Guidance Document on Environmental Technologies for Brick Kilns in India

Final Report

Submitted to

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

CONFIDENTIALITY

This guidance document is being submitted to GIZ by Enzen Global Solutions with the explicit understanding that the contents would not be divulged to any third party without prior written consent from Enzen Global Solutions.

DOCUMENT CONTROL

Document Information	
Document Title	**Guidance Document on Environmental Technologies for Brick Kilns in India**
Document Current Version	Ver. 2.0
Document Issue Date	27.01.2023
File Name	Guidance Document

Document History

Version	Release Date	Changes	Author	Status
V-1.0	26.10.2022	-	Enzen	Draft
V-2.0	30.11.2022	Added case studies and annexures	Enzen	Final

ENZEN CONTACT FOR THIS DOCUMENT

If you would need any further information or have any queries regarding this Inception Report, please contact the following persons.

Name	Designation	Contact Details
I.Thanumoorthi	Sr. Principal Consultant	thanumoorthi.i@enzen.com +91 9663380445
Dr. Uma Rajarathnam	Global Head, Applied Research and Collaborations	Uma.r@enzen.com +919880345888

Table of Contents

Table of Figures

List of Tables

CHAPTER 1 Introduction

1.1 Background

Air pollution is one of the major environmental issues in India. To address the air pollution problem in India, the Government of India through its Ministry of Environment, Forest, and Climate Change (MoEFCC) launched 'National Clean Air Programme (NCAP) in January 2019 as a national-level strategy to achieve the national level target of 20-30% reduction of PM2.5 and PM10 concentration by 2024. For priority action, 132 cities have been identified by MoEFCC as non-attainment cities due to air pollution levels in exceedance beyond ermissible National Ambient Air Quality Standards (NAAQS) based on data generated under National Air Quality Monitoring Programme (NAMP) during 2011-2015.

The Central Pollution Control Board (CPCB), the sectoral ministries of Housing & Urban Development, Power, Transport, Petroleum and Natural Gas, New and Renewable Energy and Heavy Industry and Agriculture are actively engaged for implementation of NCAP. At the state and local level, agencies of the environment, pollution control, industry, and cities are involved. At present, the city action plans of the non-attainment cities are approved by the CPCB, while detailed plans known as micro action plans are also prepared which are being reviewed by CPCB, and the focus is on the implementation of these plans.

Under the ongoing Indo-German Development Corporation, a project on "Reduction of Air Pollution in Three Indian Cities" is being implemented by GIZ. The objective of the project is to strengthen the capacities of authorities in selected cities for the effective implementation of India's National Clean Air Programme (NCAP). The project has focused on developing solutions for implementing viable environmental technologies for achieving air pollution reduction targets in the selected cities (Surat, Pune, and Nagpur). M/s Enzen Global Solutions Pvt. Ltd. has been engaged by GIZ as consultants for developing a "Guidance Document on Environmental Technologies for Brick Kilns in India". The guidance document will include the best practice and viable solutions so that the document can be used by the brick kiln industry in India for complying with the Notification dated 22nd February 2022 of the Ministry of Environment, Forest and Climate Change, Government of India (MoEF&CC) through upgrading their technologies to reduce air pollution from brick kilns as well improve their efficiency. The guidance document is expected to showcase Indian and global best practices and key learnings from them, as well as compile solutions with suitable references for use by the Indian brick kiln industry.

1.2 Context

Emissions from brick kilns are one of the significant sources of air pollution in many of the Indian cities. The National Clean Air Programme document has an action point on full enforcement of zig-zag brick technology in brick kilns. Subsequently it was decided by the authorities that the Brick Kilns in Delhi region, which have not converted to Zig -Zag technology will not operate from 30.06.2018. In Delhi's National Capital Region, total 4,247 Brick Kilns were operational in July 2017, of which 722 Brick Kilns converted to Zig -Zag technology.

Regarding the functioning of brick kilns, the Pollution Control Boards recommend measures such as the use of adequate height of stack, adoption of zig zag technology or vertical shaft, and use of coal/piped natural gas as fuel instead of charcoal and firewood. As per the Ministry of Environment, Forest, and Climate Change (MoEFCC) of Government of India notification dated 22nd Feb 2022, all new brick kilns shall be allowed only with zig-zag technology or vertical shaft or use of Piped Natural Gas (PNG) as fuel in brick making and shall comply with the standards as stipulated in the notification. The existing brick kilns which are not following zig-zag technology or vertical shaft or use Piped Natural Gas as fuel in brick making shall be converted to zig-zag technology or vertical shaft or use Piped Natural Gas as fuel in brick making within a period of (a) one year in case of kilns located within ten-kilometre radius of non-attainment cities as defined by Central Pollution Control Board (b) two years for other areas. Further, in cases where the Central Pollution Control Board/State Pollution Control Boards/Pollution Control Committees have separately laid down timelines for conversion, such orders shall prevail. All brick kilns shall use only approved fuel such as Piped Natural Gas, coal, firewood, and/or agricultural residues. Use of pet coke, tyres, plastic, and hazardous waste shall not be allowed in brick kilns. Also, the brick kilns are required to comply with emission limits, chimney heights, etc. as prescribed under the Environment (Protection) Rules, 1986.

Masonry construction using bricks is the main type of building construction technology used in India. Among various types of bricks, solid burnt clay bricks are the most widely used bricks. In recent years, several new walling construction technologies and materials have been introduced, but in the foreseeable future, bricks are expected to retain their dominant position. Given the large-anticipated growth in building construction, the annual demand for bricks in India is expected to peak at 750–1000 billion Standard Brick Units (SBUs) per year during 2032-37 from about 250 billion SBUs a year during 2012–174.

The main environmental issue associated with the brick kiln sector in greenhouse gas (including black carbon) emission and particulate emission. Top-soil utilisation by the sector is another important issue that needs to be addressed. It is estimated that to produce 200 billion bricks, 600 million tonnes of clay (topsoil), 35 million tonnes of coal, and 10 million labour days of the most migratory workforce is needed. The result: Bricks, but also 60 percent of total industrial emission of black carbon5.

The brick industry is one of the five largest industrial consumers of coal (along with steel and cement) in the country, a huge source of particulate matter emissions, and one of the largest industrial emitters of greenhouse pollutants, CO2, and black carbon. A range of technologies has been adopted to produce bricks in India6.

Following are the dominant ten methods that are used in most brick-producing countries in South Asia, including Bangladesh, India, and Nepal, listed in ascending order from the oldest to the newest technology7.

a. Clamp Kilns
b. Down Draught Kiln (DDK)
c. Mobile Chimney Kiln (MCK)
d. Fixed Chimney Kiln (FCK) also called Fixed Chimney Bull’s Trench Kiln (FCBTK)
e. Zigzag Kiln (ZZK)
f. Hoffman Kiln
g. Vertical Shaft Brick Kiln (VSBK)
h. Hybrid Hoffman Kiln (HHK)

Among these, FCBTK is the most preferred technology in India producing 74% of the country’s brick production. Shifting to modern technologies in the brick kiln sector (zig zag or vertical shaft technology or usage of PNG as per MoEFCC Notification dated 22 February 2022) will support the reduction of air pollution from these brick kilns, which in turn reduce urban air pollution, as the outdated technology used in the sector is contributing to air pollution.

In December 2019, GIZ and BEE prepared and published a report on “Market Transformation towards Energy Efficiency in Brick Sector”8. The study seeks to accelerate the shift in the brick manufacturing sector towards energy efficiency through voluntary adoption of improved production technologies and encouraging the production of porous/hollow clay products in India. In 2017, the Centre for Science and Environment (CSE) has published a “Design Manual on Zigzag Kilns”9 (ZZK) which covers the anatomy of ZZK, its design, details on apparatus used, and operational aspects. There are a few more studies on practices adopted in Brick Kilns in India and South Asian countries. Although these documents already contain a lot of relevant information on Brick Kilns and its prevalent technologies, there is a need to bring out a concise document that can help the brick kiln industry in India to comply with MoEFCC Notification dated 22nd February 2022.

The present Guidance Document on Environmental Technologies for Brick Kilns in India compile information on various technologies, cover Indian and global best practices and key learnings from them, and Recommendation of technically sound and financially viable solutions for adoption by the Indian brick kiln industry for establishing new brick kilns or for retrofitting and modernizing the existing ones to reduce air pollution in compliance with the MoEFCC Notification dated 22nd February 2022. The Viable solutions include feasibility study on the application of zigzag technology or vertical shaft in brick making, Usage of Piped Natural Gas (PNG) as fuel in brick making.

1.3 Scope of study

The study scope cover India as the target region but three cities (Nagpur, Pune, and Surat) as a priority from the viewpoint of stakeholder engagements.

- The Guidance Document covers:
- Indian and global best practices and key learnings from them, and
- Recommendation of technically sound and financially viable solutions for adoption by the Indian brick kiln industry for establishing new brick kilns or for retrofitting and modernizing the existing ones to reduce air pollution in compliance with the MoEFCC Notification dated 22nd February 2022.
- The solutions addressing (a) and (b) above would include
- Feasibility study on the application of zigzag technology or vertical shaft in brick making.
- Usage of Piped Natural Gas (PNG) as fuel in brick making.

1.4 Outline of the Report

Chapter 2 of this report provides the overview of the brick sector in India, the process of brick making and details of various technologies used for brick making in India and comparison of various technologies in terms energy, environmental performance and financial aspects various technologies used for brick making. Chapter 3 presents environmental regulations, policies associated with brick sector in India and technology solutions for meeting the standard, chapter 4 presents best practices and challenges in promoting cleaner brick making technologies in India, the chapter 5 concludes the report by summarising the key points and recommending the way forward.

CHAPTER 2 Overview of the Brick sector

2.1 Status of the brick sector in India

India is the second largest producer of bricks in the world producing around 250 billion bricks annually. Around 140,000 brick kilns are operating in India which contributes more than 10% to the total brick production of the world. Majority of the brick kilns are located in the rural and peri-urban areas. It is common to find large brick making clusters located around the towns and cities, closer to the large demand centres for bricks. Some of these clusters have up to several hundred kilns. Indian brick industry predominantly follows traditional practices which is non-mechanized. The surface soil excavated from the agriculture field or silt deposited from river and tanks are used as raw material and shaped as green bricks mostly by hand-moulding method. The green bricks are sun dried in open area and later burnt in the kiln using coal, biomass and/or other waste material such as tyre as fuel. The manual process of brick making is labour intensive. It is estimated that more than 10 million workers are employed with the Indian brick industry.

