ENERGY PROFILE

SURENDRANAGAR CERAMIC CLUSTER

The Energy and Resources Institute

SHAKTI SUSTAINABLE ENERGY FOUNDATION

Promoting Energy Efficiency in SMEs
SAMEEEKSHA



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Contents

Abbreviations

Abbreviation	Full form
DI	Development Institute
DIC	District Industries Centre
GHG	Greenhouse Gas
GIDC	Gujarat Industrial Development Corporation
HT	High Tension
kVA	kilo volt ampere
kW	kilo watt
kWh	kilowatt-hour
LT	Low Tension
MSME	Micro, Small and Medium Enterprises
NG	Natural gas
PGVCL	Paschim Gujarat Vij Company Ltd.
psi	Pound force per square inch
PV	Photovoltaic
SCM	Standard Cubic Metre
SEC	Specific Energy Consumption
SSEF	Shakti Sustainable Energy Foundation
t	tonne
toe	tonne of oil equivalent
tpd	tonne per day
tph	tonne per hour
VFD	Variable Frequency Drive
PLC	programmable logic control
PV	photo voltaic

Acknowledgements

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Last but not least, our sincere thanks to MSME entrepreneurs and other key stakeholders in the cluster for providing valuable data and inputs that helped in cluster analysis.

Surendranagar Ceramic Cluster

Overview of the cluster

Surendranagar falls within Saurashtra region of Gujarat. Ceramic is one of the major industries in Surendranagar. Thangadh, a large sanitary ware cluster is within Surendranagar district. Morbi, the largest tile manufacturing cluster in India, is located in a neighbouring district.

Surendranagar cluster has about 26 ceramic industries producing electric items, such as insulators and fuses. Most of these industries are located in GIDC Estate, Wadhwan City. Apart from Wadhwan city, few industries are located in Joravarnagar.

Location of Surendranagar (Source: Google Map)

Product, market, and production capacities

The major products of the cluster are LT insulators, electric porcelain fuses, miniatures, kit-kat fuse, bus-bar fuse and change-over. Few units are also manufacturing tiles, sanitary ware and other ceramic products like abrasive media, deburring, and grinding media.

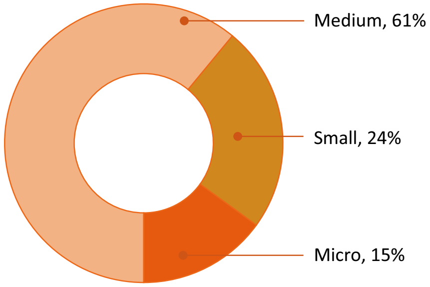
Majority of the industries fall under micro, small, and medium enterprise (MSME) category, etc. The installed capacity of the ceramic industries range between 3–10 tonne per day (tph). While the medium scale industries operate about 310 days per year, the small scale industries operate about 270 days per year. Some of the industries are working during the season only (about 5–6 months in a year). Categorization of ceramic industries in the cluster, based on their production capacities, is provided in the table below.

Categorization of ceramic industries and estimated production

Category	Installed capacity (tpd)	Number of units	Estimated production
			tonne /year
Medium	> 10 tpd	9	16,740
Small	3–10 tpd	7	6,615
Micro	< 3 tpd	10	4,200
	Total	**26**	**27,555**

Production process

Ceramic manufacturing process primarily consists of raw material preparation, drying, shaping, glazing, firing, and finishing operations. The process steps are described as.



Distribution of ceramic units

Raw materials preparation and milling

Batch preparation is the first step in ceramic production. Nowadays, ready mix raw material, after preliminary grinding of some raw materials, is available from suppliers. The ready mix is further processed for meeting product specific raw material grain size by subsequent finer grinding at the unit level. Naturally available materials such as silica, sand, quartz, flint, silicates and alumina silicates, are used to manufacture different ceramics items. Apart from these materials, the batch also requires different types of frit, feldspar, and clays depending upon the composition of the product. All the raw materials are accurately weighed, so that the quality of the product is maintained.

In wet body preparation, the raw material of the body is wet milled in a ball mill by mixing with water to a moisture content of 40%–50 % on a dry basis. The grinding media usually is natural pebbles for body casting material and high alumina balls for glaze preparation.

