFD	Installation of VFD on air compressor
8	Agitation motors continuously working	Installation of on-off system for agitation tanks
9	No preheating of slurry before entering into spray dryer	Preheating of slurry by solar heater resulting in saving in spray dryer fuel consumption
10	Standard efficiency motors used in polishing machines of vitrified tiles	Use of energy efficient motors in polishing machines
11	No concept of cogeneration technology	Use Gas engine or Gas Turbine for co-generation of electricity and heat (use exhaust in the spray dryer)

4.1.3 Techno-Economics for all Energy Saving Proposals

Sr.	Identified Saving Measures	Savings in Rs.	Investment in Rs.	Payback Period
For Vitrified Tiles, Wall tiles, Floor Tiles and Sanitary Wares				
1.	Installation of variable frequency drive (VFD) in Ball Mill and Blunger resulting in saving in electricity consumption of the ball mills and blungers	37,000 to 10,00,000	1,00,000 to 50,00,000	10 to 40 months
2.	Installation of variable frequency drive (VFD) in motors of agitation system results in saving in electricity consumption in agitation section	20,000 to 2,50,000	80,000 to 16,00,000	18 to 30 months
3.	Replacement of existing standard efficiency motors by energy efficient motors of agitation section resulting in saving in electricity consumption in agitation section	10,000 to 3,00,000	50,000 to 8,00,000	6 to 40 months

Sr.	Identified Saving Measures	Savings in Rs.	Investment in Rs.	Payback Period
4.	Implementation of ON - OFF system (10 minutes ON and 5 minutes OFF) for agitation motors resulting in saving in electricity consumption of agitation section	17,000 to 2,00,000	5,000 to 1,60,000	3 to 13 months
5.	Improvement in kiln, spray dryer & other hot surfaces insulation resulting in saving in fuel consumption	60,000 to 15,00,000	2,00,000 to 30,00,000	20 to 36 months
6.	Monitory saving in electricity bill by power factor improvement through installation of capacitors	3,000 to 3,40,000	5,000 to 5,49,000	4 to 48 months
For Vitrified Tiles, Wall tiles and Floor Tiles				
7.	Preheating of input slurry of spray dryer through solar energy resulting in saving in spray dryer fuel consumption	50,000 to 21,00,000	7,00,000 to 65,00,000	4 to 7 years
8.	Installation of briquette fired hot air generator which supplies hot air for kiln firing, dryer and spray dryer firing	12,00,000 to 40,00,000	10,00,000 to 30,00,000	10 to 12 months
For Vitrified Tiles				
9.	Installation of Natural Gas Turbine for Electricity Generation and use of exhaust flue gas of turbine in spray dryer resulting in elimination of fuel in spray dryer finally resulting in reduction in overall energy bill	25600000 to 60700000	68000000 to 137500000	31 to 37 months
10.	Installation of Natural Gas Engine for Electricity Generation and use of exhaust flue gas of engine in spray dryer resulting in overall reduction in energy bill	15700000 to 30600000	46000000 to 80000000	27 to 38 months
11.	Use of energy efficient motor for polishing line	8,00,000 to 20,00,000	16,00,000 to 27,00,000	10 to 28 months
12.	Preheating of combustion air by smoke air through recuperator in ceramic tiles resulting in saving in fuel consumption	2,00,000 to 40,00,000	2,50,000 to 24,00,000	5 to 30 months
For Sanitary Wares				
13.	Installation of low thermal mass cars in tunnel kiln for sanitary wares	5,50,000 to 6,80,000	16,00,000 to 20,00,000	7 to 32 months

Sr.	Identified Saving Measures	Savings in Rs.	Investment in Rs.	Payback Period
14.	Installation of recuperator in tunnel kiln thereby preheating combustion air through smoke air	50,000 to 4,50,000	89,000 to 5,30,000	7 to 14 months
15.	Use of hot air of cooling zone of tunnel kiln as combustion air	80,000 to 4,00,000	50,000 to 60,000	2 to 12 months
16.	Use of hot air of final cooling of tunnel kiln for preheating the input material	3,50,000 to 5,81,000	3,50,000 to 6,50,000	7 to 14 months

4.1.4 Barriers in Implementation of Identified Energy Saving Proposals

Following are the barriers in implementation of identified energy saving proposals:

1. On discussion with the plant person during the audit, many of them agree with the possible saving measures but they demanded demonstration of the suggested energy saving technologies; once it is observed by them in operation their comfort level and readiness for implementation is very high.
2. Some of the identified energy saving measures have high investment and payback period therefore proper bank financing is needed
3. Some of the projects such as Gas Turbine installation have technological issues which need to be taken care through proper training so as to facilitate such project implementation

4.1.5 Short Listed Technology/Products for DPRs

Following are the short-listed technologies for preparation of DPRs:

1. Installation of variable frequency drive (VFD) in Ball Mills and Blunger resulting in saving in electricity consumption in Ball Mills and Blungers
2. Energy saving projects for agitator section:
    a. Installation of variable frequency drive (VFD) in motors of agitation tanks resulting in saving in electricity consumption of agitation section.
    b. Replacement of existing standard efficiency motors by energy efficient motors of agitation tank resulting in saving in electricity consumption in agitation section
    c. Implementation of ON - OFF system (10 minutes ON and 5 minutes OFF) for agitation motors results in saving in electricity consumption of agitation section
3. Improvement in kiln, spray dryer and other hot surface insulation resulting in saving in respective fuel consumption
4. Monitory saving in electricity bill due to increase in PF rebate and MD charges reduction by power factor improvement through installation of capacitors & APFC panel
5. Preheating of input slurry of spray dryer through solar energy resulting in saving in spray dryer fuel consumption
6. Use of exhaust smoke air of kiln to preheat the combustion air in kiln through recuperator thereby resulting in saving in fuel consumption in the kiln