2.2 Brick making process

Bricks are produced by mixing ground clay with water, forming the clay into the desired shape, and drying and firing. The following flow chart depicts the major steps involved in brick making process.

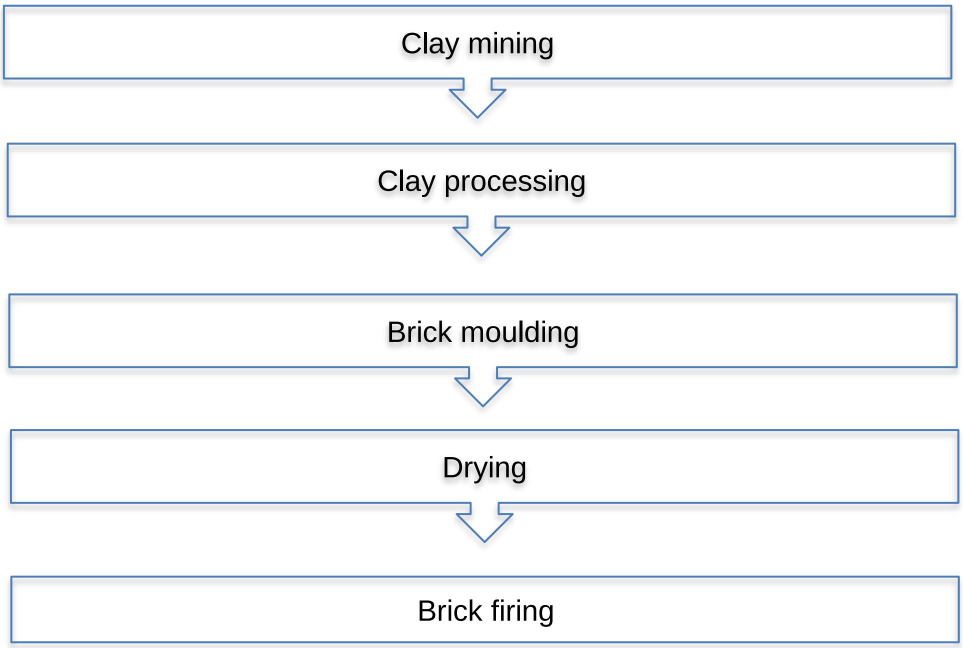

FIGURE 1 MAJOR STEPS OF BRICK MAKING PROCESS

2.2.1 Clay mining

Clay or soil is the raw material used for brick making. Typically, the clay is mined from the agriculture land or collected from silt deposits in river bank or tank and utilized. In the Gangetic plain, silt get deposited during the monsoon season, as the flood carries sediments and accumulate in the river basin. The silt is harvested during dry season and used for brick making. The soil, predominantly the silt from this region is "alluvial" in nature and considered to be good for brick making. Whereas, in the peninsular region, the soil is The Peninsular soils have varying colours and qualities and broadly, they are grouped under black cotton, red or lateritic soils. They are termed difficult for brick making. Owing to these differences in the nature and quantity of available soils, the brick industry in the Gangetic Plain is dominated by large scale brick kilns (CBTK and zigzag (where large-scale concentrated production is practiced), while the Peninsula is dominated by open clamps (where small-scale scattered production is practiced).

2.2.2 Clay processing

Clay processing involves removal of stones from the clay, breaking of big lumps into small size and mixing with water to get the right consistency for moulding. In some places, crop residues and or fine coal particles are mixed with the clay, this serves as internal fuel and reduce energy consumption during firing process. Generally, mixing is done manually with hands and feet. Sometimes and in certain areas, animal driven pug mills are used.

2.2.3 Moulding

Majority of the kilns use hand moulding process to make green bricks, in which a lump of mix is taken, rolled in sand and slapped into the mould either made of wooden frame or metal frame. Sand is used so the brick does not stick to the mould. Few kilns adopt mechanical process for making green bricks. In the mechanical process, the clay is extruded through a die to produce a column of clay and an automatic cutter then slices the clay column to create the individual brick. Moulding is also done mechanically using extruder or soft moulding machines. The use of mechanical moulding is economical when bricks in huge quantity are to be manufactured at the same spot in a short time.

2.2.4 Drying

Natural drying : The green bricks are generally dried by natural process (without use of external energy) that is by drying them under open sun or air drying by keeping them under the shed. Typically, the green bricks contains about 25 percent of moisture. The natural drying process reduces the moisture content to about 10 percent. The time required for drying depends on prevailing weather conditions. Usually it takes about 3 to 10 days for bricks to become dry.

Artificial drying : When bricks are to be rapidly dried on a large scale, the artificial drying may be adopted. In such a case, the moulded bricks are allowed to pass through special dryers which are in the form of tunnels or hot channels where the hot flue gas is passed through. In the tunnel dryers, the bricks are filled in one end and removed from other end. The temperature is usually less than 120°C and the process of drying of bricks takes about 1 to 3 days depending upon the temperature maintained in the dryer, quality of clay product etc.

2.2.5 Firing of bricks

This is a very important step in the manufacturing process of bricks. In the process of burning, the dried bricks are burned either in clamps (small scale) or kilns (large scale) up to certain degree temperature. In this stage, the bricks will gain hardness and strength so it is an important stage in the manufacturing of bricks. The temperature required for burning is about 800 to 1050^{o}C based quality and type of mud used. If bricks are over-burnt, they will be brittle and hence break easily. If they are under-burnt, they will be soft and hence cannot carry loads. Hence burning should be done properly to meet the requirements of good brick.

The overall firing process can be categorized in three steps – heating, soaking and cooling. As shown below.

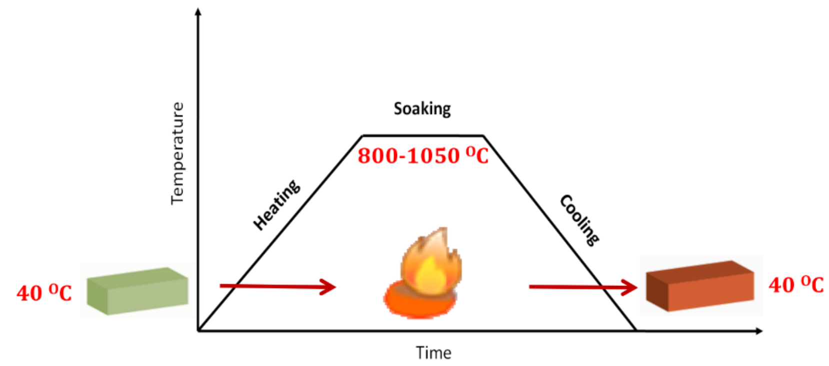

FIGURE 2 FIRING PROCESS

When the temperature of about 1050°C is reached, the particles of two important constituents of brick clay, namely, alumina and sand, bind themselves together resulting in the increase of strength and density of bricks. The burning of bricks is done either in clamps or in kilns. The various types of technologies used for firing bricks are described in the following section.

FIGURE 4 SOIL MINING

FIGURE 3 MIXING

FIGURE 5 HAND MOULDING

FIGURE 6 MACHINE MOULDING

FIGURE 7 DRYING

FIGURE 8 FIRING

2.3 Brick manufacturing technologies in India

Based on the firing practice, brick kilns can be grouped under two broad categories namely intermittent kilns and continuous kilns. In intermittent kilns, bricks are fired in batches.

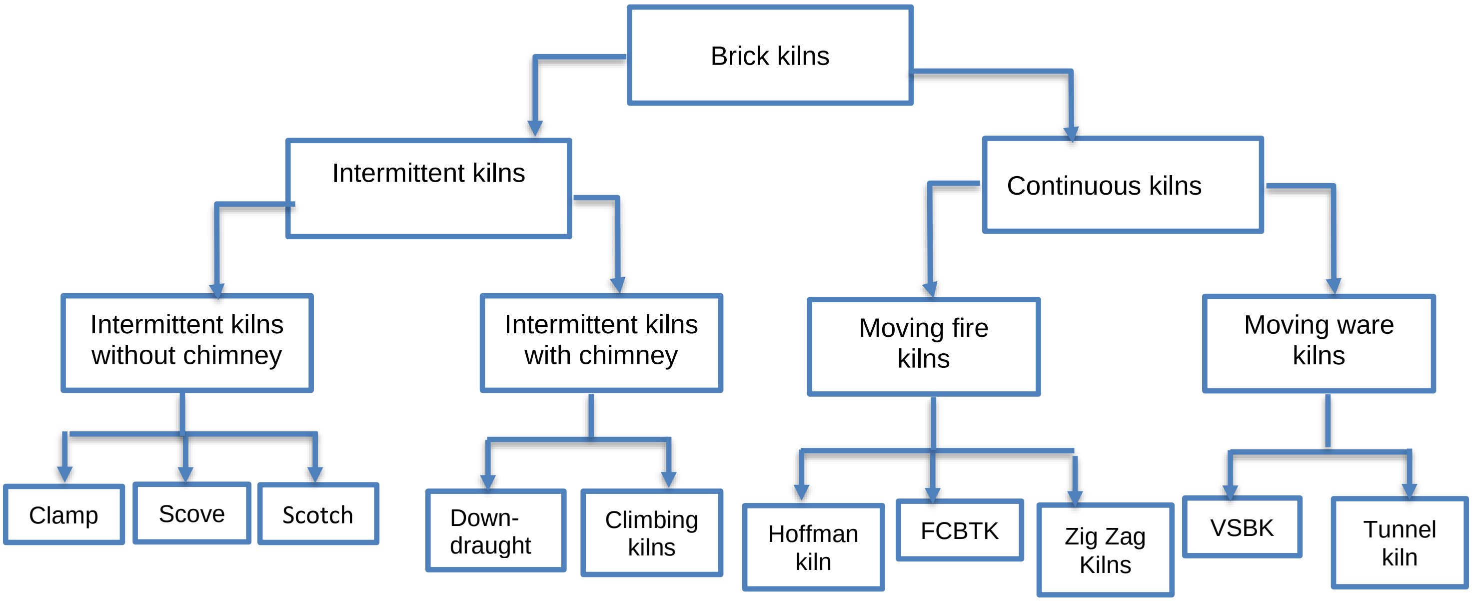

FIGURE 9 CLASSIFICATION OF BRICK KLINS

Examples of intermittent kilns include Clamp, Scove, Scotch, and Down-draught kilns (DDK). In a continuous kiln, on the other hand, the fire is always burning and bricks are being warmed, fired, and cooled simultaneously in different parts of the kiln. Examples of such kilns include Bull's trench kiln (BTK), Hoffmann, zig zag kilns, Tunnel kiln, and vertical shaft brick kiln (VSBK). The majority of the kilns in India are traditional intermittent and continuously manually operated kilns such as BTK.