Filter press and drying

The final clay slurry, known as slip, goes through a dewatering step prior to further processing and moulding into the desired form. These slurries are extremely dense and heavy and typically require dewatering at 225 psi pressure to obtain a plastic cake. Press filters are used for dewatering. The material extracted from the filter press is dried in open sun for 24–48 hours, depending upon the moisture retained after filter press and ambient conditions.

Shaping

The following shaping processes are followed in the manufacture of ceramic products in the cluster.

Pressing

Various types of presses such as mechanical, hydraulic, screw, toggle, and jigger are used in the cluster. For example, ceramic industries manufacturing LT fuses use mechanical press machines while tile manufacturing units use hydraulic press machines for shaping.

Casting/moulding

Sanitary ware and insulator industries use moulds for casting their products into different shapes. The formed materials are generally convection dried by circulating air around the ceramic pieces, to alleviate the risk of imperfections such as warping or distortion in the final product.

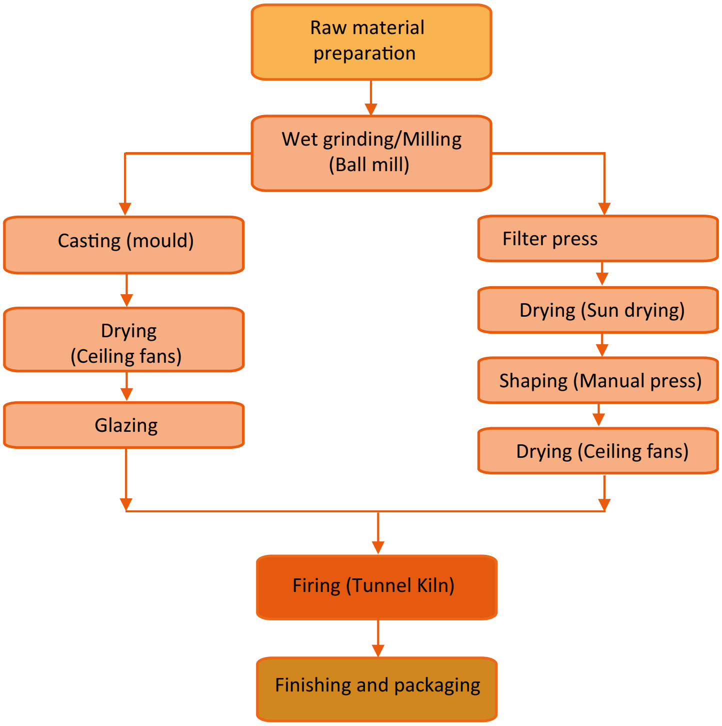
Glazing

The purpose of glazing is to provide a smooth, shiny surface that seals the ceramic body. Not all ceramics are glazed. Ceramic materials can be glazed either prior to firing or after firing, followed by re-firing to set the glaze. Post glazing inspection is carried to sort out the defectives and the material is loaded into carts for firing.

Convection drying

Firing

Firing is the process by which the ceramic materials are thermally consolidated into a dense, cohesive body composed of fine, uniform grains. This process is also referred to as sintering or densification. Firing temperatures are around 1,100–1,300 °C. The kilns use piped natural gas. Tunnel kilns of capacities between 3–5 tpd are common in the cluster. Firing is a slow process and can take upto three days. The tunnel kilns have separate zones for preheating or drying, firing, and the cooling. The kilns are designed for better heat recovery by recirculation of the hot gases from the cooling zone to the firing zone, and from the firing zone to the preheat/drying zone. In some kilns the hot air from the cooling zone is conveyed to the preheat/drying zone and gases from the firing zone are exhausted.



Ceramic manufacturing process flow chart

Finishing and packing

After firing, the products are inspected for quality and defects. Marketable products are taken for finishing and final polishing operation. Finished products are stamped and packed and sent to stockyard for onward marketing. The process flow diagram is shown on the previous page.

Technologies employed

The ceramic manufacturing process involves the following basic technologies/equipment:

Ball mill

The ball mill consists of a large rotating cylinder partially filled with spherical grinding media. The capacity of the ball mills range between 2–4 tonne for body material preparation and 1–2 tonne for glaze preparation. The typical balls sizes are in the range of 25–50 mm. The ratio of the feed to grinding media in ball mills (on dry basis) is 1:1. A gear or belt assembly, coupled with electrical motor of 10–20 hp, is used to drive the mill.

