Cluster Profile
Bikaner Plaster of Paris industries

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Promoting Energy Efficiency in SMEs
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Bikaner Plaster of Paris industries

Overview of cluster

Bikaner is one of the desert district situated in the North-West of Rajasthan. In terms of area, this is the second largest district after Jaisalmer district in the state. The district has important mineral resources such as china clay, fire clay, gypsum, silica sand and limestone. Gypsum beds up to 30 meters thick and of the best quality available in Bikaner district.

About 2.93 million tonne of gypsum mining was reported during 2013-14 by Department of mining, Government of India, of which 98.8% is mined in Rajasthan. Other gypsum reserves in the country include Gujarat, Tamil Nadu and Jammu and Kashmir. Bikaner has around 150 Plaster of Paris (POP) manufacturing units as it has a vast reserve of gypsum mineral, which is the only raw material used in POP manufacturing. About 50% of POP units are under operation and mainly located in Khara industrial area, which is about 15 kilometres north-east from Bikaner city.

The cluster generates direct employment for more than 1500 people. The annual turnover of the cluster is about Rs 150 crore. Primary market is domestic in different states of India and about 10-15% is exported; mainly to Nepal. POP produced from the cluster is mainly used for the protective and/ or decorative coating of walls and ceilings (real estate field), moulding and casting decorative elements (manufacturing industries), setting broken or fractured bones and surgical instruments (medical field) with more than 95% of POP is sold outside the state.

Gypsum reserve and mining
Source: Google maps

There are eight industrial areas in Bikaner distriect - Bichhawal, Bikaner, Khajuwala, Loonkarnsar, Napassar, Nokha, Karni and Khara. Some of the important industries in Bikaner include POP, ceramic insulators, namkeen & sweet industries, textile, wool processing and ground nut and mustard oil manufacturing industry. A few prominent industries in Bikaner are Bikaji Food International Ltd, Urmul Dairy, Wagon collides Ltd and Bikaner Handloom Carpet.

Product types and production capacities

Out of 150 POP manufacturing units, about 75 POP industries are presently operational in RIICO industrial areas under two associations such as Khara Udyog Sangh or KA Project association. Most of the units undertake job works under various brand names and are not involved in direct marketing. Some of the prominent brands of POP manufactured in the cluster include Sakarni, Aadhar Shree, JK, Taparia, Hi-Tech, Everest and Prince. POP is used in sculpture, architecture plastering, medicine, cement and paper industry. It is the most suitable material for preparation of models, moulds and finds application in ceramic industries, medical fields and artesian products apart from large applications in construction sector.

The average production capacity of BOP industries depends on capacity of drums used and the number of shifts under operation. Generally, the production capacity varies around 300–650 tonne per month (tpm) per unit. The batch capacity largely depends on size of drum used in the manufacturing, which may have either one or two tonne capacity and product yield varies in the range of 75–80%. About 20–25% is lost as vapour in dehydration during calcination of gypsum. The total production of POP in Bikaner cluster is estimated to be 470,000 tonne per year.

Energy scenario in the cluster

The POP units in located in RIICO industrial areas of Khara use pet coke as the fuel Most of the ovens operate in three shifts with batch capacities equal to either one or two tonne. Electricity from grid – Jodhpur Vidyut Vitran Nigam Limited (JdVVNL) is used for motive loads in the cluster. DG sets are used to provide backup during power failure. The details of major energy types, supply sources and existing tariffs are shown in the table.

Prices of major energy sources

Energy type	Supply source	Price
Petcoke	Reliance, Gujarat	Rs 10,000 per tonne
	Imported, Dubai	Rs 12,000 per tonne
Diesel	Retailer, local market	Rs 60 per litre
Electricity	JdVVNL, Jodhpur	Rs 7.5 per kWh

Raw material usage in cluster

The chemical composition of POP is calcium sulphate with a half molecule of water of crystallization ($CaSO_4.½\ H_2O$). Primarily, POP is highly hygroscopic and produced by duly calcined the raw material i.e. gypsum. The gypsum is widely distributed as hydrated sulphate of calcium having chemical formula $CaSO_4.2H_2O$ (79% calcium sulphate and 21% water). It has the unique property of losing three fourths of water of crystallization on heating. Gypsum occurs in sedimentary deposits and found in several varieties viz. selenite (crystalline) satinspar (fibrous), alabaster (pure, compact and fine grained), gypsite (earthy) and anhydrite (anhydrous).