Brick production and technologies for brick making varies regionally depending on the soil availability, soil quality and demand for building materials. As shown in the figure 10 Stratigraphically, India is divided into 4 broad regions – northern mountainous region, Gangetic plain, peninsula (triangular plateau region) and Malabar region.

FIGURE 10 BRICK PRDUCTION IN DIFFERENT REGIONS OF INDIA

Source: Zi, Brick and tile industry international, accessed on 10th Dec 2022. (Zi, 2010)

The brick production in the northern mountainous region is very low and is limited to valleys e.g. Srinagar, Jammu and Dehradun.

The Gangetic plains of north India account for about 65% of total brick production. Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal are the major brick producing states in this region. Brick kilns, generally of medium and large production capacities (2–10 million bricks per year), are located in clusters around major towns and cities. The availability of fertile alluvium soils in the Gangetic plains has caused the fringe areas of cities in this region to be dotted with brick kilns and consequently is a significant force in bringing about land use/ land cover changes around cities. Peninsular region account for the about 32% of brick production. In this region, bricks are produced in numerous small units (production capacities generally range from 0.1 to 3 million bricks per year). Gujarat, Orissa, Madhya Pradesh, Maharashtra, Karnataka, Kerala and Tamil Nadu are important brick producing states in the peninsular plateau and coastal India.The Malabar region covers Kundapura, Mangalore, Calicut,Trissur coastal belt, mainly producing roof tiles and bricks using machinery for moulding and firing through Hoffman kilns.

TABLE 1 TYPE OF BRICK FIRING TECHNOLOGY IN INDIA

Kiln Type	Regional spread	Approximate contribution to brick production
Fixed chimney BTK	Indo-Gangetic plains (North and East India) and several clusters in Southand West India	50%
Zigzag	Indo-Gangetic plains (Bihar, West Bengal, Punjab, Haryana, National Capital Region, etc)	15 %
Clamps	Penisular region (Central, West, and Southern India	25-30%
Hoffman Kiln	Malabar region (Karnataka & Kerala)	< 4%
VSBK	Penisular region (Central and East India)	< 1%

2.4 Description of Brick kiln Technology

A few of the prominent technologies in India is presented here.

2.4.1 Fixed Chimney Bull's Trench Kiln (FCBTK)

TABLE 2 KEY SPECIFICATIONS OF FCBTK

Type	Continuous, moving fire
Production capacity (bricks / day)	20000 to 50000
Operational season	Dry season
Capital cost	50000 – 80000 USD (excluding land and working capital)
Type of products that can be fired	Solid bricks, tiles, Hollow or perforated bricks
Specific energy consumption (MJ/Kg)	Average 1.3 ; Range 1.1 – 1.46
Environmental emission (measured levels of particulate matter in mg/NM3)	570 (average); 150 – 1250 (range)

Fixed Chimney Bull's Trench Kiln (FCBTK) is a continuous, moving fire kiln, in which the fire moves through the bricks, which are stacked in the annular space formed between the outer and the inner wall of the kiln. Green bricks are loaded in front of the firing zone, and cooled fired bricks are removed from behind. The kiln is generally of oval or circular shape. The FCBTKs are built above the ground, by constructing permanent sidewalls. Unlike the original form of BTK, which employed a moving chimney, FCBTK has a fixed chimney at the center of the kiln.
A layer of ash and brick dust is spread over the top to seal the kiln and provide thermal insulation. The bricks are stacked in a column and blade brick arrangement. The brick-unloading end is kept open for air entry into the kiln. The brick-loading end is sealed with metal, cloth, paper, or plastic damper. Figure 11 below shows a sketch of an FCBTK.

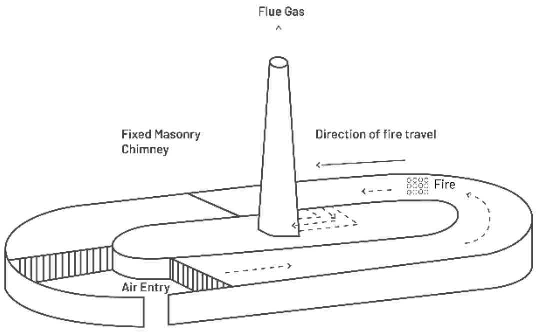

FIGURE 11 GENERAL SKETCH OF FIXED CHIMNEY BTK

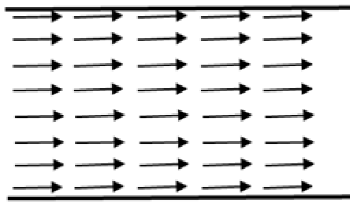

FIGURE 12 AIR FLOW IN FCBTK

Working principles of FCBTK

The kiln can be divided into three zones; brick cooling zone, combustion zone and pre heating zone. In the cooling zone, air entering from the unloading end picks up heat from fired bricks, resulting in the heating of air and cooling of fired bricks. The next zone is the fuel feeding zone or combustion zone, in which the fuel is fed from the feed holes provided on the roof of the kiln. Generally, 2-3 rows of bricks are fed at a time. Some of the coal fed into the kiln accumulates on the ledges (provided at 4-5 levels) and the rest of the coal falls to the kiln floor. Coal comes in contact with hot gases and combustion takes place in this zone. The last zone is the brick-preheating zone; in this zone, heat available in the flue gases is utilized for preheating green bricks.

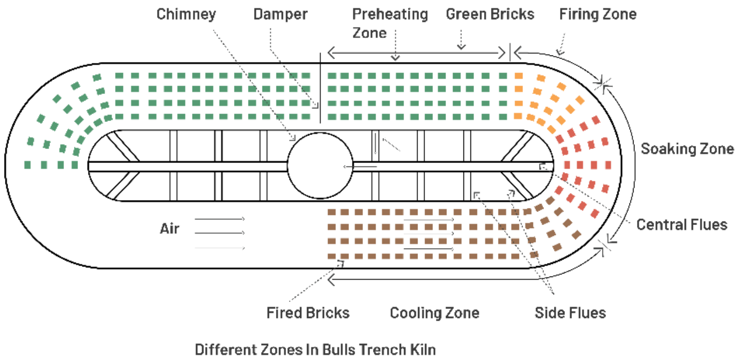

FIGURE 13 DIFFERENT ZONES IN BULLS TRENCH KLIN

In FCBTK, fire movement takes place in the direction of air travel. When the firing of a row is over, it is closed, and the next line is opened. The fire typically travels at a rate of 6-10 m/day. Once in 24 hours, the damper is shifted forward by the same distance (bringing in a new batch of green bricks in the kiln circuit), the next flue duct in the direction of fire travel is opened, and the previous one is closed. Once lit at the beginning of the brick-making season, the kiln generally remains lit throughout the season which is usually about 4-6 months.

The kiln performance and pollutant emission depend on properties of the fuel, availability of air for combustion and fuel feeding rate. In FCBTK, the coal is generally fed intermittently in 2-3 rows for a period of about 20 to 30 minutes for every hour; and due to heavy charging of coal, thick black smoke can be observed coming out during and just after the coal feeding operation. Larger the size of coal or lumps will results in higher emission and wastage.

The amount of air flow through a kiln controls both the combustion as well as heat distribution in the kiln. In general, when the air flow is high, the fire travels fast. The air flow in the kiln is achieved with the help of chimney. The hot gases inside the chimney are lighter that the ambient air outside the kiln. The difference in weight between the hot air column inside the chimney and outside air produces a pressure difference which is known as draught. This pressure difference results in air movement in the kiln. The setting in the kiln provides resistance to air flow and therefore the quantity of air flowing through a kiln depends both on the draught produced as well as resistance provided by brick setting, flue ducts and chimney. Cold air leakage is also an important parameter affecting air flow in kilns. The cold air can enter through cracks and fissures in the kiln structure. The cold air reduces the temperature of flue gas and lessen the draught created in the chimney. This results in high fuel consumption and poor performance of the kiln.

An FCBTK not only suffers from high energy consumption and emissions but also produces a low percentage of class-I bricks. Typical FCBTK operating in the Indo Gangetic plain produces about 60% class I bricks (perfectly fired), 25% is class II (a little under-fired), and 15% is class III (under-fired). Non-uniform temperature across the cross-section of FCBTK results in differences in the product quality. At places where there is a large price differentiation among the brick categories, the low percentage of class-I bricks from FCBTK results in significant revenue loss to the brick-kiln owners.

2.4.2 Zigzag kilns

TABLE 3 KEY SPECIFICATIONS OF ZIGZAG KILN

Type	Continuous, moving fire
Production capacity (bricks / day)	20000 - 50000
Operational season	Dry season
Capital cost (USD)	50000 - 80000
Type of products that can be fired	Solid bricks, Hollow bricks, Roof tiles
Specific energy consumption (MJ/Kg)	1.06 (average); 1.02 – 1.21 (Range)
Environmental emission (measured levels of particulate matter in mg/NM3)	144 (average); 31 – 263 (range)

The Zigzag kiln is an improved version of the FCBTK. The main innovation is in the arrangement of bricks. In a Zigzag kiln, the bricks are arranged in such a way that the air is forced to follow a zigzag path. The main differences between an FCBTK and a Zigzag kiln are listed below.

- In a Zigzag kiln, the air moves in a zigzag path whereas in an FCBTK, the movement of air is in a straight path.

- The length of the zigzag air path is about three times longer than the straight-line air path; the increased air velocities in the kiln, the turbulence created due to the zigzag air movement, and the longer air path result in improved heat transfer between air/flue gases and bricks.
- In a Zigzag kiln, powdered coal is fed in small quantities and the fuel feeding zone is six times longer than that of FCBTK. The longer fuel feeding zone, the smaller size of coal particles, and the turbulence created by the zigzag air movement all help to better mix the coal volatiles with air, thereby resulting in better combustion of fuel.
- An FCBTK is oval or circular in shape, while a Zigzag kiln is rectangular in shape.