7. Installation of variable frequency drive on hydraulic press motors resulting in saving in electricity consumption in press section
8. Installation of briquette fired hot air generator which supplies hot air for kiln firing, dryer and spray dryer firing
9. Installation of Natural Gas Turbine for Electricity Generation and use of exhaust flue gas of turbine in spray dryer resulting in elimination of fuel in spray dryer and reducing overall energy cost
10. Installation of Natural Gas Engine for electricity generation and using the exhaust flue gas in spray dryer resulting saving in spray dryer fuel cost
11. Use of energy efficient motors for polishing line results in saving in electricity consumption in polishing section
12. Installation of low thermal mass cars in tunnel kiln for sanitary wares resulting in saving in fuel consumption in kiln
13. Installation of recuperator in tunnel kiln thereby preheating combustion air through smoke air resulting in saving in fuel consumption in kiln
14. Use of hot air of cooling zone of tunnel kiln as combustion air resulting in saving in fuel consumption in kiln
15. Use of hot air of final cooling of tunnel kiln for preheating the input material resulting in saving in fuel consumption in kiln

4.2 Summary of Level of Awareness on Energy Efficiency and Energy Efficient Products in the Cluster

As compare to other SME units, at Morbi level of awareness on energy efficiency and energy efficient products is much better. Many of the unit owners have visited the China and Italy to see energy efficient equipments used in ceramic industries in operating condition. Many foreign vendors also participate in the workshop held at Ahmedabad on Indian ceramics every year to propagate their products and how it helps to save the energy. This exhibition is attended by Morbi units. There is competitive atmosphere to adopt energy efficiency and more productive technologies but the culture is ensuring the result by observing the demonstration before taking a decision for executing energy efficiency projects.

Annexure–1: Technology/Equipment Assessment Summary

Findings of the assessment study are as follows. These calculations are for a typical ceramic unit.

1. Installation of Variable Frequency Drive (VFD) In Ball Mills and Blunger Resulting in Saving In Electricity Consumption of the Ball Mills and Blungers

There are 7 Nos. of blungers and 2 Nos. of glaze ball mills of total installed capacity of about 97.5 kW.

1. Electricity consumption in blungers and glaze ball mills	= 4,40,310 kWh/year
2. Saving in electricity consumption	= 15 %
3. Saving in electricity consumption	= 66,047 kWh/year
4. Cost of electricity	= Rs. 3.85 /kWh
5. Saving in Rs.	= Rs. 2,54,279/year
6. Approximate investment	= Rs. 3,63,000
7. Payback period	= 17 months

2. Saving in Electricity Consumption in Agitation Section by Selecting one of the Following 3 Measures

2a. Installation of Variable Frequency Drive (VFD) in Motors of Agitation System Results in Saving in Electricity Consumption of Agitation Section

There are 8 Nos. of agitator motors of total installed capacity 60 kW.

1. Total electricity consumption in agitation section	= 3,50,989 kWh/year
2. Saving in electricity consumption	= 15 %
3. Saving in electricity consumption	= 52,648 kWh/year
4. Cost of electricity	= Rs. 4.05 /kWh
5. Total saving in Rs.	= Rs. 2,13,226 /year
6. Approximate Investment	= Rs. 3,12,000
7. Payback Period	= 18 months

2b. Replacement of Existing Conventional Motors by Energy Efficient Motors of Agitation Section Results in Saving in Electricity Consumption of Agitation Section

There are 8 Nos. of agitator motors of total installed capacity 60 kW.
Operating efficiency of the existing motors varies from 65 % to 75 %.

1. Electricity consumption of agitation section	= 3,50,989 kWh/year
2. Efficiency of proposed energy efficient motors is about	= 88.1 %
3. Saving in electricity consumption	= 14,529 kWh/year
4. Cost of electricity	= Rs. 4.05 /kWh
5. Saving in Rs.	= Rs. 55,845 /year
6. Approximate total Investment required	= Rs. 1,61,992
7. Payback Period	= 33 months

2c. Implementation of ON - OFF System (10 Minutes ON and 5 Minutes OFF) for Agitation Motors Results in Saving in Electricity Consumption of Agitation Section

ON agitator motors for about 10 minutes and switch OFF for about 5 minutes.

1.	Total electricity consumption in agitation section	= 3,50,989 kWh/year
2.	Saving in electricity consumption	= 30 %
3.	Saving in electricity consumption	= 1,05,297 kWh/year
4.	Cost of electricity	= Rs. 4.05 /kWh
5.	Total saving in Rs.	= Rs. 4,26,451 /year
6.	Approximate Investment required	= Rs. 16,000
7.	Payback Period	= 0.45 months

3. Improvement in Kiln Insulation Results in Saving in Fuel Consumption of Kiln

Heat loss in kiln is found to be 20.28 % of total heat supplied in kiln.

1.	Equivalent heat loss in natural gas consumption	= 648 SCM/day
2.	After improvement in insulation, these losses can be minimized upto 10 %.	
3.	% saving in natural gas consumption	= 2 %
4.	Saving in natural gas consumption	= 24,015 SCM/year
5.	Cost of natural gas	= Rs. 15/SCM
6.	Saving in Rs.	= Rs. 360231/year
7.	Approximate investment required	= Rs. 3,86,000
8.	Payback period	= 13 months

4. Saving in Rs. in Electricity Bill by Power Factor Improvement through Installation of Capacitors

1.	Present Power Factor	= 0.914
2.	Desired Power factor	= 1
3.	KVAR Required	= Operating kW x [Tan (A1) - Tan (A2)] = 421.35 x [Tan (23.94) –Tan (0)] = 187 KVAR
4.	Where A1	= Inverse Cosine of present power factor
a.	A2	= inverse Cosine of desired power factor
5.	Additional Capacitors Required, KVAR	= 187 KVAR
6.	Annual saving in Rs.	= Rs.2,00,856 /year
7.	Total approximate Investment required	= Rs 93,500
8.	Payback period	= 6 months

5. Preheating of Input Slurry of Spray Dryer through Solar Energy Results in Saving in Spray Dryer Fuel Consumption

1.	Production from spray dryer is about 380 MT/day	
2.	Feed rate of slurry in Spray Dryer	= 22.83 MT/Hr
3.	Slurry is preheated from 35 to 60 ^{O}C.	
4.	Heat require for preheating of slurry	= 22.83 x 0.45 x (60 – 35) x 1000 = 2,56,870 Kcal/hr
5.	This heat is supplied by solar water heater.	
6.	Natural Gas is used in spray dryer having calorific value of 8800 kcal/SCM.	