Mining of gypsum
Source: Google maps

Production process

POP manufacturing process broadly comprises batch material preparation, loading and calcination, unloading & curing, pulverization of final product and bagging. When hydrated gypsum ($CaSO_4.2H_2O$) heated to 120–180°C (depending on quality), it is transformed into semi-hydrate $CaSO_4.½H_2O$ (semi-burnt gypsum or alabaster), which is known as POP. The typical manufacturing process of POP is provided below.

(i) Batch preparation

The units procure gypsum through local traders from prescribed mining areas within Rajasthan as lumps or powder which are generally tested in laboratories to match customer requirements. Crushers are used to reduce the size of lumps before pulverized and loading into calcination drum. Petcoke used in furnace during indirect heating of the hydrated gypsum loaded in a rotating drum is pulverized to finer size before feeding for combustion.

(ii) Batch loading

Raw material becomes free from lumps and large particulates after grinding and screening. This homogeneous raw material transferred to loading area either manually or mechanical arrangement for loading to calcination drum. The yield of POP is about 80% (maximum). Depending on size of drum, 1 or 2 tonne of POP is produced per batch. The drum is provided with a batch charging point at the middle of the surface and unloading point is provided at the bottom face, which are manually operated as per requirements of the process. The fuel, petcoke is manually loaded into a hopper and fed to the combustion chamber with the help of a motorised screw feeder.

Pulverizing and loading

(iii) Calcination

Calcination takes place in the rotating drum in which entire batch material is charged initially before heating was initiated. The drum is rotated on its axis slowly at a speed of 5–10 RPM (rotations per minute) with the help of a belt and pulley arrangement placed outside the furnace. The drum is heated externally with direct contact of hot products of combustion with burning of pulverized petcoke. Combustion takes place following fluidized bed principle.

Upon heating the drum, the flue gases leave the system through a small chimney at comparatively very high temperature (more than700°C). With non-recovery of waste heat, it results in high energy losses. Pulverized gypsum is heated at around 150 – 200°C to get converted to POP. The completion of batch processing is done visually i.e. upto the point when no water vapour comes out from rotating drum. The entire process is manually controlled and there is no instrumentation in place. A sample of the final product is taken out from the drum for quality analysis in an in-house laboratory before unloading of the final product and minimize rejection of the lot due to improper calcination.

Calcination drum

Calcination in progress

(iv) Firing

Petcoke is fed from the top using screw feeder. The air required for combustion is supplied from the bottom through prefabricated orifices which help in creating a fluidized bed mechanism to help in better combustion. However, there is no control in place to ensure proper synchronization between combustion air supply and petcoke feeding to maintain proper furnace temperature.

Fluidized bed combustion

Typically, the petcoke feed rate is kept constant while airflow is varied manually to control heating of drum. The consumption of petcoke varies in the range of 50 – 60 kg per tonne of batch raw material. Cold start is initiated with the help of external pilot flame; the residual hate available in bottom ash on burner surfaces helps in resuming firing in subsequent batches. The bottom ash is removed periodically to clean up burner top surface and orifices and ensure supply of combustion air. The burners require replacement in case of deposition of soot and clinkers, which block the orifices making it non-suitable for further use.