The zigzag kiln was introduced in India by the Central Building Research Institute during the early 1970s in the form of a high-draught kiln. Several hundred zigzag kilns are operational, mostly in the eastern region of the country. The high draught also known as forced draught kilns use a fan to create a draft (and hence are called forced draught zigzag kilns). The requirement of a reliable electricity supply 24/7 for the continuous operation of a forced draught zigzag kiln is an important barrier to wide-scale adoption. In recent times, some brick manufacturers have modified the brick setting and practices and have successfully operated the kiln with natural draught.

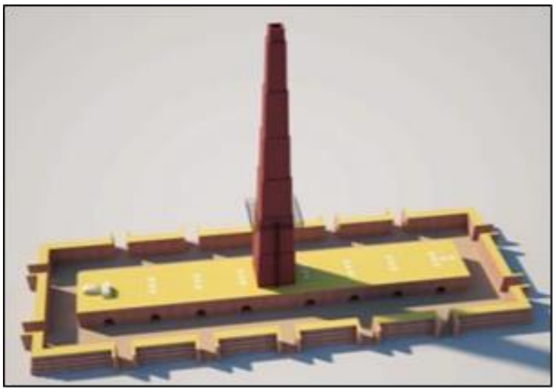

FIGURE 14 AIR FLOW IN ZIGZAG KLIN

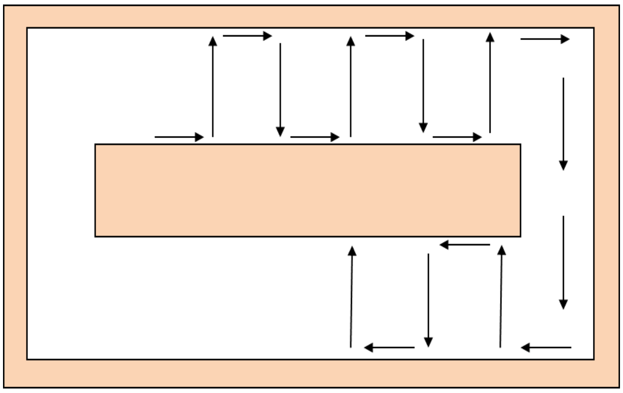

FIGURE 15 SCHEMATIC OF NATURAL DRAUGHT ZIGZAG KILN

In a Zigzag kiln, green bricks to be fired are placed in the annular space and covered with a layer of partially fired or green bricks. Similar to an FCBTK, a layer of ash and brick dust is spread over the top to seal the kiln and provide thermal insulation. The brick-unloading end is kept open for air entry into the kiln. The brick-loading end is sealed with the help of a metal, cloth, paper, or plastic damper. Fuel is fed manually and intermittently in the feed holes provided on the top of the kiln.

TABLE 4 COMPARISION BETWEEN NATURAL AND FORCED ZIGZAG KLINS

Comparison between natural draught zigzag and forced draught zigzag kilns

Natural draught zigzag	*Forced draught zigzag*
• Draught is created naturally with the help of a chimney.	• Draught is created artificially with the help of a fan.
• Operates under negative pressure of 8 – 10 mm water column.	• Operates under negative pressure of around 50 mm water column.
• The brick setting is less dense to reduce pressure drop to operate with natural draught.	• The brick setting is very dense. •
• The height of the Chimney is around 120 – 130 ft.	• The height of the chimney is around 55 – 60 ft.
• No electricity/diesel is required for the operation of the kiln.	• Electricity /Diesel are required for the operation of the kiln.

Similar to FCBTK, three distinct zones can be identified in a zigzag kiln. Proceeding from the unloading end, the first zone is the brick cooling zone. In this zone, air entering from the unloading end picks up heat from fired bricks, resulting in the heating of air and the cooling of fired bricks. The next zone is the fuel feeding zone (combustion zone), in which coal is fed from the feed holes provided on the roof of the kiln. Coal comes in contact with hot gases, and combustion takes place in this zone. The last zone is the brick-preheating zone; in this zone heat available in the flue gases is used to preheat green bricks.

The fuel feeding zone in zigzag kiln is larger than in FCBTK. Usually, solid fuels such as coal, firewood, and agriculture residue are used in Zigzag kilns. Fuel is fed continuously in smaller quantities, the smaller size of coal particles, and the turbulence created by the zigzag air movement all help to better in better combustion of fuel.

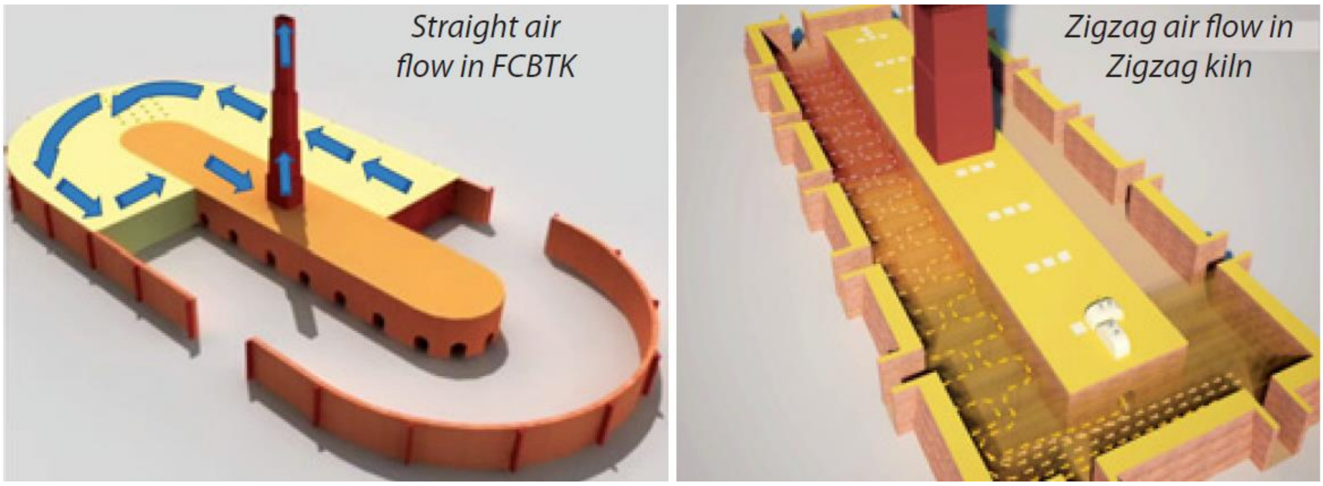

FIGURE 16 AIR FLOW IN FCBTK AND ZIGZAG KLIN

Source: Greentech knowledge solutions, 2013 (Maithel, 2013)

2.4.3 Vertical Shaft Brick Kiln (VSBK)

TABLE 5 KEY SPECIFICATIONS OF VSBK

Type	Continuous, moving ware
Production capacity (bricks / day)	8000 to 12000
Operational season	Perennial
Capital cost	60000 – 80000 USD (excluding land and working capital)
Type of products that can be fired	Solid bricks, Hollow or perforated bricks
Specific energy consumption (MJ/Kg)	0.8 (average) ; 0.54 – 1.1 (range)
Environmental emission (measured levels of **particulate matter in mg/NM3)**	144 (average); 31 – 263 (range)

The evolution and initial development of the Vertical Shaft Brick Kiln (VSBK) technology took place in rural China. The first version of VSBK in China originated from the traditional updraft intermittent kiln during the 1960s. In the following decade, the kiln became popular in several provinces. In 1985, the Chinese Government commissioned the Energy Research Institute of the Henan Academy of Sciences in Zhengzhou, Henan, to study the kiln and improve its energy efficiency. The institute came up with an improved design of VSBK in 1988. The improved design had a higher shaft height and also a provision for a pair of chimneys. Around 1996, several thousand VSBKs were reported to be operating in China. Since then the technology has been transferred (under various development projects) to several countries, including India, Nepal, Afghanistan, Vietnam, Pakistan, Sudan, and South Africa. Among these countries the technology has gained widespread popularity in Vietnam only; in other countries, the dissemination of the VSBK technology is still limited to a small number of enterprises.

VSBK has a vertical shaft of rectangular or square cross-section. The shaft is located inside a rectangular brick structure where the gap between the shaft wall and outer kiln wall is filled with insulating materials – clay, fly ash, and rice husk. Some of the kilns in countries like Vietnam have also used modern insulating materials like glass wool. The kiln works as a counter-current heat exchanger as shown in Figure 19, with heat exchange taking place between the air moving up (continuous flow) and bricks moving down (intermittent movement). Green bricks are loaded from the top in batches; the bricks move down the shaft through brick pre-heating, firing, and cooling zones and are unloaded at the bottom. The combustion of powdered coal (put along with bricks at the top), takes place in the middle of the shaft. Air for combustion enters the shaft at the bottom and gets preheated by the hot fired bricks in the lower portion of the shaft before reaching the combustion zone. Hot flue gases preheat the green bricks in the upper portion of the shaft before exiting from the kiln through the shaft or the chimney.

The brick setting in the kiln is supported on bars at the bottom of the shaft. Brick unloading is carried out from the bottom of the shaft using a trolley. For unloading, the trolley is lifted (using a screw mechanism or chain pulley blocks) until the rectangular beams placed on the trolley touch the bottom of the brick setting, and the weight of the bricks is transferred onto the trolley. The support bars, now freed of the weight of bricks, are removed. The trolley is then lowered by one batch (four layers of bricks). Support bars are again put in place through the holes provided in the brick setting for the purpose. With a slight downward movement, the weight of the brick setting is again transferred back to the support bars. The trolley (with one batch of fired bricks on it) is further lowered till it touches the ground and is pulled out of the kiln on a pair of rails. In traditional operations, every 2-3 hours one batch is unloaded at the bottom and a batch of fresh green bricks is loaded at the top. At any given time, there are typically 8 to 12 batches operating in the kiln.
Two chimneys located diagonally opposite each other are provided for the removal of flue gases. Sometimes, a lid is also provided on the top opening of the shaft. The lid is kept closed during normal operation and hence flue gases do not pollute the working area on the top of the kiln.