7.	Fuel saving due to solar heating	= 2,56,870/8800 = 29.19 SCM/hr
8.	Indirect efficiency of spray dryer efficiency is found to be 79%.	
9.	Therefore, saving in fuel consumption = 29.19/0.79	= 36.94 SCM/hr
10.	Cost of Natural Gas	= 15 Rs. /SCM
11.	Saving in natural gas consumption in spray dryer per day as the solar energy can be available only for 8 hours per day	= 36.34 x 8 = 295.48 SCM/day
12.	% saving in fuel consumption per day	= 2 %
13.	Saving in natural gas consumption per year	= 60,270 SCM/year
14.	Saving in Rs.	= 60,270 x 15 =Rs. 9,04,050/year
15.	There are two small capacity pumps are required. One pump is used for water circulation from solar collector to storage tank and one pump used for water circulation through heat exchanger.	
16.	Pumps of capacity of 0.37 kW of each are required.	
17.	Therefore, electricity consumption of pumps	= 1420 kWh/year
18.	Operating cost of pumps in Rs.	= Rs. 5754 /year
19.	Therefore, saving in Rs.	= Rs.8,98,296 /year
20.	Approximate investment required (considering subsidy)	= Rs. 29,09,710
21.	Pay back period	= 39 months

6. Use of Exhaust Smoke Air of Kiln to Preheat the Combustion Air in Ceramic Tiles Kiln through Recuperator Thereby Resulting in Saving in Fuel Consumption in Kiln

1.	Smoke air temperature	= 249 ^{o}C
2.	Smoke air flow rate	= 3,365 m^3/hr
3.	Natural Gas Consumption	= 9,540 SCM/day
4.	Combustion air flow rate	= 2,968 m^3/hr
5.	Present combustion air temperature	= 40 ^{o}C
6.	Proposed preheated combustion air temperature	= 153 ^{o}C
7.	Heat gain by combustion air	= 89,885 Kcal/hr
8.	Equivalent saving natural gas consumption	= 10.21SCM/hr
9.	Saving in natural gas consumption	= 245 SCM/day
10.	% saving in natural gas consumption	= 3 %
11.	Heat transfer area of heat exchanger required	= 34 m^2
12.	Saving natural gas consumption	= 58,071 SCM/year
13.	Cost of natural gas	= Rs.15/SCM
14.	Therefore, saving in natural gas	= Rs. 8,71,058 /year
15.	Approximate investment required	= Rs. 6,81,255
16.	Payback period	= 9 months

7. Installation of Variable Frequency Drive On Press Motors Results in Saving in Electricity Consumption in Press Section

1.	Electricity consumption in press	= 62.54 kWh
2.	Electricity Consumption in Press	= 2,70,158 kWh/year
3.	Saving in electricity consumption	= 15 %
4.	Saving in electricity	= 40,524 kWh/year
5.	Cost of Electricity	= Rs. 3.85 /kWh
6.	Total saving in Rupees	= Rs. 1,56,016 /year
7.	Approximate Investment	= Rs. 2,85,000
8.	Payback period	= 22 months

8. Installation of Briquette Fired Hot Air Generator which Supplies Hot Air for Kiln Firing, Dryer, Spray Dryer Firing

In case of natural gas, we get the 587 Kcal/Rs. whereas in case of briquette it is about 1142 Kcal/Rs. Therefore a saving of 555 Kcal/Rs.

Total Natural Gas consumption in 3 pre-dryer and 2 spray dryers is about 81,42,808 SCM/year which will cost Rs. 12,21,42,120/year.

Installation of briquette fired hot air generator and generating the hot air at a temperature of about 300 ^{o}C and utilizing it for as a combustion air results in saving in fuel consumption cost.

This results in saving in fuel consumption cost of about Rs.36,11,343/year.

Total investment required = Rs. 34,00,000

Payback period = 11 months

9. Installation of Natural Gas Turbine for Electricity Generation and Use of Exhaust Flue Gas of Turbine in Spray Dryer Results in Elimination of Fuel in Spray Dryer and Also Saves Rs. of Energy Charges in Electricity Bill

Use of cogeneration technology through gas turbine results in more availability of heat in exhaust for utilization in spray dryer as compare to engine but the installation cost is high as compare to engine.

Installation of this technology also requires the installation of another one spray dryer. Gas Turbine of capacity of about 1.5 MW will be required to install.

Sr.	Parameter	Value	Unit
1	Power Generation efficiency of Gas Turbine	19	%
2	Heat goes to exhaust of Gas Turbine	81	%
3	Calorific Value of NG (Taken here)	8800	Kcal/m^3
4	Cost of natural Gas	15	Rs./m^3
5	Cost of Electricity	4.05	Rs./kWh
6	Plant electricity consumption	1108	kW
7	Auxiliary Consumption of Gas Turbine required	4	%
8	Total Electricity to be generated by Gas Engine	1152	kW
9	Working hours of spray dryer	24	Hours
10	Working days of spray dryer in a year	330	Days
11	Natural Gas required in Gas Turbine for power Generation	593	SCM/hr
12	Exhaust waste heat of Gas Turbine available for use in spray dryer	42,24,769	Kcal/hr
13	Equivalent natural gas saving	497	SCM/hr
14	Natural gas consumption in Gas Turbine	46,94,188	SCM/year
15	Cost of natural used in turbine	704	Rs. Lacs/year
16	Electricity Generation from gas turbine	91,26,374	kWh/year
17	Cost equivalent of electricity presently paid	370	Rs.

Sr.	Parameter	Value	Unit
			Lacs/year
18	Equivalent natural gas saving	3936491	SCM/year
19	Cost of natural gas saving	590	Rs. Lacs/year
20.	Saving in Rs.	256	Rs. Lacs/year
21.	Total approximate investment required	680	Rs. Lacs
22.	Payback period	32	months

10. Installation of Natural Gas Engine for Electricity Generation and Use of Exhaust Flue Gas of Engine in Spray Dryer Results in Elimination of Fuel in Spray Dryer and Also Saves Rs. of Energy Charges in Electricity Bill.

Use of cogeneration technology reduces energy consumption cost of plant. Here, we propose the natural gas fired gas engine of 1.36 MW. Exhaust heat of gas engine should be used in spray dryer.