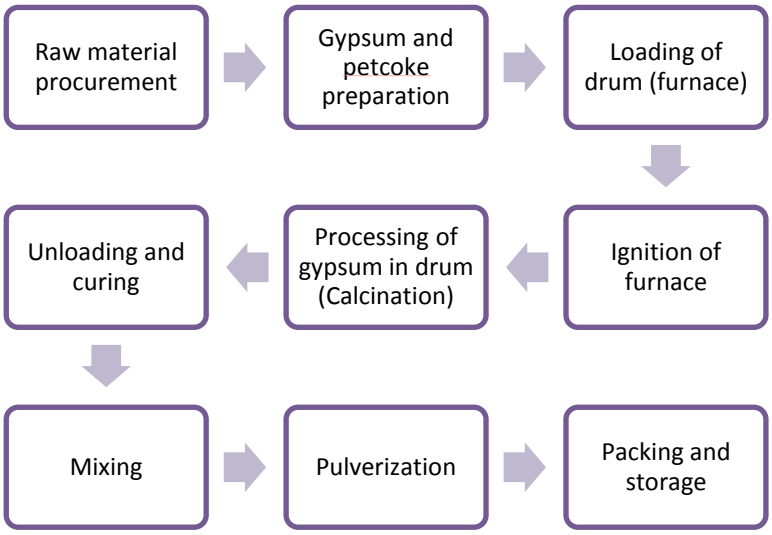
(v) Weighing and bagging

On completion of calcination, the final product is unloaded from the drum and allowed to cure on shop floor. The yield is churned and mixed properly to prepare homogeneous lot before it is further pulverized, weighed and bagged. Bagging is done manually and the weight of a bag contain depends on the size and brand. POP being highly hydroscopic, water proof bags are used to store the final yield with minimum delay and stacked under proper shed.

Mixing and pulverizing of POP

Bagging of POP

A typical manufacturing process followed in the cluster for production of refractory products is shown in the figure.



POP manufacturing process

Typical production process in a Plaster of Paris industry

Technologies employed

Traditionally, POP industries in Bikaner use locally fabricated furnace for heating of gypsum. The typical dimensions of the furnaces are 72 X 102 X 100 inch. The drum is made up of mild steel of 3 feet diameter and 6 feet length. The loading of the gypsum into the drum is done manually. The drum is provided with two gates – one at the top and the other at the bottom of its diameter.

From the top door, the material is loaded into the drum while the bottom door is used to remove the processed material i.e. gypsum. A low pressure burner is used to reach the calcinations temperature. Furnace temperature is subjectively maintained at around 1000°C. There is no instrumentation is use for monitoring and controlling of process parameter.

The process of calcination is a batch process and batch cycle depends on capacity and operating practices. Around 1½ hour is needed to complete a batch operation including loading and unloading operations. In calcination process, 1½ molecule of water from hydrated gypsum is removed to obtain the required properties of POP. After cooling, the calcined powder is passed through 150 mesh and packed in airtight polythene lined gunny bags.

Furnace with plant yard

Burner and drum under fabrication

Some of the important features of the traditional furnaces used in the cluster include the following.

- High temperature of flue gases (more than 700 ºC)
- Manual judgments are used to monitor furnace operation and no instrumentation is used
- Use of improper refractories for wall construction
- No insulation on the furnace wall
- There is no external fin on drum surface
- Burner used is of crude type

Based on market demands, a POP unit may interchange operating time within one to three shifts using drum with 1 or 2 tonne capacity. The number of units in the Bikaner cluster and their operational status is given in the table below.

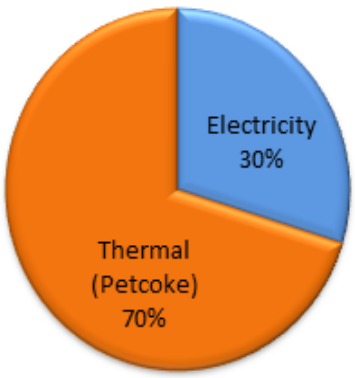
Details of POP units in Bikaner cluster

Total units in cluster	150
Number of operational units	75
Unit with one shift using 1 tonne drum	10
Unit with three shift using 1 tonne drum	40
Unit with three shift using 2 tonne drum	25

Energy consumption

The POP manufacturing units use petcoke and electricity. Electricity from grid is used to operate various drives. DG sets are used to meet electricity requirements only during power cuts. The energy consumption in different ovens is also dependant on the drum capacity and operating practices.

The cost of raw materials is predominant in the manufacturing of POP accounting for about 40-50% of total production costs. The share of energy costs in overall production of POP in the cluster is about 25%.