FIGURE 17 PICTURE OF VSBK WITH THREE SHAFTS

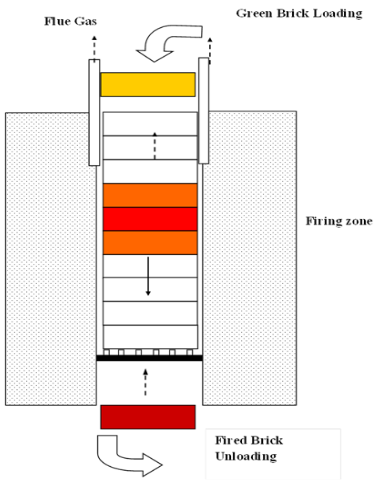

FIGURE 18 SCHEMATIC OF VSBK WITH ONE SHAFT

2.4.4 Hybrid Hoffmann Kiln (HHK)

TABLE 6 KEY SPECIFICATIONS OF HHK

Type	Continuous, moving fire
Production capacity (bricks / year)	15 – 18 million bricks/year
Operational season	Perennial
Capital cost	600 000 – 650 000 USD (excluding land and working capital)
Type of products that can be fired	Solid bricks, Hollow or perforated bricks
Specific energy consumption (MJ/Kg)	1.2 (average) ;
Environmental emission (measured levels of particulate matter in mg/NM3)	20.3 (average); 15.8 – 26.9 (range)

The Hybrid Hoffmann Kiln (HHF) is a modified form of Hoffmann kiln patented by German Friedrich Hoffmann for brick making in 1858, it was later used for lime-burning and was known as the Hoffmann continuous kiln. Hybrid Hoffman Kiln (HHK) is popular in China. In construction, a hybrid Hoffman kiln has a lot of similarities with a Homan kiln. The hybrid Hofman kiln consists of a rectangular shaped annular circuit with arched roof. Hybrid Homan kiln does not have a tall chimney. Hot flue gases from the central flue duct of the kiln are first diverted to the drying tunnels through duct and then are released in the atmosphere through a rectangular opening. Three distinct zones appear in an operating HHK: brick firing zone where the fuel is fed and combustion is happening, brick preheating zone (in front of the firing zone) where green bricks are stacked and being pre heated by the hot flue gases and brick cooling zone (behind the firing zone) where fired bricks are cooled by the cold air flowing into the kiln. Heat contained in the hot flue gases from the kiln is utilized in the drying tunnels. The temperature in the drying tunnel is maintained at around 120°C and the drying time is around 24 hours. The fire moves through the bricks stacked in the annular space. The fire movement is caused by a blower which forces the air required for combustion from behind.

The Hybrid Hoffman kilns are efficient and less polluting when compare to BTKs, clamps and downdraught kiln. Internal fuel (mixing coal or fuel with clay to produce green bricks) is extensively used in bricks produced in Hybrid Hoffmann kiln.

Use of internal fuel and waste heat utilisation lead to lower energy consumption and reduction of air pollution. In South Asia, the HHK technology was first introduced in Bangladesh in 2006 under an UNDP-GEF supported project and since then it is being promoted with support from various development projects.

FIGURE 19 PICTURE OF HYBRID HOFFMANN KILN (HHK)

2.4.5 Down-Draught Kiln (DDK)

TABLE 7 KEY SPECIFICATIONS OF DOWN DRAUGHT KILN

Type	Continuous, moving fire
Production capacity (bricks / year)	15 – 18 million bricks/year
Operational season	Perennial
Capital cost	600 000 – 650 000 USD (excluding land and working capital)
Type of products that can be fired	Solid bricks, Hollow or perforated bricks
Specific energy consumption (MJ/Kg)	1.2 (average) ;
Environmental emission (measured levels of particulate matter in mg/NM3)	20.3 (average); 15.8 – 26.9 (range)

The down-draught kiln (DDK) is intermittent. In an intermittent kiln, one batch of bricks is fired at any given point in time. The kiln is first filled with green bricks. It is then fired and the batch is heated up to the maximum temperature and left to cool before being drawn out from the kiln. In the process of heating, the kiln structure also gets heated up and while cooling, the stored heat in the structure is lost into the atmosphere. In an intermittent kiln, the heat recovery from the hot exhaust gases is only partial, resulting in high exhaust gas losses. Intermittent kilns, though suitable for small-scale production, are not fuel efficient.

In a DDK, fuel is burnt in external fuel boxes, provided on the outer periphery of the kiln. The hot gases from burning fuel rise to the roof of the kiln. Gases after being deflected from the roof flow down through the brick setting and in the process warm and fire the bricks. The bricks rest either upon an open-work support of previously fired bricks or upon a perforated floor, through which the flue gases flow down into an underground channel that is connected to the chimney and is exhausted out of the kiln. The warm gases rising through the height of the chimney provide sufficient draught to pull the hot gases down continually through the stack of green bricks.

The DDK is located mostly in the southern region of India. These kilns are generally constructed with red bricks, with an inner layer of refractory bricks. The thickness of the wall is about 5 feet. The total cycle time required from loading green bricks to cooling fired bricks is about 7 days. The production capacity of typical down-draught kilns ranges from 20,000 to 40,000 bricks per batch operation. There are about 12 fireboxes in a down-draught kiln, with 6 fireboxes located on each side.

FIGURE 20 DOWN-DRAUGHT KLIN

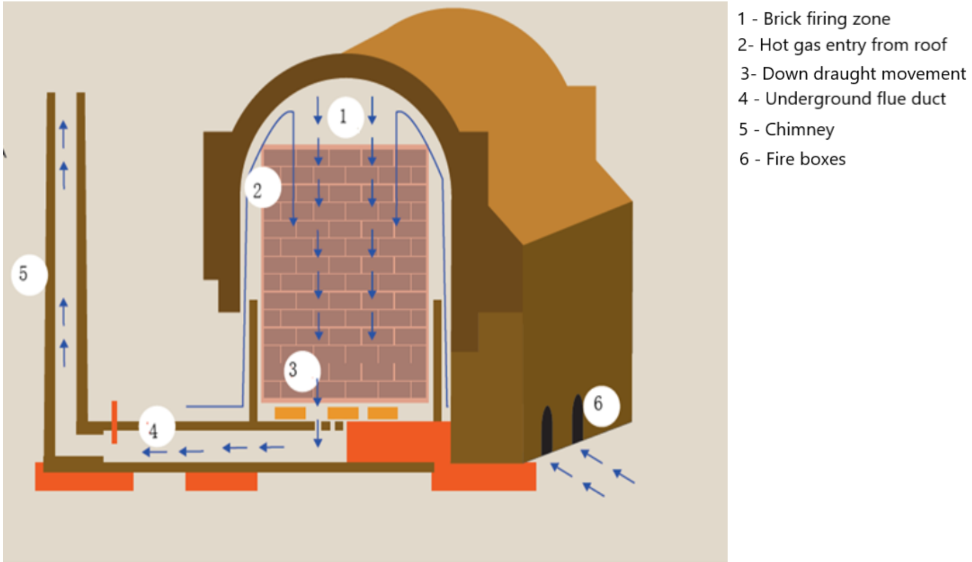

FIGURE 21 CROSS SECTION OF DDK

A typical operation sequence of a DDK is as follows:

- Stacking of dry bricks in the kiln with no gap provided between bricks and the wall of the kiln.
- The kiln doors are closed with bricks and sealed.
- Firing is initiated by feeding fuel (non-coal like eucalyptus branches/twigs and leaves) in the kiln's firebox.
- The fuel feeding rate is increased, and fuel feeding is continued till the bricks have attained the firing temperature – around 500-600°C. The fire men judge the temperature by observing the color of the fire from peek-holes provided in the kiln.
- Upon reaching this temperature, the fireboxes are shut off.
- The kiln is left to cool for 2-3 days before it is opened for unloading the fired bricks.

2.4.6 Tunnel kiln (TK)

TABLE 8 KEY SPECIFICATIONS OF TUNNEL KLIN

Type	Continuous, moving ware
Production capacity (bricks / day)	60000 to 200 000 bricks/day
Operational season	Perennial
Capital cost	~ 1000 000 USD (excluding land and working capital)
Type of products that can be fired	Solid bricks, Hollow or perforated bricks, Roof tiles, floor tiles
Specific energy consumption (MJ/Kg)	1.4 (average) ; 1.34 - 1.47 (range)
Environmental emission (measured levels of particulate matter in mg/NM3)	41 (average); 21 – 53 (range)

In a tunnel kiln, which is a horizontal moving ware kiln, bricks to be fired are passed on cars through a long horizontal tunnel. The firing zone remains stationary near the center of the tunnel, while the bricks and air move in counter-current paths. Cold air is drawn from the car exit end of the kiln, cooling the fired bricks. The combustion gases travel towards the car entrance, transferring part of their heat to the incoming green bricks. The cars can be pushed either continuously or intermittently at fixed time intervals. The tunnel kilns have provisions for air extraction and supply at several points along the length of the kiln.

Tunnel kilns are the preferred technology for firing bricks in developed countries. The advantages of tunnel kiln technology lie in its ability to fire a variety of products, good control over the firing process, and ease of mechanization, thus reducing the labour requirement and large production volume. Typically the capacity of a single tunnel kiln ranges from 60,000 to 200,000 bricks per day. While fewer tunnel kilns are operating in South Asia for brick firing, the technology has become very popular in Vietnam, where a large number of tunnel kilns are in operation. Figure 23 shows a schematic of a typical tunnel kiln.

FIGURE 22 TUNNEL KLIN

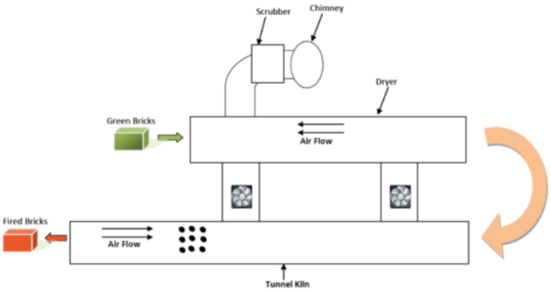

FIGURE 23 SCHEMATIC OF A TUNNEL KILN

2.4.7 Clamp kiln

TABLE 9 KEY SPECIFICATIONS OF CLAMP KILN

Type	Intermittent
Production capacity (bricks / batch)	10 000 to 200000 bricks/batch
Operational season	Dry season
Capital cost	No major capital cost as there is no permanent structure
Type of products that can be fired	Solid bricks
Specific energy consumption (MJ/Kg)	2.0 – 4.0 MJ/kg
Environmental emission (measured levels of particulate matter in mg/NM3)	Not available

A clamp kiln is one of the most basic types of kiln since no permanent structure is built. It consists of layers of green brinks generally piled up on a thin bed of fuel. In cases where the spreading of fuel in a thin bed is not possible, tunnels are made through the base of the pile to feed the fuel. Modern clamp kilns have versions where outer walls are plastered with mud or in certain cases fire tunnels and outer walls are permanently built with bricks.

