ENERGY PROFILE

GHAZIPUR BRICK MANUFACTURING CLUSTER

The Energy and Resources Institute

SHAKTI SUSTAINABLE ENERGY FOUNDATION

Promoting Energy Efficiency in SMEs

SAMEEEKSHA



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Abbreviations

Abbreviation	Full form
BTK	Bull's Trench Kiln
CO	Carbon monoxide
CO_2	Carbon dioxide
DIC	District Industries Centre
MSME	Micro Small and Medium Enterprises
MSME-DI	MSME-Development Institute
REBs	Resource efficient bricks
SEC	Specific energy consumption
SSEF	Shakti Sustainable Energy Foundation
t	tonne
toe	tonne of oil equivalent

Acknowledgements

Shakti Sustainable Energy Foundation works to strengthen the energy security of India by aiding the design and implementation of policies that support renewable energy, energy efficiency, and sustainable transport solutions. TERI places on record its sincere thanks to the Shakti Sustainable Energy Foundation (SSEF) for supporting the project on Advancing Energy Efficiency in the Micro, Small and Medium Enterprise (MSME) sector in India. TERI team is indebted to Ghazipur Janpath Int Nirmata Samiti for providing support and information related to Brick kiln units in Ghazipur cluster. TERI extends its sincere thanks to Mr Akshay Kumar Dubey (President, Ghazipur Janpath Int Nirmata Samiti), Mr Kailashpati Pandey (Vice-President, Ghazipur Janpath Int Nirmata Samiti and Mr Kamla Kant Pandey (President, Int Nirmata Parishad, Varanasi) for preparation of this cluster profile report.

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

Ghazipur Brick Manufacturing Cluster

Overview of cluster

Ghazipur city is the administrative headquarters of Ghazipur district, one of the four districts of Varanasi division in Uttar Pradesh. Ghazipur is an important brick manufacturing cluster in Varanasi division. Being located in the Indo-Gangetic belt, the soil in this region is more suitable for manufacturing good quality bricks. Therefore, clay-fired bricks are the preferred walling material for building construction in the region.

Location of Ghazipur and Varanasi
Source: Google maps

Product type and production capacities

There are about 480 brick manufacturing units in Ghazipur cluster. However during 2017-18, about 380 of these brick kilns were operated. Almost all the brick manufacturing units use fixed chimney Bull's Trench Kilns (BTKs) for firing of green bricks. A few brick units in the cluster have switched over to zig-zag firing process. All the brick kilns are engaged in production of clay fired solid bricks through conventional handmade process. The average production capacity of a typical unit in Ghazipur cluster is about 25,000 bricks per day. Brick manufacturing is a seasonal activity and the units operate for about six months (January to June) in a year. The average size and weight of a fired brick is 9×4×3 inch and 3 kg, respectively. The fired bricks are generally classified into five to seven classes based on their quality judged through visual observation. The best quality bricks (Class-1) give out a good ringing sound, when stuck and are dark red in colour. The typical production of different classes of bricks in the cluster is shown in the table below.

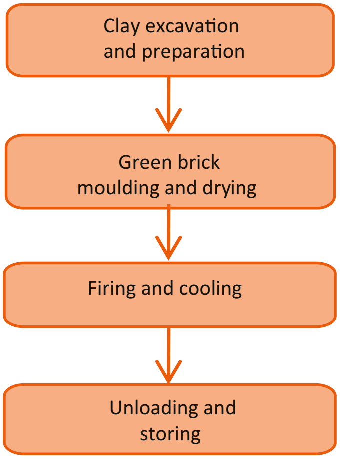
Fixed chimney BTK

Production from a brick kiln

Brick class	Average share (%)	Selling price (₹/1,000 bricks)
Class-1	60–65	4,000
Class-2	25–30	3,100
Class-3 and others	5–15	1,700

Production process

Brick making in the cluster follows traditional, labour-intensive processes and practices, with minimal use of mechanization. The major steps involved in brick production process include clay excavation and preparation, green brick moulding and drying, firing and cooling inside the kiln, followed by unloading and storing. The basic raw materials required for manufacturing bricks are clay and water. The different steps involved in brick manufacturing are briefly described in the following section.



Brick production process

Clay/soil excavation and preparation

Generally, top soil from nearby agricultural fields is excavated for manufacturing bricks. The clay is subjected to processes that render it homogeneous, workable and makes it suitable for shaping process. The clay is processed to free it from gravel, lime, 'kankar' particles, and organic matter. It is then puddled, watered and left over (generally for 12–24 hours) for weathering and subsequent processing. It is followed by kneading of homogenized clay with spade or other mechanical equipment into a plastic mass.