For installation of this technology, another spray will also require to be install because the present spray dryer runs 15 - 20 days in a month and then require maintenance work. After implementation of this technology, as one spray dryer is under maintenance then we can run the second spray dryer. This will increase the production of the plant also.

Sr.	Parameter	Value	Unit
1	Power Generation efficiency of Gas Engine	40	%
2	Heat goes to exhaust of Gas Engine	30	%
3	Heat loss due to jacket cooling	20	%
4	Calorific Value of NG (Taken here)	8800	Kcal/m3
5	Cost of natural Gas	15	Rs./m3
6	Cost of Electricity	4.05	Rs./kWh
7	Plant electricity consumption	1108	kW
8	Auxiliary Consumption of Gas engine required	3	%
9	Total Electricity to be generated by Gas Engine	1141	kW
10	Working hours of spray dryer	24	Hours
11	Working days of spray dryer in a year	330	Days
12	Natural Gas required in Gas Engine for power Generation	279	SCM/hr
13	Exhaust waste heat of gas engine available for use in spray dryer	736100	Kcal/hr
14	Equivalent natural gas saving	84	SCM/hr
15	Heat loss due to jacket cooling can be recovered for preheating air	10	%
16	Heat of jacket cooling can be utilized for air preheating	245367	Kcal/hr
17	Equivalent natural gas saving	28	SCM/hr
18	Total natural gas saving due to use of both the heat sources	112	SCM/hr
19	Natural gas consumption in Gas Engine	22,08,299	SCM/year

Sr.	Parameter	Value	Unit
20	Cost of natural used in engine	331	Rs. Lacs/year
21	Electricity Generation from gas engine	87,75,360	kWh/year
22	Cost equivalent of electricity presently paid	355	Rs. Lacs/year
23	Equivalent natural gas saving	8,83,320	SCM/year
24	Cost of natural gas saving	132	Rs. Lacs/year
25.	Saving in Rs.	157	Rs. Lacs/year
26.	Total approximate investment required	460	Rs. Lacs
27.	Payback period	35	months

11. Use of Energy Efficient Motors for Polishing Line Results in Saving in Electricity Consumption in Polishing Section

Polishing section is the major electricity consuming section in vitrified tiles industry. About 40 - 50 % of electricity out of total is consumed by the polishing section.

During electrical measurements at the audit period, it was observed that the loading of the machines of polishing section is less than 50 %. Efficiency of motors decreases with the decreasing in loading of motors.

Also the motors installed on the polishing machines are of rated efficiency of about 85 % only. Therefore, there is more scope of saving by replacement of the existing conventional motors of the polishing machines by the energy efficient motors.

Sr. No.	Equipment Name	Connected load, kW	Measured Machine kW	Electricity Consumption, kWh/year	Saving in Electricity Consumption, kWh/year
1	Rough Grinding	96.56	46.2	199,584	70,042
2	Calibration 1	118.32	47.51	205,258	61,177
3	Calibration 2	118.32	33.28	143,798	38,986
4	Polishing 1	174.4	50.95	220,118	94,932
5	Polishing 2	174.4	100.4	433,728	117,387
6	Polishing 3	174.4	129.7	504,274	70,581
7	Sizing	114.72	93.06	402,048	49,803
	TOTAL	**971.12**	**501.1**	**2,108,808**	**502,908**

1. Total electricity consumption of polishing section = 2108808 kWh/year
2. Saving in electricity consumption of polishing section = 5,02,908 kWh/year
3. Cost of electricity = Rs. 4.05 /kWh
4. Saving in Rs. = Rs.20,36,776/year
5. Approximate investment required = Rs.20,21,396
6. Payback Period = 12 months

12. Installation of Low Thermal Mass Cars in Tunnel Kiln for Sanitary Wares Results in Saving in Fuel Consumption in Kiln

1. Natural gas consumption	= 1800 SCM/day
2. Natural gas consumption	= 5,78,431 SCM/year
3. % reduction in weight of kiln car	= 23 - 24 %
4. Heat gain by kiln car	= 60,45,930 Kcal/day
5. Equivalent natural gas consumption	= 687 SCM/day
6. Heat gain by low thermal mass car	= 46,55,366 Kcal/day
7. Equivalent natural gas consumption	= 529 SCM/day
8. Saving in natural gas consumption	= 158 SCM/day
9. % saving in natural gas consumption	= 9 %
10. Saving natural gas consumption	= 50,779 SCM/year
11. Cost of natural gas	= Rs.15/SCM
12. Therefore, saving in natural gas	= Rs. 7,61,691 /year
13. Approximate investment required	= Rs. 20,00,000
14. Payback period	= 32 months

13. Installation of Recuperator in Tunnel Kiln Thereby Preheating Combustion Air through Smoke Air Results in Saving in Fuel Consumption in Kiln

1. Smoke air temperature	= 192 ^{o}C
2. Smoke air flowrate	= 935 m^3/hr
3. Natural Gas Consumption	= 1800 SCM/day
4. Combustion air flowrate	= 860 m^3/hr
5. Present combustion air temperature	= 40 ^{o}C
6. Proposed preheated combustion air temperature	= 107 ^{o}C
7. Heat gain by combustion air	= 17,806 Kcal/hr
8. Equivalent saving natural gas consumption	= 2.02 SCM/hr
9. Saving in natural gas consumption	= 48.56 SCM/day
10. % saving in natural gas consumption	= 2.7%
11. Heat transfer area of heat exchanger required	= 8 m^2
12. Saving natural gas consumption	= 15,605 SCM/year
13. Cost of natural gas	= Rs.15/SCM
14. Therefore, saving in natural gas	= Rs. 2,34,082 /year
15. Approximate investment required	= Rs. 2,80,516
16. Payback period	= 18 months