Clamp kilns being one of the ancient technologies has been phased out in large parts of the developed world but continue to be in operation in developing countries. In India, about 100,000 clamps are in operation, which constitutes about 70% of total number of brick kilns. Majority of them are in the peninsular region. The production capacity is small; clamps contributes to 25 - 30 percent of total production in the country.

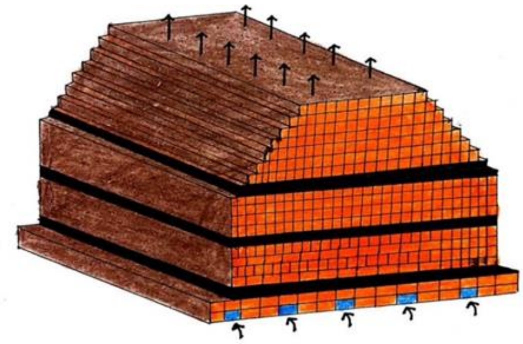

FIGURE 24 SCHEMATIC DIAGRAM OF CLAMP KLIN

FIGURE 25 CLAMP KLIN

In Clamp, the green bricks are organized in layers, and bricks interspersed with combustible material. The base of the clamp is first laid with fired bricks. Generally, in case of coal fired bricks, a thin layer of fuel is spread over the base on which the green bricks are stacked. In case of firewood fired clamps, tunnels are made through the base of the pile to feed firewood. In a rice husk fired clamp, bricks are stacked in parallel columns and the fuel is fed from the top and burned in the gaps between the brick columns. The clamps are ignited at the bottom. Air required for combustion, enters through the openings provided in the base of clamp. During burning, the hot air rises up through the bricks and heats the bricks. Smoke and fumes leave from the top of the clamp. In a clamp, the operator has very little control over the burning rate. The burning rate is affected by the weather particularly by the direction and speed of the wind.

Since they don't have any chimneys, the environmental performance is not monitored but because of the fuel (coal and biomass) and inefficient combustion with no heat recovery feature, these kilns are largely inefficient compared with other technologies on specific energy combustion terms.

Advantages of clamp kilns

- Flexibility of size (production capacity) and fuel: according to the requirement the green bricks can be arranged in clamps and burnt with any solid organic fuel such as coal, wood, crop residues
- The burning of bricks by clamp proves to be cheap and economical.
- Skilled labour and supervision are not required for the construction and operation of clamps.

Disadvantage of clamp kilns

- The quality of bricks is not uniform. The bricks near the bottom are over burnt and those near sides and top are under burnt
- Inefficient and very slow process.
- It is not possible to regulate fire in a clamp once it starts burning and the bricks are liable to uneven burning.
- The clamp is liable to damage/affected from high wind or rain.
- Contribute to air pollution and fugitive emission

2.5 Comparison of various brick kiln technologies

The technologies of brick kiln products have evolved over the years with a significant emphasis on promoting cleaner technologies for brick production. A comparison of five different technologies based on their environmental performance, energy efficiency parameters, quality of brick produced, and economic aspect is presented in Table 10. The tunnel kiln ranks better in terms of environmental parameters and quality of bricks produced, however, the return on investment is low and requires electricity for operation, which may be a constraint in many parts of India as continuous electricity supply is not available. Zigzag firing ranks better than FCBTK with better performance in terms of environmental and efficiency parameters and better return on investment. Among the small kilns, VSBK performs better than DDK in terms of environmental and efficiency parameters, but fast firing may not be suitable for certain clay types.

TABLE 10 COMPARISON OF VARIOUS BRICK MAKING TECHNOLOGIES

Kiln type	Particulate matter EF (g/kg of fired brick)	CO EF (g/kg of fired brick)	Specific energy consumption (MJ/kg of fired brick)	Return on investment (years)
Clamp			2.1	NA
DDK	1.56	5.01	1.2	1.2
FCBTK	0.89	3.63	1.3	0.4 -1.1
Natural draught Zigzag	0.22	0.35	1.06	0.3 – 0.9
Forced draught Zigzag	0.24	2.04	1.03	0.4 – 1.1
Tunnel Kiln	0.24	3.31	1.4	2
VSBK	0.09	4.14	0.8	1.8

CHAPTER 3 Environment Policies and Regulations

3.1 Emission standards for various brick technologies

The notification on emission standards for brick kilns was last revised by MoEFCC in February 2022. The emission standards provide the allowable particulate matter in stack (mg/Nm^3) and 'stack height '.

TABLE 11 EMISSION STANDARDS AS PER NOTIFICATION FEBRUARY 2022

Parameter	Standard
Particulate matter in stack emission	250 mg/Nm^3
Minimum stack height (Vertical Shaft Brick Kilns) a) **Kiln capacity less than 30,000 bricks per day** b) **Kiln capacity equal or more than 30,000 bricks per day**	a) 14 m (at least 7.5m from loading platform) b) 16 m (at least 8.5m from loading platform)
Minimum stack height (Other than Vertical Shaft Brick Kilns) a) **Kiln capacity less than 30,000 bricks per day** b) **Kiln capacity equal or more than 30,000 bricks per day**	a) 24 m b) 27 m

The Emission Standards further states that:

- All new brick kilns shall be allowed only with zigzag technology or vertical shaft or use of Piped Natural Gas as fuel in brick making and shall comply to these standards as stipulated in this notification.

- The existing brick kilns which are not following zig-zag technology or vertical shaft or use Piped Natural Gas as fuel in brick making shall be converted to zig-zag technology or vertical shaft or use Piped Natural Gas as fuel in brick making within a period of (a) one year in case of kilns located within ten kilometre radius of non-attainment cities as defined by Central Pollution Control Board (b) two years for other areas. Further, in cases where Central Pollution Control Board/State Pollution Control Boards/Pollution Control Committees has separately laid down timelines for conversion, such orders shall prevail.

- All brick kilns shall use only approved fuel such as Piped Natural Gas, coal, fire wood and/or agricultural residues. Use of pet coke, tyres, plastic, hazardous waste shall not be allowed in brick kilns.

- Brick kilns shall construct permanent facility (port hole and platform) as per the norms or design laid down by the Central Pollution Control Board for monitoring of emissions.

- Particulate Matter (PM) results shall be normalized at 4% CO2as below:PM (normalized) = (PM (measured)x 4%)/ (% of CO2measured in stack), no normalization in case CO2measured ≥ 4%. Stack height (in metre) shall also be calculated by formula H=14Q0.3(where Q is SO2emission rate in kg/hr), and the maximum of two shall apply.

- Brick kilns should be established at a minimum distance of 0.8 kilometre from habitation and fruit orchards. State Pollution Control Boards/Pollution Control Committees may make siting criteria stringent considering proximity to habitation, population density, water bodies, sensitive receptors, etc.

- Brick kilns should be established at a minimum distance of one kilometre from an existing brick kiln to avoid clustering of kilns in an area.

- Brick kilns shall follow process emission/fugitive dust emission control guidelines as prescribed by concerned State Pollution Control Boards/Pollution Control Committees.

- The ash generated in the brick kilns shall be fully utilized in-house in brick making.

- All necessary approvals from the concerned authorities including mining department of the concerned State or Union Territory shall be obtained for extracting the soil to be used for brick making in the brick kiln.

- The brick kiln owners shall ensure that the road utilized for transporting raw materials or bricks are paved roads.

- Vehicles shall be covered during transportation of raw material/bricks.

3.2 Key advantages of Zigzag technology

The MOEFCC notification stipulating zigzag technology for brick making will pave way to reduce air pollution from brick kilns. In addition to the emission reduction, it is a win-win opportunity to promote energy efficiency, greenhouse gas reduction. In addition, it will improve the profit of kiln owners and working conditions of workers, and production of better quality building material. Following are the key advantages of Zigzag fi ring technology over FCBTK.

3.2.1 Emission reduction

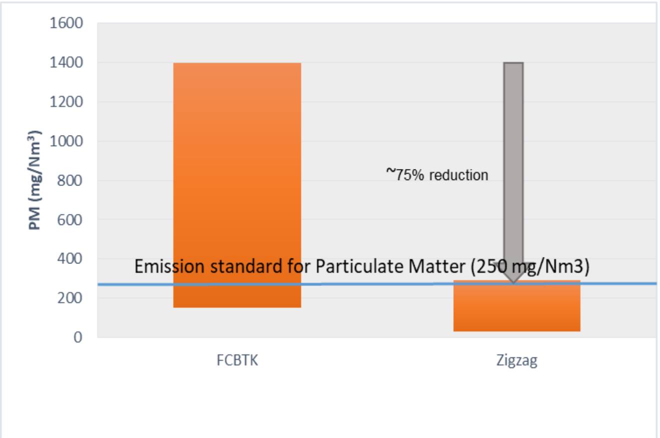

FIGURE 26 EMISSION LEVELS OF FCBTK AND ZIGZAG

The reported concentration of Particulate Matter (PM) in stack gas of Zigzag kilns ranged from 30 to 263 mg/Nm3, which is about 75% less than reported PM levels in the range of 150 to 1250 mg/NM^3

from FCBTK (Figure 26 emission levels of fcbtk and zigzag(Figure 26). Apart from SPM emissions, a Zigzag kiln emits 20% less CO_2 emissions and 75% less BC emissions as compared to those of an FCBTK.

3.2.2 Lower energy consumption and savings on energy cost

One of the main advantages of a Zigzag kiln is its lower specific energy consumption (SEC) as compared to that of FCBTK. The Zigzag kilns have SECs in the range of 0.95–1.20 MJ/kg fi red brick. On an average, in comparison to conventional FCBTK, Zigzag kilns require about 20% less energy.