Ball mill

Filter

Water (about 40% by weight of the total raw material) is added during the grinding process. A filter press is used to convert the slurry/sludge from the ball mill to semi-solid cakes. The industries in the cluster are using the filter presses of different sizes. The design feed pressure varies between 3–20 bar.[1] The motors associated with these filter presses are in the range of 3–5 hp.

Filter press

Press machine

Manual press is commonly used in the cluster to shape the product. Few units have installed motorised press machines. These presses produce uniform shape, size and density of products.

Press machine

Kiln

The tunnel kiln is a continuous type of kiln having preheating, firing/calcinating, and cooling zones. The products are placed on cars/trucks. The length of the tunnel kilns go upto 45 m with each truck of about 1.4 m length. The maximum temperature of the calcination is about 1300 °C. The firing control mechanism is based on the set temperature in each zone.

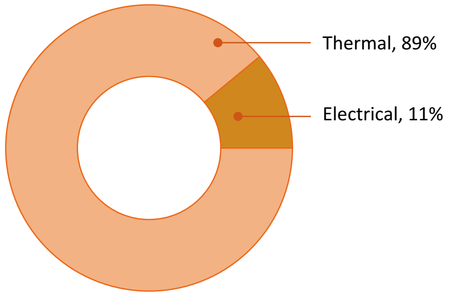
Tunnel kiln

[1] 1 bar = 14.5038 PSI

Energy scenario in the cluster

The major energy forms used by ceramic industries in the cluster are natural gas and electricity. Grid electricity is supplied by Paschim Gujarat Vij Company Limited (PGVCL). Electricity from the grid is used for different motive loads in the material preparation, body casting and kiln auxiliaries. Thermal energy is used for drying and firing in the kiln. The consumption of diesel for backup power generation is almost nil in the cluster due to good and reliable power supply.

The details of major energy sources and tariffs are shown in the table below.



Share of energy in ceramic units

Prices of major energy sources

Source	Remarks	Price
Electricity	LT	Demand Charges: For first 40 kW of billing demand ₹98/ kW/month Next 20 kW of billing demand ₹130/ kW/month Above 60 kW of billing demand ₹195/ kW/month Energy Charges: @ ₹4.60/ kWh Reactive energy charges: @ ₹0.10/ kVAh
	HT	Demand charges: For first 500 kVA of billing demand: ₹150/- per kVA per month For next 500 kVA of billing demand: ₹260/- per kVA per month Energy charges: @ ₹4.20/kWh Power factor penalty: 1% of energy charges for every point drop in PF between 0.85 to 0.90 2% of energy charges for every point drop in PF below 0.85 Power factor rebate: 0.5% of energy charges for every point increase in PF over 0.95.
Natural gas	Gujarat Gas Ltd.	Minimum Guaranteed Off take : ₹32.70/SCM Non-Minimum Guaranteed Off take : ₹35.97/SCM

Energy consumption

Unit level consumption

The specific energy consumption (SEC) of the units range between 0.128–0.176 toe per tonne. The typical energy consumption of different capacities of industries are shown in the table.

Typical energy consumption of a ceramic industry

Type of unit	NG (SCM/year)	Electricity (kWh/year)	Total energy (toe/year)	Total CO_2 emissions (t CO_2/year)
Medium	2,84,038	3,38,706	278	822
Small	1,28,880	94,514	121	316
Micro	80,333	43,926	74	183

Cluster-level consumption

The annual energy consumption of the cluster is estimated to be 4,086 toe. The estimated 'greenhouse gas' (GHG) emissions from the ceramic industries at cluster level is 11,443 tonne of CO_2 per annum.

Energy consumption of the Surendranagar ceramic cluster (2017–18)

Energy type	Annual consumption	Equivalent energy (toe)	Equivalent CO_2 emissions (t)
NG	4.26 million SCM	3,729	7,460
Electricity	4.14 million kWh	357	3,983
	Total	**4,086**	**11,443**

Potential energy efficient technologies

Ceramic industries offer significant scope for energy efficiency improvements in both thermal and electrical areas. Some energy efficiency options are discussed below.