Clay preparation

Green brick moulding

Subsequent to kneading, plastic clay mass becomes ready for forming or moulding step. Wooden/plastic moulds are used for making solid green bricks (freshly moulded brick with moisture).


Brick moulding

Brick drying

The moisture present in green bricks is removed through drying process. Generally, sun drying is practiced in the cluster. Green bricks are stacked in open field for natural drying. The dried bricks are manually taken for loading in the kiln.


Brick drying

Brick firing, unloading, and storing

Leather-hard dried bricks are loaded and stacked manually inside the kiln for firing. The purpose of firing is to convert the clay mass into a strong, hard, and stable product—fired brick. Firing is the most energy-intensive process in brick manufacturing. The

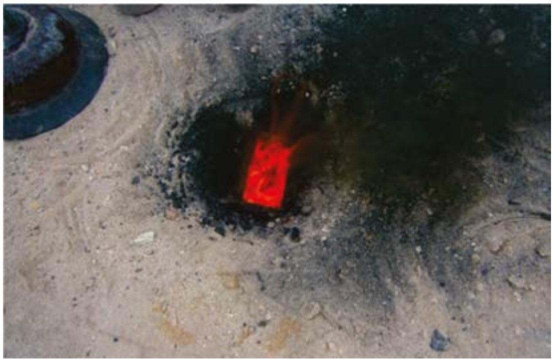

Brick firing


Brick unloading

firing process determines the desirable properties of the fired brick—strength, porosity, stability against moisture, hardness, etc. The fired bricks, after cooling are taken out from the kiln and based on visual inspection classified into different classes. Each class of fired brick is stacked separately for selling.

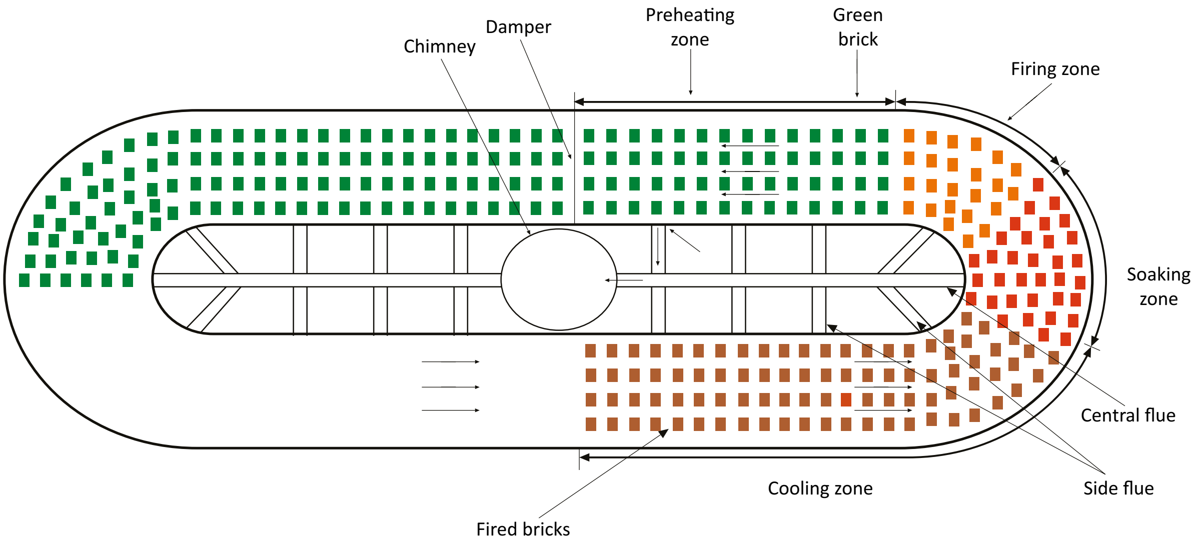
Technologies employed

The cluster predominantly uses fixed chimney BTKs for firing of bricks. BTK is a continuous type of kiln in which the bricks are stacked inside the kiln and the fire is made to move. In the cluster, oval shaped BTKs are used. Green bricks are placed in the kiln and covered with partially fired / green bricks layer.



Feed hole in firing zone

The whole arrangement is then thermally insulated by spreading 4–6 inch brick dust or ash on the partially stacked fired/green bricks. The brick-loading end is sealed with metal, jute or plastic damper and brick unloading end is kept open for ingress of air required for combustion of fuel. Fuel is fed manually at more or less constant rate through feed hole covers provided at the top of the kiln. The kiln can be divided into three distinct zones as shown in schematic diagram of BTK.