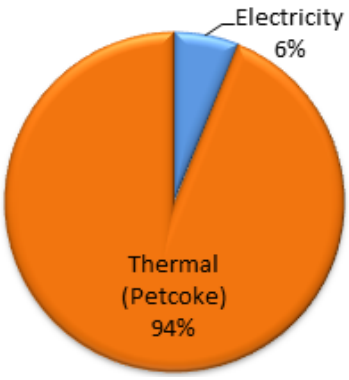
Share of energy costs

Share of different costs

Cost head	Share (%)
Energy	24-26
Labour	15-20
Raw material	40-50
Others	10-15

(i) Unit level consumption

Preparatory work for raw material and petcoke requires electrically driven equipment like pulverizer, crusher and mesh. These equipment's are operated manually. However, the energy consumption due to electrical energy systems is negligible as compared to the energy consumption incurred in fring process to de-hydrate gypsum during calcination stage.



Share of energy consumption

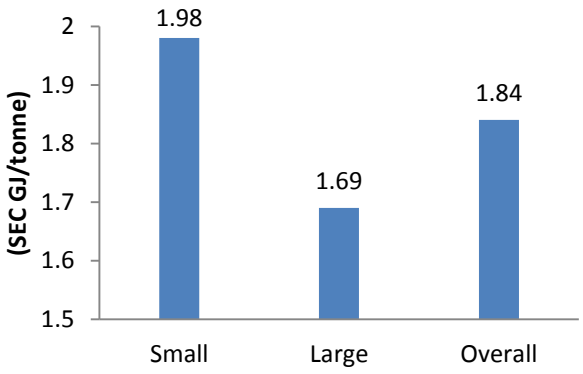
Thermal energy accounts for about 94% of total energy consumption in a POP manufacturing industry (figure).

The total energy consumption of a POP unit varies between 170 toe per year (operates one shift) to 314 toe per year (operates two shifts with larger drum).

Typical energy consumption of kilns

Production (tpy)	Electricity (kWh)	Petcoke (tonne)	Total energy (toe)	Annual energy bill (million INR)
3600	95,000	216	170	2.9
6000	175,000	330	263	4.6
7800	250,000	390	314	5.8

With the batch type process, the overall cluster level "specific energy consumption" (SEC) of POP manufacturing units is about 1.84 GJ per tonne of POP product whereas the SEC of the units varies between 1.69 to 1.98 GJ per tonne depending upon production capacity and duration of operation. Continuous oven operation under three shift production conditions reduces energy losses occurring in a POP furnace.



SEC variations of POP production at cluster level

Specific energy consumption of POP units

Kiln operation	Specific energy consumption	
(shift)	(kcal/ kg)	(GJ/ t)
One shift operation	472	1.98
Two shift operation	438	1.84
Three shift operation	403	1.69

(ii) Cluster level consumption

The total annual energy consumption of POP units at cluster level is estimated to be 20,050 toe. The primary share of energy consumption is by petcoke (about 96%) for converting hydrated gypsum raw material into POP product. The break-up energy consumption and annual energy cost in the cluster based on different energy sources is shown in table.

Energy consumption of Bikaner POP cluster

Energy type	Annual consumption	Equivalent energy (toe/yr)	Annual energy bill (million INR)
Petcoke	269,000 tonne	18,830	251.1
Electricity	14.2 million kWh	1,220	106.5
	Total	**20,050**	**357.6**

Energy saving opportunities and potential

The potential energy saving opportunities for Bikaner POP units are discussed below.

(i) Enhanced insulation in furnace wall

The traditionally built furnace walls are constructed mainly with clay fired red bricks without use of proper insulation. The improper thicknesses of the side walls and crown have led to higher surface temperatures resulting in considerable heat losses. It is suggested to use insulating refractory bricks in bottom layer as well as in all side walls of the furnace. Ceramic fibre blankets can be added between the layers of bricks in bottom layer, side wall and the crown that would help in substantial reduction in heat losses.

(ii) Improved fuel feeding practices

Pulverized petcoke is used as the fuel in all furnaces. The existing feeding of petcoke is not integrated with furnace temperature and airflow. Further, the unburnt fuel which falls over burner surfaces cause blockage of air orifices and clinker formation resulting in black smoke from chimney exhaust. The improper combustion affects the thermal performance of the furnace leading to higher fuel consumptions. The burner and fuel feeding system needs improvements to ensure proper combustion to help in avoiding unburnt and carryover of black smoke through exhaust chimney.