FIGURE 27 COMPARISION OF SEC

3.2.3 Higher percentage of class-I bricks

A significant advantage of using a Zigzag kiln is the production of a higher percentage (80%–90%) of class-I bricks as compared to that of FCBTK (50%–60%) (Figure 27). An increase in the proportion of higher quality product results in an increase in the revenue for the brick-kiln owner and acts as a major incentive.

3.3 Retrofitting of FCBTKs into Zigzag kilns

Most of the FCBTKs can be retrofitted into natural or high-draught Zigzag kiln. The cost of retrofitting varies from INR.15 lakh to INR. 35 lakh (INR. 1.5 million to INR. 3.5 million) depends upon the condition of the existing kiln and the extent of retrofitting required. Retrofitting involves:

- Partial reconstruction of the chimney and reconstruction of the flue-ducts and the outer wall of the kiln (Figure 28) and
- Change from column-blade brick setting in FCBTK to chamber-wise brick setting for Zigzag(Figure 29)
- Changing the firing practice – increasing the feeding zone from 3-6 ft in FCBTK to ~36 ft in Zigzag kilns; also the fuel is fed continuously in smaller quantities in zigzag kilns(Figure 30)

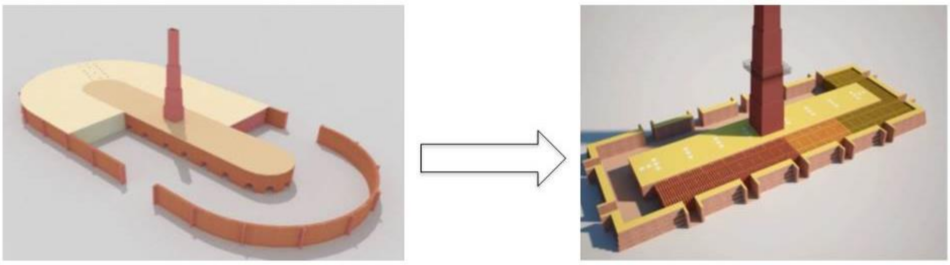

FIGURE 28 RECONSTRUCTION OF THE KILN FOR SWITCHING FROM FCBTK TO ZIGZAG KILN

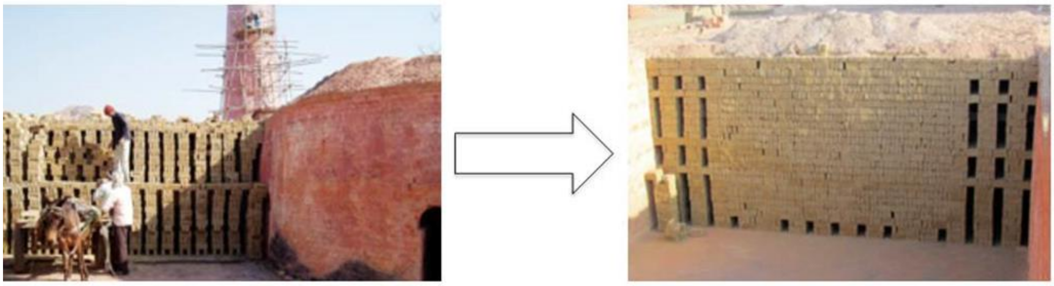

FIGURE 29 CHANGE IN BRICK SETTING- COLUMN BLADE TYPE SETTING IN FCBTK TO CHAMBER TYPE BRICK SETTING IN ZIGZAG KILN

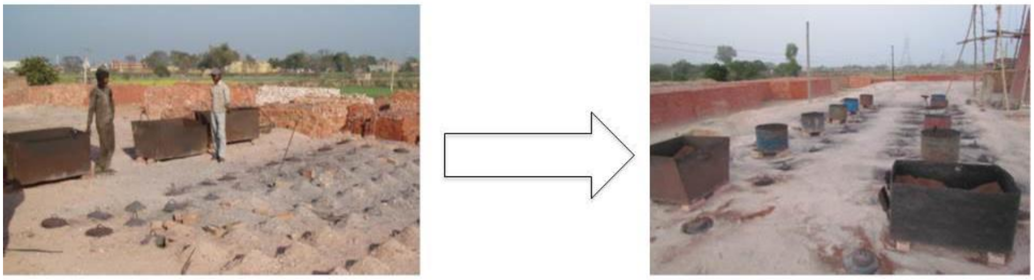

FIGURE 30 CHANGE IN FIRING PRACTICE

3.4 Techno economics of retrofitting FCBTK into Zigzag kiln

Shifting from FCBTK to zigzag technology is an attractive option in terms of efficiency improvement and emission reduction. Approximate cost of retrofitting an FCBTK into a zigzag kiln ranges from Rs. 17.5–38.5 lakh (and depends on the size and condition of the kiln).[1] The typical payback is about a year from the savings in fuel and gains from improved product quality. The techno economics of retrofitting FCBTK into Zigzag technology published by Centre for Science and Environment (CSE) in 2017 is reproduced here for reference.

[1] Nivit Kumar Yadav and Rahul Kumar 2017, *Zigzag Kilns: A Design Manual*, Centre for Science and Environment, New Delhi

TABLE 12 COMPARISON OF RETROFITTING

	Initial FCBTK	Retrofitted Zigzag
Annual production	40 lakh	40 lakh
Coal consumption per lakh bricks	16 tonne	12 tonne
Class I bricks produced (%)	55 – 60	80 - 90
Breakup of the cost		
,	Induced Zigzag	Natural Zigzag
Labour cost Material (other than brick)	Rs. 5.5 – 7.5 lakhs	Rs. 5.5 – 7.5 lakhs
Material (other than brick)	Rs.1-1.5 lakhs	Rs 1-1.5 lakhs
Equipment	Rs 2 – 2.5 lakh	Rs 2-2.5 lakhs
Fan (with engine)	Rs 3 – 4 lakh	Not applicable
Chimney	Same can be used	Rs 8- 10 lakh
Bricks @ Rs 3/brick	Rs 6–9 lakh (for additional 2–3 lakh bricks)	Rs 9–12 lakh for additional 3–4 lakh bricks)
Total estimated cost	Rs 17.5–24.5 lakh	Rs 25.5–38.5 lakh
Annual expenditure on operation and maintenance of fan	2.5 lakh	
Retrofitting Benefits		
Annual coal savings 160 tonne @ Rs 10,000 per tonne	Rs 16 lakh	Rs 16 lakh
Increase in revenue due to higher number good quality bricks (considering 8 lakh additional Class-I bricks annually) @ Rs 1 per brick	Rs 8 lakh	Rs 8 lakh
Total annual savings	Rs 21.5 lakh (Rs 16 +8 – 2.5)	Rs 24 lakh

The previous table shows that the cost incurred for retrofitting FSBK into zigzag technology can be recovered in one or maximum two brick seasons.

CHAPTER 4 Best practices and lessons learned in promoting cleaner technologies for brick making

Air pollution from brick kilns received a lot of attention from various stakeholders, Government and other organizations such as the German Development Cooperation (GIZ), Bureau of Energy Efficiency (BEE), Swiss development cooperation (SDC), United Nations Development Programme (UNDP) Shakti sustainable energy foundation, Greentech Knowledge Solutions, Punjab state council for science and Technology, Development Alternative and The Energy and Resources Institute have been facilitating the adoption of cleaner and more resource efficient brick production in India. This section discusses best practices and lessons learned from their experience in promoting cleaner technologies for brickmaking in India.

4.1 Case studies

Case study 1. Learnings from Bihar state's experience on replacement of FCBTKs with Zigzag Kilns -[2]

Background

Bihar is one of the largest burnt clay brick producing states in the country having about 6000 brick kiln enterprises, the majority of them before 2018 were of Bulls Trench Kilns. An emission inventory study for Patna conducted in 2014 reported that brick kilns contribute to roughly 20% of PM 2.5 concentration. Recognizing the need to control air pollution from brick kilns, the Bihar State Pollution Control Board (BSPCB) issued a directive in 2016 to all brick kiln enterprises located in five blocks of Patna district to shift to cleaner brick kiln technologies within a year. The directive mandated 190 kilns, located in five blocks of Patna, which falls under the purview of the directive to shift from FCBTK to natural or induced draft Zig Zag technology. The Patna directive was the first such directive on replacing FCBTKs in the country. Since then, similar directives have been issued elsewhere, for example, in the NCR and the 2022 directive from the MoEF for other parts of the country.

Intervention

BSPCB adopted a multi-pronged and phased approach for implementation, going beyond its role as a regulator. The approach consist of the following.

- *Pre directive awareness generation and sensitization*
  Though the directive was issued in February 2016, efforts towards sensitizing and building awareness amongst brick kiln owners had already begun by 2012. Several workshops and seminars were organized to promote awareness and sensitise the kiln owners.

- *Policy directive for technology upgradation and strict enforcement*
  Prior to the directive (2015- 2016), voluntary adoption was promoted, however only 11 kilns out of 190 shifted to zigzag technology during this period. The policy directive, direct communication and strict enforcement helped in better adoption of the technology

[2] Learnings from Bihar's Experience of Implementing Cleaner Brick Kiln Directive: A Case Study, GKSPL, 2018

- *Clear and continuous government communication during the implementation phase*
  During the implementation phase (post February 2016), BSPCB and the Department of Environment and Forest (DoEF) maintained continuous communication with brick makers through workshops, seminars, newspapers, and other channels to highlight the benefits and clarify questions from the kiln owners.

- *Technical support to brick makers on technology upgradation during the implementation phase*
  A comprehensive technical support programme consisting of awareness generation seminars, technical training programmes, and expert advice was put in place to facilitate the implementation of the directive.

Results

The strategy helped in motivating and mobilizing the kilns owners to adopt zigzag technology. 103 out of 190 (54%) converted to Zig Zag technology within the stipulated period of one year. After the upgradation and operation of one year, a survey was conducted among 66 kilns which were randomly selected. Summary of the survey results are as follows.