Schematic diagram of BTK


Fixed brick unloading

Starting from the unloading end, the first zone in a brick kiln is brick cooling zone. Ambient air enters through this end, picks up heat from the fired bricks and gets preheated. In this way, the fired bricks are cooled down and the air gets heated up. Next zone is the firing zone in which fuel is fed through feed hole covers. Pre-heated air coming from cooling zone carries out the combustion of fuel in this zone. The next zone is brick preheating zone in which the hot gases coming from combustion zone preheats the green bricks, takes up moisture from them, and finally leave as flue gases through the chimney. Generally, two to three rows of bricks are fired at a time and when firing of one row is complete, it is closed and next row of stacked green brick is opened. The direction of fire travel in the kiln is the same as direction of air travel (mostly anticlockwise). A firing temperature of 1000–1100 °C is maintained in the firing zone of the kiln. The flue gases are allowed to pass through stacks of green bricks to preheat them before they join the central flue gas duct and exit through the chimney. Typically, the temperature of flue gases leaving the chimney is about 80–120 °C.

Energy scenario in the cluster

Coal is the main fuel used in the cluster. Use of diesel is limited only to cater for water pumping requirements in clay preparation and moulding area of brick kiln. The average cost of coal used by brick kilns is provided in table below.

Average cost of coal in the cluster

Energy type	Price (₹)
Coal	8,500 per tonne

Energy consumption

Unit level consumption

Thermal energy accounts for almost 100% of energy consumption in brick kilns. The average coal consumption is about 18 tonne per lakh brick produced. Apart from coal, some diesel for operation of DG sets to pump the water for clay preparation is consumed. Considering 200 days of operation of a brick kiln in a year, the total energy consumption of a brick kiln is estimated to be 473 toe per year. The Specific Energy Consumption (SEC) for manufacturing bricks is about 1.51 MJ per kg fired brick.

Typical energy consumption in fixed chimney BTKs

Production capacity	Production (lakh bricks/year)	Coal (tpy)	Total energy (toe/yr)	Annual energy bill (million ₹)
25,000 bricks per day	44	788	473	7

Cluster level consumption

The total energy consumption of Ghazipur brick kiln cluster is estimated to be 181,632 toe. The break-up of energy consumption is given in the table below.

Energy consumption of the Ghazipur brick kiln cluster

Energy type	Annual coal consumption	Equivalent energy (toe)	GHG emissions (tonne CO_2)	Annual energy bill (million ₹)
Coal	302,592 tonne	181,632	329,856	2,572
	Total	**181,632**	**329,856**	**2,723**

Potential energy efficient technologies

The average SEC of brick kiln in the cluster is estimated to be 1.51 MJ per kg fired brick which is higher compared to the optimal level of 1.1–1.2 MJ/kg-fired brick for fixed chimney BTKs and 0.9–1.1 MJ/kg-fired brick for zig-zag firing process. This clearly indicates that there is a good potential for improving the energy efficiency of the brick kilns in the cluster. Some of the major energy-saving options for the brick kiln units in the cluster are discussed below.

Firing zone in zig-zag firing process

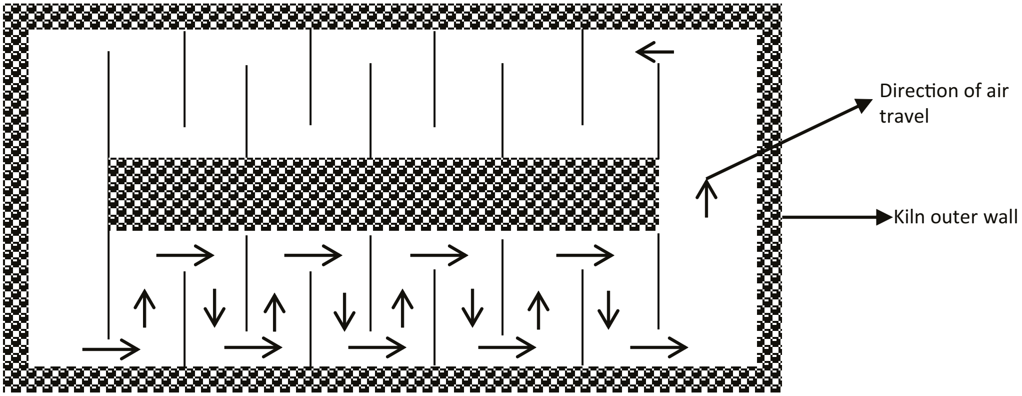
Adoption of zig-zag firing process

Conventional firing process followed in brick kilns generally leads to poor combustion and substantial surface heat loss resulting in more fuel consumption. In place of conventional firing, zig-zag firing process can be adopted. In zig-zag firing, the kiln has long firing zone and the travel path of fire is increased with specific green brick stacking pattern. The stacking pattern results in creating turbulent conditions which help in better mixing of air and fuel. Some of the benefits of adopting zig-zag firing process include:

Brick stacking in zig-zag firing process

- Better combustion of fuel due to improved mixing of air and fuel leading to reduced coal consumption
- Reduced surface heat losses
- Reduced carbon monoxide (CO) and particulate emissions

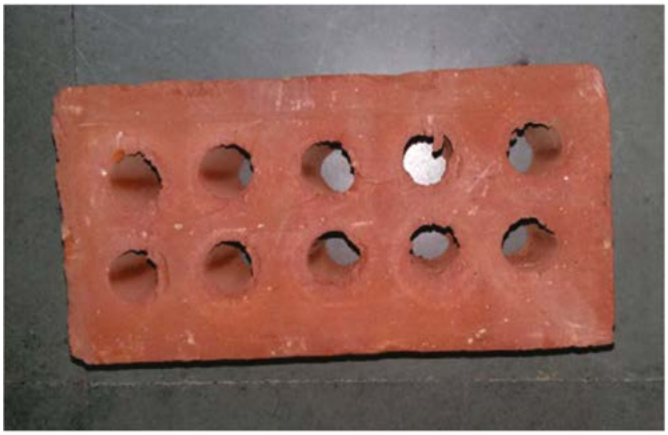
About 10% of fuel saving can be achieved with adoption of zig-zag firing process. This is equivalent to saving of about 30,259 tonnes of coal (~ 18,163 toe) at cluster level.



Air flow in single zig-zag firing process

Shift to Resource Efficient Bricks (REBs)

Conventional brick kilns produce solid bricks. With increased emphasis on RCC (Reinforced Concrete Cement) column construction, bricks are used as filler rather than load bearing material for wall construction. Shifting to Resource Efficient Bricks (REBs), such as perforated bricks and hollow blocks will save fuel and reduce pollution during brick manufacturing process. Some of the benefits of producing REBs include the following:



Perforated bricks

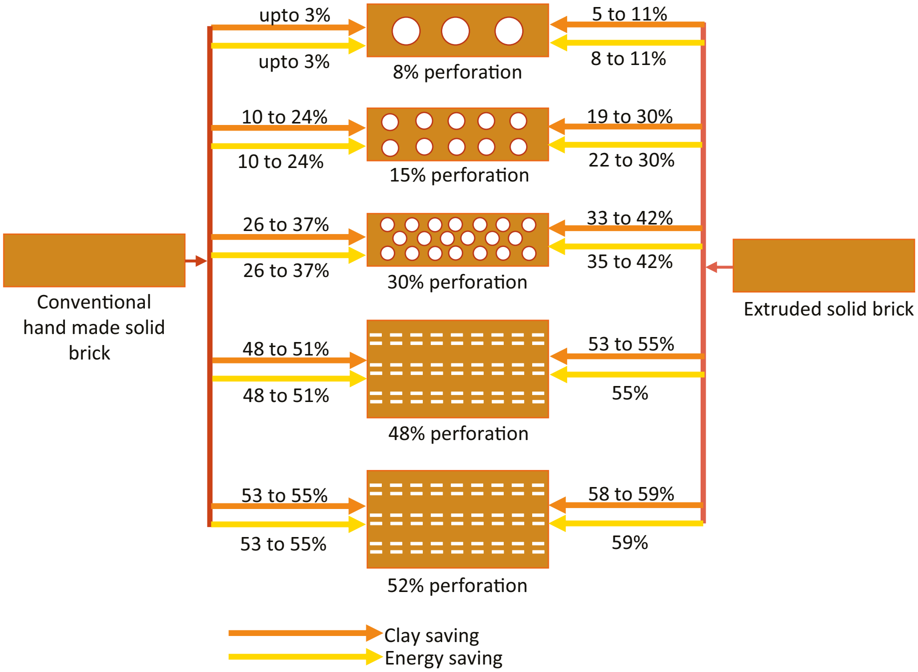
Hollow blocks

Resource savings

Clay and fuel (coal) are the main resources used for manufacturing bricks. The production of REBs results in substantial resource savings as compared to production of conventional/extruded solid bricks.

Improvement in product quality

Adoption of mechanization for clay preparation and moulding process helps in proper homogenization of clay particles. The process also helps in manufacturing bricks with proper size and shape. This leads to production of better quality of green as well as fired bricks and increased output of best quality (Class-1) bricks from the kiln.



