ENERGY PROFILE

LUDHIANA BRICK MANUFACTURING CLUSTER

The Energy and Resources Institute

SHAKTI SUSTAINABLE ENERGY FOUNDATION

Promoting Energy Efficiency in SMEs
SAMEEEKSHA

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Certificate of originality

Original work of TERI done under the project “Advancing Energy Efficiency in the Micro, Small and Medium Enterprise (MSME) sector in India”.

Suggested format for citation

TERI. 2018
Energy Profile: Ludhiana Brick Manufacturing Cluster
New Delhi: The Energy and Resources Institute; 20pp.
[Project Report No. 2017IE03]

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Published by

TERI Press
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Contents

Abbreviations

Abbreviation	Full form
BTK	Bull's Trench Kiln
CO	Carbon monoxide
CO2	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 (SSEF) works to strengthen India's energy security 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 SSEF for supporting the project on Advancing Energy Efficiency in the Micro, Small and Medium Enterprise (MSME) sector in India.

The TERI team is indebted to Brick Kiln Owners Association, Ludhiana for providing support and information related to the brick kiln units in the Ludhiana cluster. TERI extends its sincere thanks to Mr Ramesh Sohi (President, Brick Kiln Owners Association, Ludhiana), Mr Praveen Jindal (General Secretary, President, Brick Kiln Owners Association, Ludhiana, and Mr Pritpal Singh (Senior Engineer, Punjab State Council for Science and Technology) for the 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 the cluster analysis.

Ludhiana Brick Manufacturing Cluster

Overview of the cluster

Ludhiana is one of the important cities in the state of Punjab. The city has a large number of small-scale units that produce industrial goods, machine parts, auto parts, household appliances, hosiery, apparel, and garments. In addition, Ludhiana is one of the largest clusters of clay-fired brick manufacturing in the state of Punjab.

Location of Ludhiana and Amritsar (Source: Google Maps)

Product type and production capacities

There are about 330 brick manufacturing units around Ludhiana. 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 a conventional production process. The average production capacity of a typical unit in, Ludhiana cluster is about 40,000 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 four to five classes based on their quality. The best quality brick (Class-1) give-out a good ringing sound when stuck and is dark red in colour. The typical production of the different classes of bricks in the cluster is shown in the following table.

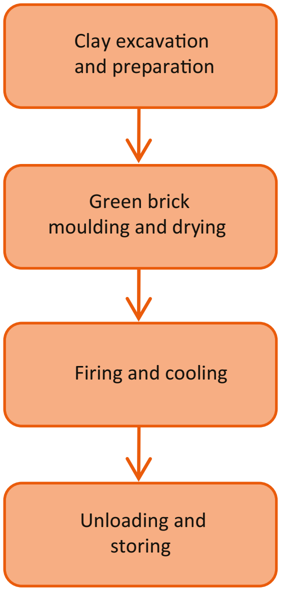
Fixed chimney BTK

Production from a brick kiln

Brick class	Average share (%)	Selling price (Rs/1000 brick)
Class-1	65 - 70	4200
Class-2	20 - 25	3250
Class-3 and others	5 - 15	1500

Production process

Brick making in the cluster follows traditional, labour-intensive processes and practices with minimal 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 the 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 the nearby agricultural fields is excavated for manufacturing bricks. The clay is subjected to processes that render it homogeneous and, workable and makes it suitable for the 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. This is then followed by kneading the homogenized clay—using a space or other equipment—into a plastic mass.

Clay preparation

Green brick moulding

Subsequent to kneading, the 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 fields, for natural drying. The dried bricks are manually taken for loading in the kiln.

Brick firing, unloading, and storing

Leather-hard[1] 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 firing process determines the desirable properties of the fired brick, such as 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.