Energy efficiency improvement options in tunnel kilns

All the kilns in the Surendranagar ceramic cluster are fabricated by local service providers/kiln fabricators, there is lack of control and automation for material movement, monitoring of operational parameters such as temperature, retention time of car, and productivity.

In the existing kilns, natural gas flow is varied as per the temperature requirement of the firing zone; however the air flow is kept constant. After reaching the set temperature, the supply of gas is cut off but air is not controlled leading to high flue gas losses and rapid cooling.

To optimize combustion, PLC-based kiln combustion control system is needed in the cluster. PLC-based combustion control systems regulates firing by controlling the air flow and gas flow ratio which is accomplished by the opening degree of combustion air valves and gas valves. The benefits of PLC combustion control system are:

- Reduced fuel consumption
- Lower blower power consumption
- Lower exhaust gas temperature

Heavy refractory cars are generally used for carrying ceramic products inside the kiln. The dead weight of these cars are quite high (around 24%). These heavier refractory cars can be replaced with lower thermal mass cars which would substantially reduce heat loss. Adoption of new insulating materials such as ultralite and hollow ceramic coated pipes for supporting pillars will also help reduce the thermal mass of the cars. The estimated energy saving by use of low thermal mass cars is about 3%–7%.

Kiln car

The heat loss from the kiln structure can be reduced by reinforcing their insulation. This would include covering of internal walls with ceramic fibre insulation and putting ceramic fibre or rock wool insulation on the external walls. The potential energy savings by improved insulation can be up to 1-2%.

Cost–benefit analysis of energy improvement options in kilns

Energy saving measure	Existing scenario	Proposed scenario	Energy saving potential (%)	Simple payback period
Air-fuel ratio controller	Excess combustion air	PLC-based combustion control system	7–12	12–18 months
Use of low thermal mass kiln cars	Solid insulating bricks used in kiln cars	Use of low thermal mass for kiln cars with hollow bricks	3–7	6–8 months
Use of appropriate surface insulation	High surface temperatures in the firing zone	Improved insulation in internal and external walls of the furnace	1–2	9–12 months

Energy efficiency improvement options in wet grinding/ball mill

The grinding media for body material preparation in ball mills is natural pebbles of different sizes. The density of the natural pebble is low and sizes uneven/non circular due to which the grinding time is about 5-8 hours per batch. The SEC of grinding is presently about 17-21 kWh per tonne. It is recommended to replace the existing natural grinding media with high alumina balls of desired sizes. The density of high alumina balls is higher and they are evenly shaped. As compared with natural pebble grinding media, the alumina grinding balls offer better wear resistance, uniform size, high density, and high mechanical strength.

The SEC of ball mills using high alumina grinding media is between 13–16 kWh per tonne.

Existing: Natural pebbles

Proposed: High alumina (68%) balls

Cost–benefit analysis of energy improvement in ball mill

Energy saving measure	Existing scenario	Proposed scenario	Energy saving potential (%)	Simple payback period
Use of high alumina media in ball mill	Natural pebbles are used leading to higher SEC	Use of high alumina will reduce SEC	15–25	12–16 months

Compressed air system

In the cluster, the maximum pressure requirement at the utilization end is 5.5-6.5 bar. However the set generation pressure in the air compressors was observed to be in the range of 7.5–8.0 bar. As a thumb rule, 1 bar increase in air pressure leads to 7% additional electricity consumption. For energy efficiency it is recommended to keep the set pressure of compressed air about 1 bar above the pressure requirement at the point of utilization.

The temperature of intake air to compressors was observed to be 4–7 °C higher than ambient temperature in some units. An increase in intake air temperature by 4 ºC increases the electricity consumption by 1%. Hence, it is important that the intake air temperature must be minimized.

The capacity utilization of screw compressors are usually low (30%–55%). Use of VFD air compressors or retrofitting of existing screw type air compressor with VFD will lead to reduction in electricity consumption.