14. Use of Hot Air of Cooling Zone of Tunnel Kiln as Combustion Air Results in Saving in Fuel Consumption in Kiln

1. Natural gas consumption	= 1800 SCM/day
2. Hot air temperature at exit of final cooling zone	= 120 ^{o}C
3. Present combustion air temperature	= 40 ^{o}C
4. Combustion air blower flowrate	= 860 m^3/hr
5. Proposed combustion air temperature becomes	= 120 ^{o}C
6. Heat save due to use of hot air for combustion	= 14,860 Kcal/hr
7. Saving in natural gas consumption	= 1.69 SCM/hr
8. Saving in natural gas consumption	= 40.53 SCM/day
9. % saving in natural gas consumption	= 2 %
10. Saving natural gas consumption	= 11,794 SCM/year

11. Cost of natural gas	= Rs.15/SCM
12. Therefore, saving in natural gas	= Rs. 1,76,908 /year
13. Approximate investment required	= Rs. 50,000
14. Payback period	= 3 months

15. Use of Hot Air of Final Cooling of Tunnel Kiln for Preheating the Input Material Results in Saving in Fuel Consumption in Kiln

1. Natural gas consumption	= 1800 SCM/day
2. Hot air temperature at exit of final cooling zone	= 120 ^{o}C
3. Rapid cooling air blower flow rate	= 2826 m^3/hr
4. Ambient temperature	= 40 ^{o}C
5. Heat given by the hot air to the material	= 48,833 Kcal/hr
6. Equivalent saving in natural gas consumption	= 5.55 SCM/hr
7. Saving in natural gas consumption	= 133 SCM/day
8. % saving in natural gas consumption	= 7 %
9. Saving natural gas consumption	= 38,755 SCM/year
10. Cost of natural gas	= Rs.15/SCM
11. Therefore, saving in natural gas	= Rs. 5,81,327 /year
12. Approximate investment required	= Rs. 5,00,000
13. Payback period	= 10 months

Annexure–2: Details of Technologies/Services Providers for the Cluster

Details of the vendors for supply of the identified technologies

Sr.	Technology	Name of Service Provider	Address	Contact Person and No.
1.	Variable Frequency Drive and capacitors	Crystal Controls	309, Abhishree complex, Opp. Star India Bazar, Nr. Jodhpur Char Rasta, satellite, Ahmedabad – 15	Mr. Dhanji Ghinaiya - 09714714192, 079 – 26923306
2.	Solar Heating System	NRG Technologists Pvt Ltd	989/6, GIDC Makarpura Vadodara - 390 010,Gujarat State	Mr. Chaitanya Yardi - 0265-2642094, 2656167
3.	Energy Efficient Motors	ABB/National Electrical Industry (NEI)	NEI - Vimla Complex, second Floor, Nr. Old Shardamandir Rly. Crossing, Ahmedabad - 380006 ABB - Ahmedabad	National Electrical Industry - Mr. Anuj Patel - 09898084805 ABB- Mr. Dinesh Mistry - 0265 - 2642141/42
4.	Instrumentation such as moisture measuring instrument, ON - OFF system, Power meter etc.	Shiwkon Digitek Pvt. Limited	309 - Pushpam, Opp.Seema Hall, 100 Feet ,Shyamal - Anand Nagar Road. Satellite, Ahmedabad - 380 015	Mr. Hardik Patel - 09825050706
5.	Briquette fired hot air generator	Yajna Fuel Services	B – 15, Dattaviahar Co – Operative Housing Society, Ground Floor, Shivaji Nagar, B – Cabin, Thane (W) – 400602	Mr. Mukund Gharpure - 09969410594, 022 – 25424983

Sr.	Technology	Name of Service Provider	Address	Contact Person and No.
6.	Gas Engine	Green Power International Pvt. Ltd., Wartsila India Ltd. Cummins	E – 12/A, Sector – 63, Noida – 201 301 (U.P.), India	Mr. Ashish Trikha - 0120-4655 460 / 4655 455 / 458, 09717790676
7.	Gas Turbine	Turbo Mach India Pvt. Ltd.	5 & 6, Papa Industrial Estate, Suren Road, Andheri (East), Mumbai - 400093	Mr. Pradeep Yadav - 09833491235
8.	Energy Efficient Burners	Wesman Thermal Engg. Processes Pvt. Ltd	B/702, Sagar Tech Plaza, Andheri-Kurla Road, Saki Naka, Mumbai 400 070	Mr. Frederick C Pinto - 0 2850 9521/22, 0 9324384381
9.	Low thermal Mass car of tunnel kiln, other projects of sanitary ware tunnel kiln	Payal Allien Engineering	Morbi	Mr. Hasmukh Patel - 09427934644
10.	Recuperator	Chemequip Industries	451/2 GIDC Makarpura Industrial Estate Vadodara -390 010	Mr. Parthiv Adeshra - 09824209898
11.	Kiln insulation improvement	Poonam Refractories	Bazar Road, Post Box No. 2, Wankaner-363621 (Dist. Rajkot)	Mr. Ketan Mehta - 09825224640
12.	Ceramic fibre supplier for tunnel kiln car	Orient Refractory	220, Ambawadi, GIDC, Wadhwan city, Surendranagar	Mr. R.K.Jain - 09825355877

Details of the identified technical experts to assist for implementation of above identified projects in ceramic industry

Sr.	Technology	Name of Service Provider	Address	Contact Person and No.
1.	Technical Expert to provide the guidance or design for implementation of identified projects	Yajna Fuel Services	B – 15, Dattaviahar Co – OperativeHousing Society, Ground Floor, Shivaji Nagar, B – Cabin, Thane (W) – 400602	Mr. Mukund Gharpure - 09969410594, 022 - 25424983
2.	Roller Kiln Expert	Perf ,,ect Mechanical System	8 A - National Highway, Lakdhirpur Road, Morbi	Mr. Bakulbhai - 09825230692
3.	Tunnel Kiln Expert	Sharma Kiln Technology		Mr. Adir Sharma - 09327039235
4.	Ceramic Plant Expert in operation and maintenance	Individual Consultant	Morbi	Mr. Omesh Gandhi - 09879417065

Annexure–3: Financial Schemes Available with Local Banks for Improving Energy Efficiency in the Cluster

There are 2 to 3 banks at Morbi providing loans to the required ceramic unit owners. As such there is no such scheme specially for improving the energy efficiency in the cluster.

Government Fiscal Incentives for MSME Sectors

The Ministry of micro, Small and Medium Enterprises (MoMSME) provides support to activities in MSME units. The schemes that are eligible for the ceramic industry are given below.