(iii) Instrumentation to monitor operating parameters

The furnaces used in POP units do not use temperature indictors to monitor temperatures. The temperature control is done based on eye judgement and skills of firemen. Non-use of temperature indicator can lead to variations in required firing temperatures vis-à-vis actual requirements that may lead to higher fuel consumption or inferior product quality. On-line temperature probes at crown level may be installed in at least 3 different locations for monitoring temperature of furnaces and control fuel feeding and furnace temperatures either manually or automatically. Rotating drum could also be equipped with temperature monitoring arrangement to ensure consistent temperature raise during calcination process.

(iv) Installation of waste heat recovery system

The sensible heat in high temperature flue gases can be recovered using suitable “Waste Heat Recovery” (WHR) system and preheat combustion air, which will reduce overall energy consumption. Presently, the flue gases temperature is about 700–800 ºC, which could be utilized to preheat combustion air to about 250-300 oC. Every 22 ºC reduction in flue gas temperature or 20 ºC rise in combustion air temperature lead to 1% fuel saving. About 10-15% fuel saving potential exists in the existing firing practices in the cluster.

(v) Installation of fins on external drum surface

The heat available from hot gases from combustion is transferred to gypsum through metallic drum surface through conduction process. There exists a potential to modify the external surfaces of the drum with fin arrangement that would help in maximising heat transfer, reducing batch cycle and enhancing overall energy efficiency.

(vi) Switch over from traditional furnaces to energy efficient furnaces

The POP furnaces in the cluster can be modified to improve its overall performance and reduce energy consumption. The furnace and its utilities can be scientifically designed to

optimised open area of furnace chamber, use of better refractory material and ceramic insulation in civil construction, modify rotating drum, install WHR system to reduce flue gas heat losses and equipped with necessary instrumentation for better monitoring of operating parameters and ensure automatic control of oven operation. Modified furnaces with added features would also help in automation, close control of operating parameters resulting in low rejections and enhanced productivity. It is expected that the modified furnaces can reduce energy consumption by about 20%, which will result in total energy saving about 4000 toe per year at cluster level.

Other energy saving measures

Other energy saving measures relevant for refractory industries in the cluster include the following:

- Power factor improvement
- Use of energy efficient motors in different drives
- Use of clogged V-belts in place of flat belts
- Avoid rewinding of motors more than two times
- Adopt energy efficient lighting

Major stakeholders

There are two major industry associations related to the POP industry in Bikaner, Khara Udyog Sangh and KA Project Association. Both the industry associations are located within the same industrial estate of Rajasthan State Industrial Development & Investment Corporation Ltd (RIICO), Khara (Bikaner).

- Khara Udyog Sangh has 225 number of primary registered member, out of which around 100 members are engaged in manufacturing POP. The association actively promotes business interests of POP industries in general and mining & procurement of gypsum within the Rajasthan in particular.
- KA Project Association has more than 50 POP members. The Association promotes energy efficient technologies for POP industries in close coordination with government bodies such as MSME-DI, Jaipur.

Cluster development activities

There are no specific cluster development activities focusing on POP industry cluster in Bikaner.

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 SDC

SDC (Swiss Agency for Development and Cooperation) has been working in India since 1961. In 1991, SDC established a Global Environment Programme to support developing countries in implementing measures aimed at protecting the global environment. In pursuance of this goal, SDC India, in collaboration with Indian institutions such as TERI, conducted a study of the small-scale industry sector in India to identify areas in which to introduce technologies that would yield greater energy savings and reduce greenhouse gas emissions. SDC strives to find ways by which the MSME sector can meet the challenges of the new era by means of improved technology, increased productivity and competitiveness, and measures aimed at improving the socio-economic conditions of the workforce.

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 are of SAMEEEKSHA platform are (1) SDC (2) Bureau of Energy Efficiency (BEE) (3) Ministry of MSME, Government of India and (4) TERI.

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