Brick drying

Brick unloading

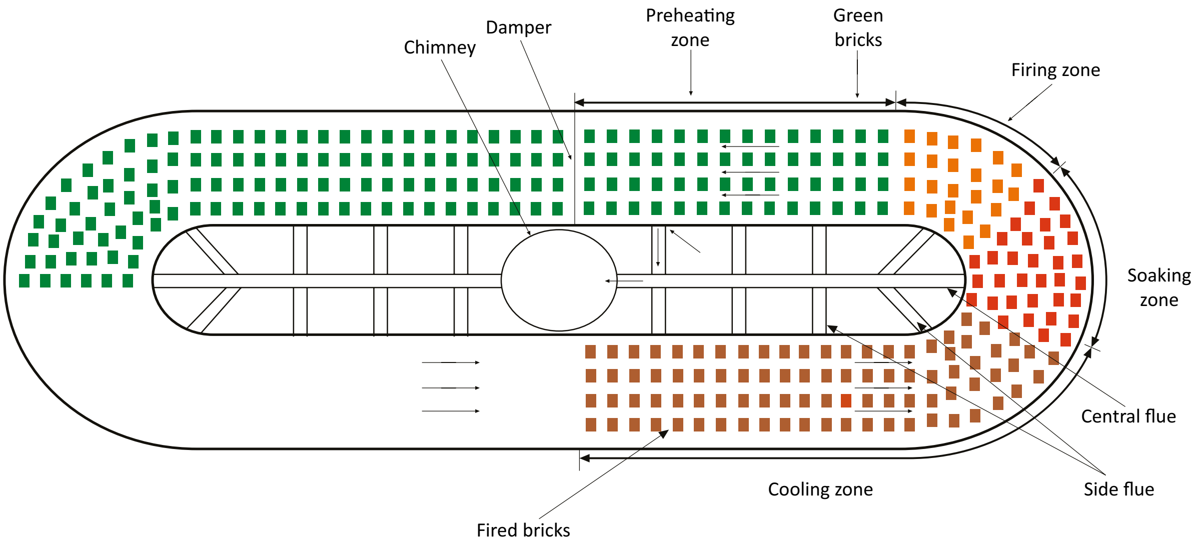
Brick firing

Technologies employed

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

Starting from the unloading end, the first zone in a brick kiln is the brick cooling zone. Ambient air enters through this end, picks up heat from fired bricks, and gets preheated. In this way the fired bricks are cooled and the air gets heated up. The next zone is the firing zone in which fuel is fed through feed hole covers. Pre-heated air coming from cooling zone carries out combustion in this zone. The next zone is the brick preheating zone in

[1] Leather-hard is the condition of a clay when it has been partially dried to the point where all shrinkage has been completed, and it has a consistency similar to leather of the same thickness as the clay. The clay is still visibly damp but has been dried enough for handling without deformation.



Schematic diagram of a BTK

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 the firing of one row is complete, it is closed and the next row of stacked green brick is opened. The direction of fire travel in the kiln is the same as the direction of air travel mostly anticlockwise. A firing temperature of 1,000–1,100 °C is maintained in the Kiln's firing zone. 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.

Brick unloading

Fixing zone

Feed role in firing zone

Energy scenario in the cluster

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

Average cost of coal in the cluster

Energy type	Price (Rs)
Coal	9,000 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 14 tonne per lakh of the bricks produced. Apart from coal, some, diesel for the operation of DG sets to pump mount of water for clay preparation is consumed. Considering the 200 days of operation of a brick kiln in a year, the total energy consumption of a brick kiln is estimated to be 728 toe per year. The Specific Energy Consumption (SEC) for manufacturing bricks is about 1.27 MJ per kg of fired bricks.

Typical energy consumption in fixed-chimney BTKs

Production capacity	Production (lakh bricks/year)	Coal (tpy)	Total energy (toe/yr)	Annual energy bill (million INR)
40,000 brick per day	80	1120	728	10

Cluster-level consumption

The total energy consumption of the Ludhiana brick kiln cluster is estimated to be 243,152 toe. The break-up of energy consumption is given in the table below.

Energy consumption of the Ludhiana brick kiln cluster

Energy type	Annual coal consumption	Equivalent energy (toe)	GHG emissions (tonne CO_2)	Annual energy bill (million INR)
Coal	374,080 tonne	243,152	441,548	3367
	Total	243,152	441,548	3367

Potential energy-efficient technologies

The average SEC of brick kilns in the cluster is estimated to be 1.27 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 the 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 in the following section.

Adoption of the zig-zag firing process

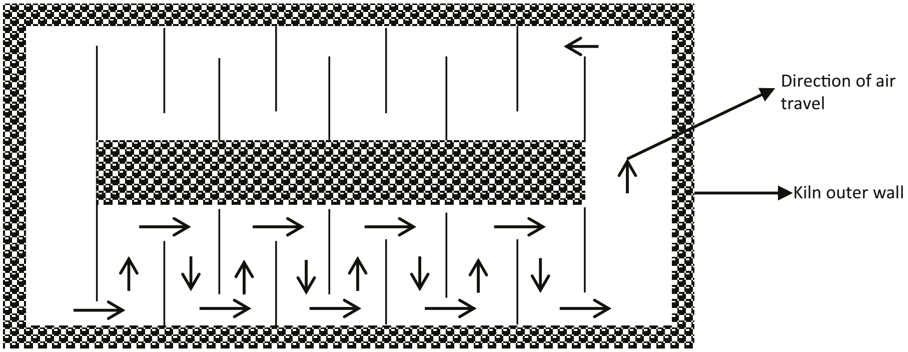
The conventional firing process followed in brick kilns generally leads to poor combustion and substantial surface heat loss resulting in more fuel consumption. In place of conventional firing, the zig-zag firing process can be adopted. In zig-zag firing, the kiln has a long firing zone and the travel path of fire is increased with a specific green-brick stacking pattern. The stacking pattern results in creating

Brick stacking in zig-zag firing process turbulent conditions' which help in the better mixing of air and fuel. Some of the benefits of adopting zig-zag firing process include:

- Better combustion of fuel due to improved mixing of air and fuel, thus leading to reduced coal consumption
- Reduced surface heat losses
- Reduced CO and particulate emissions

Brick-stacking in zig-zag firing process

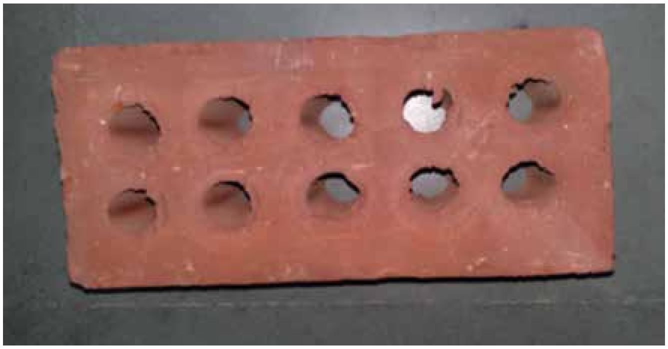
A saving of about 10% fuel can be achieved with the adoption of the zig-zag firing process. This is equivalent to a savings of about 37,408 tonne of coal (~ 24,315 toe) at the cluster level.