1. Credit Linked Capital Subsidy Scheme (CLCSS)

Under this scheme, the Ministry of MSME is providing subsidy to upgrade technology (Machinery/Plant equipments). Subsidy limit per unit is Rs. 15 lacs or 15% of investment in eligible Machinery/ Plant equipments whichever is lower. For more details of the scheme visit www.laghu-udyog.com/schemes/sccredit.htm

2. Credit Guarantee Fund Trust for MSE

This scheme will cover both term loan and working capital facility upto Rs.100 lacs. Under this scheme, loan will be sanctioned without any collateral security or third party guarantee. For more details of the scheme visit www.cgtmse.in

3. Market Development Assistance Scheme

To encourage MEME entrepreneurs to tap overseas market potential and represent India in the overseas market, Government of India is reimbursing 75% of air fare by economy class and 50% space rental charges of stalls for exhibition of their products in the overseas trade fairs/ exhibitions. For more details of the scheme visit www.fisme.org.in/MDA%20Faq.doc

4. Quality Up-Gradation/Environment Management Scheme

Under this scheme charges would be reimbursed for acquiring ISO - 9000/ISO - 14001/HACCP certifications to the extent of 75% of the expenditure (maximum to Rs. 75,000/- in each case). For more details of the various schemes visit http://msme.gov.in/

5. SIDBI Financing Scheme for Energy saving project in MSME Sector

To improve the energy efficiency levels in various MSME sectors, SIDBI is providing loans to eligible projects under JICA line of credit at a nominal rate of interest of 9.5 - 10% p.a. For more details of the list of eligible projects under this line of credit visit: www.sidbi.in

SIDBI Financing Scheme for Energy Saving Projects in MSME Sector under JICA Line of Credit

The Japan International Cooperation Agency (JICA) has extended a line of credit to SIDBI for financing Energy Saving projects in Micro, Small and Medium Enterprises (MEMEs). This project is expected to encourage MSME units to undertake energy saving

investments in plant and machinery to reduce energy consumption, enhance energy efficiency, reduce CO2 emissions, and improve the profitability of units in the long run.

Eligible Sub projects/ Energy Saving Equipment List under JICA Line of Credit

- Acquisition (including lease and rental) of energy saving equipments, including installing, remodeling and upgrading of those existing
- Replacement of obsolete equipments and/or introduction of additional equipments which would improve performance.
- Equipments/Machinery that meet energy performance standards/ Acts
- Introduction of equipments that utilize alternative energy sources such as natural gas, renewable energy etc., instead of fossil fuels such as oil and coal etc.
- Clean Development Mechanism (CDM) projects at cluster level that involve change in process and technologies as a whole, duly supported by technical consultancy, will be eligible for coverage.

Eligible Criteria for Units (Direct Assistance)

- Existing units should have satisfactory track record of past performance and sound financial record
- Projects will be screened as per Energy Saving list, which is available on the SIDBI website
- Units should have minimum investment grade rating of SIDBI
- Projects which may result in negative environmental and social impacts are also not eligible under this scheme.

Parameter	Norms
Minimum assistance	Rs. 10 lakh
Minimum promoters contribution	25 % for existing units; 33 % for new units
Interest rate	The project expenditure eligible for coverage under the line will carry the following rate of interest Fixed rate: 9.5 to 10 5 per annum based on rating Floating rate: 9.75 to 10.5 % per annum based on rating
Upfront fee	Non - refundable upfront fee of 1 % of sanctioned loan plus applicable service tax
Repayment period	Need based. Normally the repayment period does not extend beyond seven years. However, a longer repayment period of more than seven years can be considered under the line, if necessary.

List of Equipments which are Already Approved for Loan from JICA (SIDBI)

Sr.	Registered Equipment/Technology
1	**Ceramics Industry**
1.1	Insulation for Kiln, Top Chamber & Furnace
1.2	Low thermal mass cars
1.3	Recuperator for kiln (hot air generation)
1.4	variable speed drive for circulation air fans in vertical dryer
1.5	Roller kiln (by replacing Tunnel kiln)
2	**Ceramic Items (Insulator ceramics, electrical ceramics, porcelain, Bone China ware, Stone ware, Earthen ware, Terra - cotta ceramic) including Tiles**
2.1	Ball mill with high alumina tile lining, high alumina balls of different size (Raw material processing)
2.2	Isostatic Press, Fettling machine, Stacking equipment (Fabrication)
2.3	Fully automatic vertical copying Machine for Insulator (Fabrication)
2.4	Roller Head machine for cup & saucer (fabrication)
2.5	Pressure casting plant (Fabrication)
2.6	Humidity Driver Chamber (Drying)
2.7	Gas/Oil fired Roller Hearth Kiln (Firing Section)
3	**Ceramics & Sanitary ware**
3.1	Gas/Oil fired Tunnel Kiln (Firing Section)
3.2	Gas/Oil fired Shuttle Kiln (Firing section)
3.3	Automatic Tile Pressing Unit
3.4	Alumina Brick insulation for Electric Arc Furnace
3.5	Improved Insulation for Ring Chamber
3.6	Recuperator

Annexure–4: Name and Addresses of Units in the Cluster (Audited)