Energy saving measures in air compressors

Energy saving measure	Existing scenario	Proposed scenario	Energy saving potential (%)	Payback period
Optimum setting of compressed air generation pressure	Set pressure is much higher than end use requirement	Adjust set pressure to about 1 bar more than end use pressure requirement	5–7	Immediate
Ensure that intake air temperature is close to ambient temperature	Intake air temperature is much higher than ambient temperature	Keep compressor room well ventilated and discharge hot air exhaust from compressor outside the room	1.5–2.0	Immediate
Install VFD on existing screw compressor	Capacity utilization is low/unload running period is more than 50%	Unload period is minimized	20–22	About 18 months

Energy efficient motors

Motors are used in ceramic industry in ball mills, filter presses (feed pumps and tightening), and other utilities. The rating of these motors varies from 1 hp to 40 hp depending on the application, capacity, and operation. Most of these motors operate on low loads. Also, the installed motors are of standard efficiency class, with several rewound multiple times. The motor efficiency drops 1–5% each time a motor is rewound. Energy savings is possible in motor systems by replacing the under loaded and rewound motors with premium efficiency (IE3) motors. The average efficiency improvement by doing this will be in the range of 3%–7%.

Energy saving measures in motors

Energy saving measure	Existing scenario	Proposed scenario	Energy saving potential (%)	Payback period
Replacement of under-loaded motors with optimum capacity IE3 motors	Motor loading is low	New energy efficient motor with optimum loading	5–7%	18–24 months
Replacement of rewound motors with IE3 motors	Many motors rewound more than 3 times	Replacement with IE3 motor	3–7%	18–24 months

Grids connected rooftop solar PV

Based on the area availability amongst the ceramic units in the cluster, it is feasible to install solar PV system up to 90 kWp capacity. The system will yield about 75,000 kWh per year, which is about 28% of their annual electricity consumption. The investment in solar PV can be recovered within 4–5 years.

Major cluster actors and cluster development activities

Major stakeholders

The major industry associations are Zalawad Chamber of Commerce & Industries, Surendranagar, and Wadhwan Industries Association. The associations are engaged in lobbying with government agencies on various policy issues. These associations are not having any activities related to technology upgradation of the cluster at present. However, there is an interest amongst them to facilitate activities related to technology up-gradation of ceramic industries in the future.

Other important stakeholders in the cluster are MSME Development Institute (MSME DI), Ahmedabad and state government agency, the District Industries Centre (DIC) at Surendranagar.

Cluster development activities

No major cluster development activities have been taken in the cluster. Hence, there is a good potential to undertake interventions on energy efficiency improvement amongst the ceramic units in the cluster.

Notes

About TERI

A dynamic and flexible not-for-profit organization with a global vision and a local focus, TERI (The Energy and Resources Institute) is deeply committed to every aspect of sustainable development. From providing environment-friendly solutions to rural energy problems to tackling issues of global climate change across many continents and advancing solutions to growing urban transport and air pollution problems, TERI's activities range from formulating local and national level strategies to suggesting global solutions to critical energy and environmental issues.

The Industrial Energy Efficiency Division of TERI works closely with both large industries and energy intensive Micro Small and Medium Enterprises (MSMEs) to improve their energy and environmental performance.

About SSEF

Shakti Sustainable Energy Foundation established in 2009, is a section-25 not-for-profit company that works to strengthen the energy security of the country by aiding the design and implementation of policies that encourage renewable energy, energy efficiency and sustainable transport solutions. Based on both energy savings and carbon mitigation potential, Shakti focuses on four broad sectors: Power, Transport, Energy Efficiency and Climate Policy. Shakti act as a systems integrator, bringing together key stakeholders including government, civil society and business in strategic ways, to enable clean energy policies in these sectors.

About SAMEEEKSHA

SAMEEEKSHA (Small and Medium Enterprises: Energy Efficiency Knowledge Sharing) is a collaborative platform set up with the aim of pooling knowledge and synergizing the efforts of various organizations and institutions - Indian and international, public and private - that are working towards the development of the MSME sector in India through the promotion and adoption of clean, energy-efficient technologies and practices. The key partners of SAMEEEKSHA platform are (1) Swiss Agency for Development and Cooperation (2) Bureau of Energy Efficiency (3) Ministry of MSME, Government of India (4) Shakti Sustainable Energy Foundation, and (5) The Energy and Resources Institute.

As part of its activities, SAMEEEKSHA collates energy consumption and related information from various energy intensive MSME sub-sectors in India. For further details about SAMEEEKSHA, visit http://www.sameeeksha.org

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