Direction of 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 fillers rather than a load-bearing material for wall construction. Shifting to REBs like perforated bricks and hollow blocks will save fuel and reduce pollution during the brick manufacturing process. Some of the benefits of producing REBs include the following:

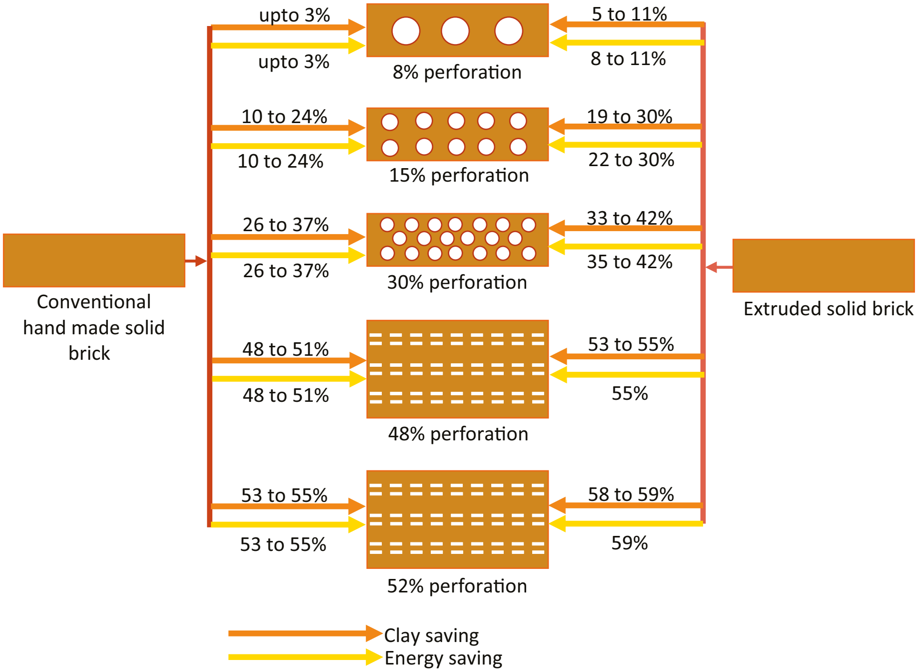


Perforated bricks

Hollow blocks

Resource saving

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



Resource (clay and energy) savings in REB production

Improvement in product quality

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

Reduction in green brick wastage

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

Reduction in plaster and mortar[2] requirement

REBs such as hollow blocks have uniform size and shape and can be used as such without any plaster on the

[2] 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.

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, the use of REBs results in reduced dead load of the building that leads to a substantial reduction in the requirement of steel as reinforcement.

Reduction in the energy bills of buildings

The REBs have a 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%.

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 fuel combustion and improve the overall thermal efficiency of the kiln. Besides, it helps in reducing the formation of various undesirable products, such as carbon monoxide (CO) and soot. About 10% fuel-saving potential exists by adopting better fuel-feeding practices (equivalent to 37,408 tonne of coal or 24,315 toe at cluster level). For bricks kilns to operate efficiently, the following practices should be adopted:

- Large lumps of coal should not be used for firing purposes. The maximum size of coal should be less than 10 mm. coal crusher should be used for getting the proper coal size.
- 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 the formation of black smoke for a substantial period of time after the 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 (750–1000 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 the firing zone should be increased by feeding coal in at least three lines.
- The optimum length of the 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 rods should be poked intermittently to prevent the formation of a coal bed at the bottom of the firing zone.
- A new row should be taken on coal feeding only when-red-coloured bottom is visible through a 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's 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 a brick wall (1½ brick thick) plastered with a mix of clay, sand and cow dung.
  - » Providing ash layer of about 7-inch with the thickness above the brick setting.
- Keeping the kiln's floor level at least one foot above ground level to help ith the drainage of rainwater.

Major cluster actors and cluster developmental activities

Major stakeholders

The major industry associations, such as the All India Brick & Tile Manufacturers Federation, Punjab Brick Kiln Owners Association, and Brick Kiln Owners Association Ludhiana generally engage with the government on policy-related issues. The associations, involvement in activities related to the technology upgradation of the cluster is very limited. However, the associations are interested to collaborate in future activities related to the technology upgradation of brick kilns.

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

Cluster development activities

No major cluster developmental activities have been taken in the Ludhiana 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 the Ludhiana 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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