Sr	Company name	Product Manufa-ctured	Address	Contact Person name	Contact No
1.	Active Ceramic Pvt. Ltd.	Wall Tiles	8A, National Highway, Lakhdirpur road, Morbi	Mr. Bhavesh Patel	9909035137
2.	Airson Ceramic Industries	Floor Tile	8-A,National Highway,Opp.G.E.B. Feeder Lalpar,Morbi-363642	Mr. Mahadevbhai Ambani	9825224562
3.	Akruti Ceramic	Floor Tiles	8A, National Highway, Old Ghuntu road, Morbi	Mr. Ashok Bhai	9825313935
4.	Alfa gold Suntop Ceramic	Wall Tiles	8A, National Highway, Lakhdirpur road, Morbi	Mr. Pranjivanbhai	9825530556
5.	Antique Granito Pvt. Ltd.	Vitrified Tiles	8A, National Highway, Lakhdirpur road, Morbi	Mr. Paresh Kundaria	9879310277
6.	Apolo Sanitary ware	Sanitary	8A, National Highway, Lalpar, Morbi	Mr. Kantibhai	9823492507
7.	Apple Tiles Pvt. Ltd.	Floor Tile	8-A,National Highway,Bandu Nagar,Near 20 Nala, Morbi-363642	Mr. Satish Patel	9825258516
8.	Arrow ceramic	Wall Tile	8-A,National Highway,Jambudia,Morbi	Mr. Ashok Bhai	
9.	Bell Sanitary Wares	Sanitary	8-A,National Highway,Jambudia,Morbi-363642	Mr. Amit Bhai	9825222810
10.	Captain Ceramic	Wall Tiles	8A, National Highway, Lalpar, Morbi	Mr. J. D. Patel	9825255774
11.	Delphi Ceramics	Sanitary	8-A,National Highway, Lakhdirpur Road,Morbi-363642	Mr. Suresh Patel	9879078068
12.	Dolphin Tiles	Wall Tiles	8A, National Highway, Jombudiya, Morbi	Mr. Vinodbhai	9879492370
13.	Excel Ceramic Pvt. Ltd.	Floor Tile	Morbi-Wankaner Highway, Makanser,Tal-Morbi,Dist-Rajkot	Mr. Suresh J Patel	9825223476
14.	Face Ceramics	Wall Tiles	8A, National Highway, Lakdhirpur road, Morbi	Mr. Ramesh Patel	9879511601

Sr	Company name	Product Manufa-ctured	Address	Contact Person name	Contact No
15.	Favourite Ceramic Pvt. Ltd.	Wall Tiles	8A, National Highway, Lakhdirpur road, Morbi	Mr. Vijay Patel	9898591857
16.	Foton Ceramic	Wall Tiles	8A, National Highway, Lakhdirpur road, Morbi	Mr. Rajeshbhai	9825565009
17.	Gangotri Glaze Tiles Pvt. Ltd.	Wall	8/A,National Highway Dhuva-363622,Ta.Wakaner,Dist:Rajkot	Mr. Pravin Bhai C. Patel	99099022270
18.	Gokul Ceramic Pvt. Ltd	Floor	8/A,National Highway Dhuva-363622,Ta.Wakaner,Dist:Rajkot	Mr. Pravin Bhai C. Patel	99099022270
19.	Jet Granito Pvt Ltd	Vitrified	8-A,National Highway,Matel Char Rasta,Ta-Wankaner,Dist.Rajkot	Mr. Chetan Patel	9909012893
20.	Keda Ceramics	Floor Tile	8-A,National Highway, Paneli Road.opp. Rataleshwar ,Morbi-363642	Mr. Paresh bhai Patel	
21.	Lexus Ceramic	Wall Tiles	8A, National Highway, Lakhdirpur road, Morbi	Mr. Nileshbhai	9825750960
22.	Lorenzo Vitrified Tiles	Vitrified Tiles	8A, National Highway, Lalpar, Morbi	Mr. Ashok Agravat (Manager)	9909977787
23.	Mark Glaze Tiles Pvt. Ltd.	Wall Tiles	8A, National Highway, Old Ghuntu road, Morbi	Mr. Dilip Bhai (MD)	9825839562
24.	Marshal Ceramic	Wall Tiles	8A, National Highway, Old Ghuntu road, Morbi	Mr. Anilbhai	9825173064
25.	Mega Vitrified Pvt. Ltd.	Vitrified Tiles	8A, National Highway, Old Ghuntu road, Morbi	Mr. Prakash Bhai Patel (Director)	9909955580
26.	Metro Ceramic	Wall Tiles	8A, National Highway, Lakhdirpur road, Morbi	Mr. Pratheesh	9925432000
27.	Metrocity Tiles Pvt. Ltd.	Wall Tiles	8A, National Highway, Lakhdirpur road, Morbi	Mr. Pratheesh	9925432000
28.	New Royal Ceramic	Floor Tiles	8A, National Highway, Lakhdirpur road, Morbi	Mr. Vijaybhai	9879110983
29.	Nobel Industries	Sanitary	8A, National Highway, Old Ghuntu road, Morbi	Mr. Kailashbhai	9825394246
30.	Novel industries	Spray dryer	8-A,National Highway,Jambudia,Morbi-363642	Mr. Mahendra Patel	9825776504

Sr	Company name	Product Manufa-ctured	Address	Contact Person name	Contact No
31.	Ocean ceramics Ltd	Floor Tile	8-A,National Highway, Makansar,Morbi-363642	Mr. Jayprakash Patel	9825224615
32.	Optel Ceramic Pvt. Ltd.	Floor Tiles	8A, National Highway, Lakhdirpur road, Morbi	Mr. Pravin Patel	9825416400
33.	Option Ceramic	Wall Tiles	8A, National Highway, Lakhdirpur road, Morbi	Mr. Dipakbhai	9825121615
34.	Orange Ceramics	Spray dryer	8-A,National Highway,Lakhdhirpur Road,Morbi	Mr. Vimal bhai	9825962445
35.	Pengvin Ceramics	Wall Tile	8-A,N.H,Near Makansar,Morbi-363642	Mr. Arvind Bhai	9825262789
36.	Priya Ceramics	Sanitary	8-A,National Highway, P.B.No. 361, Lalpar,Morbi-363642	Mr. Sandip Patel	9726200700
37.	Priya Gold	Wall Tile	8-A,National Highway, Lalpar,Morbi-363642	Mr. Kishor Bhai	9825497785
38.	Regal Ceramic	Sanitary	8-A,National Highway,Jambudia,Morbi-363642	Mr. Amit Bhai	9825222810
39.	Sacmi Ceramic Pvt. Ltd.	Wall Tiles	8A, National Highway, Lakhdirpur road, Morbi	Mr. Chhagan Patel	9825203960
40.	Salou Ceramic Pvt. Ltd.	Floor Tiles	8A, National Highway, Old Ghuntu road, Morbi	Mr. Chetan Patel	9825223840
41.	Samay Sanitary Wares	Sanitary	8-A,National Highway,Lakhdhirpur Road,Morbi-363642	Mr. Dilip Patel	9979133300
42.	Santro Ceramic Pvt. Ltd.	W & F	8-A,National Highway,Bandu Nagar ,Morbi	Mr. Bipin Bhai	9825085721
43.	Sanyo Ceramic	Sanitary	8A, National Highway, Lalpar, Morbi	Mr. Kantibhai	982524994
44.	Satyam Ceramic	Wall Tiles	8A, National Highway, Lakhdirpur road, Morbi	Mr. Vasant Patel	9825627161
45.	Savio Vitrified Tiles	Vitrified Tiles	8A, National Highway, Lakhdirpur road, Morbi	Mr. Samjibhai	9825216154
46.	Shree Nilkanth Sanitary wares	Sanitary	8A, National Highway, Jombudiya, Morbi	Mr. Kantibhai	9925259179