Resource (clay and energy) savings in REB production

Reduction in green brick wastage

During the brick-making season, about 20% of total green brick production of a kiln is wasted due to rain. However, with adoption of mechanization and installation of shed for drying of bricks, the wastage of green bricks can be avoided.

Reduction in plaster and mortar[1] requirement

REBs, such as hollow block have uniform size and shape and can be used as such without any plaster on the surface. This results in substantial saving in mortar requirements. For example, hollow blocks (400×200×200 mm) are equivalent to 9 solid bricks (230×110×70 mm) and their use as walling material can help in 40–70% savings in mortar requirements.

Reduction in steel requirements

The weight of REBs is less than the equivalent size of solid bricks. Therefore, use of REBs results in reduced dead load of the building that leads to substantial reduction in requirement of steel as reinforcement.

Reduction in energy bills of buildings

The REBs have lower heat transfer coefficient as compared to conventional solid bricks; therefore, their use as walling material in buildings improves the insulating property and, depending upon the climatic zone, can reduce the energy bill by 2–6%.

1 Mortar is a workable paste used to bind building blocks such as bricks, stones, and concrete masonry units together. Mortars are typically made from a mixture of sand, a binder (generally cement), and water.

Improved skill set of workers

The operation/maintenance of machinery/equipment will help upgrade the skill sets of workers and also reduce the drudgery involved in manual clay preparation and the green brick moulding process.

Adoption of better kiln operating practices

Improved fuel (coal) feeding practices help in better combustion of fuel and improve the overall thermal efficiency of the kiln. Besides, it helps in reducing formation of various undesirable products, such as CO and soot. About 10% fuel saving potential exists by adopting better fuel feeding practices (equivalent to 30,259 tonne of coal or 18,163 toe at cluster level). For efficient operation of brick kiln, following practices should be followed:

- Large lumps of coal should not be used for firing purpose. The maximum size of coal should be less than 10 mm. Coal crusher should be used for getting proper size of coal.
- Coal feeding in the BTKs is carried out intermittently. The gap between two successive feeding cycles is about 45–60 minutes. This long gap results in increased coal consumption and leads to formation of black smoke for a substantial period of time after completion of a coal feeding cycle. The coal should be fed more frequently, say after every 20 minutes.
- To ensure better coal combustion, smaller amounts (750–1,000 g) should be used for feeding at a time.
- In a majority of brick kilns in the cluster, coal feeding is practised in two lines at a time. However, to ensure complete combustion, the length of firing zone should be increased by feeding coal in at least three lines.
- The optimum length of cooling zone is about 150–170 feet. The increase in length of cooling zone limits the availability of sufficient quantity of air in the firing zone that results in incomplete combustion of fuel.
- Iron rod should be poked intermittently to prevent formation of coal bed at the bottom of firing zone.
- A new row should be taken on coal feeding only when red coloured bottom is visible through brick setting. The red colour generally corresponds to about 650 °C temperature.
- The major heat losses from kiln components (wickets, dampers, and feedhole covers) can be controlled by adopting the following practices:
    - Sealing the wickets (i.e., openings in the kiln outer wall which are used to carry green and fired bricks inside/outside the kiln) with at least two-brick thick walls followed by mud plastering on both sides.
    - Closing side flues with brick wall (1½ brick thick) plastered with a mix of clay, sand, and cow dung.
    - Providing ash layer of about 7 inch thickness above the brick setting.
- Keeping the floor level of the kiln at least one foot above ground level to help in drainage of any rain water.

Major cluster actors and cluster development activities

Major stakeholders

The major stakeholders of the Ghazipur brick manufacturing cluster are brick kiln entrepreneurs and coal suppliers. The industry associations, such as All India Brick & Tile Manufacturers Federation, Int Nirmata Parishad, Varanasi, Uttar Pradesh Brick Manufacturers Association, Lucknow and Ghazipur Janpath Int Nirmata Samiti generally engage with the government on policy related issues. The associations involvement in activities related to technology upgradation of the cluster is very limited. However, the associations have shown keen interest to collaborate in future activities related to technology upgradation of brick kilns.

Other important stakeholders in the cluster are MSME-Development Institute (DI), Varanasi and state government agencies, such as Pollution Control Board and District Industries Centre (DIC).

Cluster development activities

No major cluster development activities have been taken in Ghazipur brick manufacturing cluster. With the cluster exhibiting significant potential for energy saving, there is a good potential to undertake interventions on energy efficiency improvement amongst the brick kilns in Ghazipur cluster.

Notes

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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