Sr	Company name	Product Manufa-ctured	Address	Contact Person name	Contact No
47.	Shreeji Gold Ceramic	Wall Tiles	8A, National Highway, Lalpar, Morbi	Mr. Hirabhai Patel	9825309770
48.	Shubham Ceramics	Wall Tiles	8A, National Highway, Lakhdirpur road, Morbi	Mr. Pratap Patel	9978960005
49.	Signet Ceramics	Floor Tile	Old Guntu road, Morbi-363642	Mr. Mansukh Bhai	9825227500
50.	Silk Ceramic	Wall	8A, National Highway, Old Ghuntu road, Morbi	Mr. Jitubhai	9925027701
51.	Silvenia Ceramic Pvt. Ltd.	Wall & Floor	8A, National Highway, Old Ghuntu road, Morbi	Mr. Manshukhbhai Patel	9725459222
52.	Simco Tiles	Wall Tile	P.B.No.347,Lakhadirpur road,8-A, N.H,Morbi-363642	Mr. Vishal Patel	9825232417
53.	Simpolo Sanitary	Sanitary	8A, National Highway, Old Ghuntu road, Morbi	Mr. Jayesh Patel	9825801450
54.	Simpolo Vitrified Tiles	Vitrified Tiles	8A, National Highway, Old Ghuntu road, Morbi	Mr. C.P. Kamra (DGM)	9998951005
55.	Skymax	Spray dryer	8-A,National Highway, Lalpar,Morbi-363642		
56.	Sober Ceramic	Wall & Floor	8A, National Highway, Jombudiya, Morbi	Mr. Rakeshbhai	9825314272
57.	Sogo Ceramic Pvt. Ltd.	Vitrified	P.O.Box No. 222, Old Ghuntu Road, Morbi-363642	Mr. Kaushik Bhai	9978987787
58.	Somex Ceramic	Sanitary	8A, National Highway, Lalpar, Morbi	Mr. Manshukhbhai	9909917993
59.	Sona Ceramic	Sanitary	8A, National Highway, Old Ghuntu road, Morbi	Mr. Kishor Patel	9898521999
60.	Sonafield Ceramic	Sanitary	8A, National Highway, Old Ghuntu road, Morbi	Mr. Kishor Patel	9898521999
61.	Sonara Sanitery Wares Pvt. Ltd.	Sanitary	Nava Jambudia 8-A National Highway,Morbi-363642	Mr. Chetan Patel	9825672160
62.	Sonet Ceramics	Sanitary	8A, National Highway, Old Ghuntu road, Morbi	Mr. Dinesh Bhai Patel (Director)	9979007475
63.	Sonex Ceramic	Sanitary	8-A,National Highway, Lalpar,Morbi-363642	Mr. Ajay Patel	9825610309
64.	Sorento granito Pvt. Ltd.	Vitrified Tiles	8A, National Highway, Old Ghuntu road, Morbi	Mr. Hasubhai	9825231152

Sr	Company name	Product Manufa-ctured	Address	Contact Person name	Contact No
65.	Soriso Ceramics	Vitrified Tiles	8A, National Highway, Old Ghuntu road, Morbi	Mr. Raju Patel	
66.	Starware Ceramics	Wall Tile	8-A,National Highway,Jambudia, P.B.No. 379,Morbi-363642	Mr. Gopal Patel	9825262848
67.	Sunsilk Ceramics	Sanitary	8/A,National Highway ,Jambudia ,Morbi	Mr. Denis Patel	
68.	Surani Ceramic	Wall Tiles	8A, National Highway, Lakhdirpur road, Morbi	Mr. Rasik Patel	9825315023
69.	Surya Ceramic	Wall Tiles	8A, National Highway, Dhuva, Morbi	Mr. Jagdish Bhai	
70.	Suzlon Ceramics	Floor Tiles	8A, National Highway, Lakhdirpur road, Morbi	Mr. Hasubhai Patel (Director)	9825223247
71.	Suzuki Ceramic	Floor Tiles	8A, National Highway, Old Ghuntu road, Morbi	Mr. Himat Bhai Patel (MD)	9825672773
72.	Swagat Ceramic	Wall Tiles	8A, National Highway, Old Ghuntu road, Morbi	Mr. Hiteshbhai Patel (Marketing Manager)	9879633095
73.	TipTop Ceramics	Spray dryer	Lakhdirpur Road,Bh. Antique Ceramic,8-A,National Highway,Morbi	Mr. Dilip Bhai	9978996496
74.	Verona Granito Pvt. Ltd.	Vitrified	8-A,National Highway,Makansar Tal ,Morbi	Mr. Jasmin	9825278576
75.	Vraj Ceramic Pvt. Ltd.	Spray dryer mud	8/A,National Highway Dhuva-363622,Ta.Wakaner,Dist:Rajkot	Mr. Pravin Bhai Mr. C. Patel	9909922270
76.	Vridavan Ceramic Pvt Ltd	Floor	8/A,National Highway Dhuva-363622,Ta.Wakaner,Dist:Rajkot	Mr. Pravin Bhai Mr. C. Patel	9909922270

Bureau of Energy Efficiency (BEE)
(Ministry of Power, Government of India)
4th Floor, Sewa Bhawan, R. K. Puram, New Delhi – 110066
Ph.: +91 – 11 – 26179699 (5 Lines), Fax: +91 – 11 – 26178352
Websites: www.bee-india.nic.in, www.energymanagertraining.com