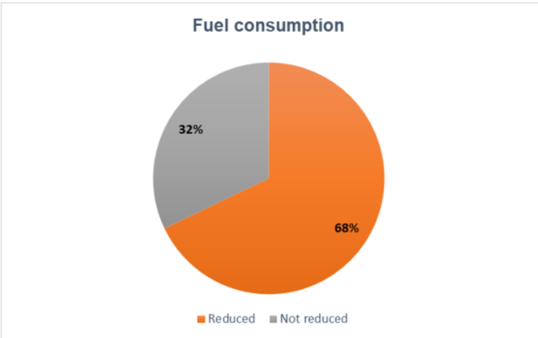

FIGURE 32 SURVEY RESULTS : FULE CONSUMPTION

FIGURE 31 SURVEY RESULTS : PRODUCT QUALITY

FIGURE 33 SURVEY RESULTS : OVERALL SATISFACTION

- Sixty-eight percent (68%) of the surveyed kilns reported a reduction in fuel consumption after adopting zigzag kilns.
- Seventy-two percent (72%) of the surveyed kilns reported an improvement in the percentage of Class I bricks after adopting zigzag kilns. The remaining 28% either reported no improvements or a few cases reported a decrease in the percentage of Class I bricks.
- Fifty-seven percent (57%) of the surveyed kilns expressed satisfaction with the adoption of

zigzag kilns. 29% felt that though the technology is good, but due to various reasons they have not been able to operate kilns satisfactorily. 14% were not satisfied with the technology change.

Overall, the Bihar state experience in upgradation of technology was positive. Following factors contributed to the positive outcome.

Key learnings

.

- *Need for capacity development and skill enhancement*- Since the level of mechanization is minimum in zigzag tech still depends on highly skilled masonry to produce top quality products. Also, to construct new zigzag kilns there is a requirement for skilled masons which again continues to be a shortfall due to lack of training.

- *Semi mechanization of the Process* - The net savings on fuel and overall efficiency largely depends on the type of fuel and the fuel feed practices considering the fuel feeding zones in zigzag technology is more than the FCBTK. Manual feeding is a challenge due to exposure of firemen to high temperatures and hence semi-mechanised fuel feeding systems are recommended.

FIGURE 34 FUEL FEEDING AT ZIG ZAG KILN

FIGURE 35 LOCALLY MANUFACTURED TRICKLE FUEL FEEDING SYSTEM USED IN MADHYA PRADESH

FIGURE 36 PNEUMATIC FUEL-FEEDING SYSTEM OF A EUROPEAN COMPANY 'BERALMAR'

Monitoring & inspection – The success of zigzag kiln adoption has largely been due to the increased support in the technology adoption and monitoring and inspection especially through periodic inspection of operations. In large cases, hand-holding support is required for the initial couple of brick making seasons. Even for enforcement of compliance there is a need for stringent monitoring and inspection.

Case study 2: Learnings from Vertical Shaft Brick Kiln promotion in India

Background

VSBK in India was launched in 1995 by Swiss Agency for Development and Cooperation (SDC) as a project on introducing sustainable production systems for construction materials, including kilns for burnt bricks. Under the technical action research program, SDC worked with various partners such as Development Alternative (DA), The Energy and Resources Institute (TERI), Gram Vikas, Damle clay structural, Commonwealth Trust and two Swiss consulting organizations namely Skat and Soren SA and provided technical guidance and support to promote the energy efficient VSBK technology in India. Chinese and Danish experts shared their international experience in the transfer of VSBK technology. Under this program, five VSBKs were constructed in different agro-climatic zones considering the variation in soil, climatic condition and market.

Intervention

A holistic approach including technolgy demonstration and improvement, Institutional strengthening and socio economic aspects were adopted for promotion of VSBK technology in India. First pilot plant was constructed at Datia (Madhya Pradesh) in 1996, followed by construction of three pilot plants in peninsular India by 1999. Improvements in energy and environment performance of VSBKs were reported. Key stakeholder engagement such as Central pollution Control Board, brick industry and NGOs helped in promotion of VSBK technology. By 2005, about 120 VSBKs were constructed.

Result

Experience during the initial period was positive and encouraging. Technical viability and energy efficiency and fuel savings were demonstrated in these pilot kilns. The technical guidance and knowledge dissemination helped in achieving the commercial scale dissemination of the VSBK technology in the country. Within the span of three years (2000 – 2003), more than 30 VSBKs were established in a commercial mode. The unique selling proposition of the VSBK during this phase was energy efficiency and saving in fuel reduction. Minimum of 30 to 40 percent efficiency improvement was achieved in comparison with best operating kilns during that period. Significant reduction (more than 5 times) in air pollution was observed in VSBKs. The Central Pollution Control Board (CPCB) monitored various VSBKs and acknowledged the VSBK technology is one of the cleaner brick production technologies. The VSBK technology has been specifically adopted to suit a scale of production between 15 to 35 lakhs of bricks annually.

Learnings

The VSBK technology has some limitations, which resulted in poor adoption /scale up. Some of them, who adopted the technology early, also discontinued the operation or shifted back to other technology. As of now, only very few kilns are in operation, in spite of the directive from the Government to adopt cleaner technology for brickmaking.

FIGURE 37 VSBK UNIT

FIGURE 38 INSIDE A VSBK UNIT

The major concern reported was on the quality of the bricks. Rejections due to over-burned or under-fired bricks, crack, and breakage was also high in VSBK products. The unsatisfactory quality can be attributed to a combination of factors:

- The technology is operationally very sensitive and requires higher management skill
- The technology is also susceptible to the quality of clay. Firing temperature and operational practice need to be customized for soil which requires high firing temperature (above 950 degree)
- The fast heating and cooling of bricks in the kiln can cause cracks in the bricks.
- Due to the nature of the process, the high static and dynamic load on the lower part of the brick stacking results in damage to the bricks.
- Some damage is also caused by the excessive handling of bricks during lifting-up to the kiln top and loading process.
- Due to the lower density and lower compressive strength of hand-moulded bricks, the problems in brick quality are more pronounced when hand-moulded bricks are fired in VSBK
- VSBK has a limitation in terms of the variety of clay products that can be fired in its present configuration; it is well-suited for firing solid bricks. It can be used to fire bricks with perforations but is not suitable for firing hollow bricks or thinner products like roofing

Case study 3: Natural Gas for brick making

Wienerberger, the world's largest clay building material solution provider, started its production in India in 2009. The company manufactures high-quality clay building materials such as hollow bricks, tiles, and facades from its state-of-the-art production facility in Kunigal, Karnataka. Their manufacturing facility uses tunnel kilns for firing bricks and other clay products. The facility is highly automated, engaging robots for material handling and mechanized dryers. In 2020, the company switched its production facility in Kunigal from coal-based to natural gas. The key benefits of the natural gas firing technology for its Brick Klin firing (Gas firing) are:

- Higher fuel efficiency, reducing Carbon Monoxide emission by > 75%
- Reduction in Carbon dioxide emissions by > 40%
- Consistent and higher quality of the fired bricks

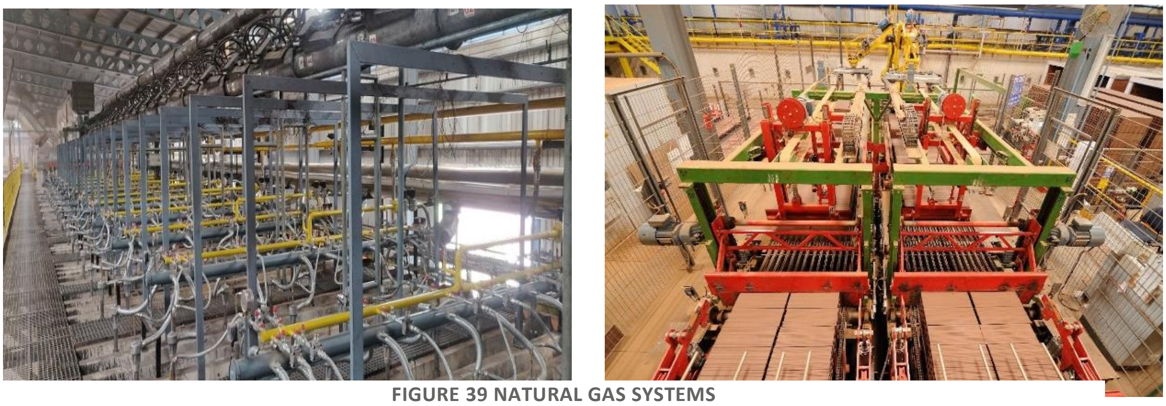

FIGURE 39 NATURAL GAS SYSTEMS

The technology is expected to reduce the particulate emission significantly, with almost no particulate emission from the firing process is change in technology will almost eliminate the particulate matters emitted from the kiln during the firing process. The facility can match world-class norms in emission and would be substantially better than the emission norms laid out as per the Indian environmental standards. The technology was provided by Beralmar Technologic S.A., a European company (Spain), that specialized in manufacturing of firing and drying equipment for clay roof tiles and bricks.[3]

Case study 4. Learnings from Bengaluru's experience on Hybrid Hoffman kiln for brick making[4].

Background

Bengaluru is one of the brick clusters in the southern India, there are approximately 150 (Hundred and fifty) brick kilns in operation in Bengaluru cluster. The kilns are majorly located in clusters in the areas such as Kolar, Malur, Devanahalli, Hoskote, Anekal, Chandapura, White field, Chikka Tirupathi regions of Bengaluru district. Presently the brick market is highly competitive due to imbalance in demand and supply, late onset of spring weather and scattered rainfall are the two major factors responsible for this. This made brick kilns of Bengaluru cluster to operate entire year. Brick industries in the Bengaluru cluster use clay as raw material which is from nearby land and de-silting tanks. Down draught kiln (DDK) is the predominant technology used for brick making in the Bengaluru cluster. The typical production capacity is in the range of 1 to 4 million bricks per season. In recent years, Hybrid Hoffman technology (HHK), the modified version of Hoffmann technology got introduced in the Bengaluru cluster. Fuel saving and improvement in working environment are reported. Also the brick making is done throughout the entire year (all the 12 months).

Intervention

Fortes brick industry in Kolar district of Bengaluru cluster adapted HHK. Forte's Hybrid Hoffman Kiln (HHK) produce about 3 to 3.5 million bricks a year, consuming around 350 tonnes of coal and 300

[3] https://www.wienerberger.in/Press/News0.html

4[4] Energy and Resources mapping study done by Enzen for Bangalore cluster for Bureau of Energy Efficiency, Karnataka: A Case Study, Enzen , 2021 tonnes of wood per annum. HHK installed is a continuous, cross-draught, annular, moving fire kiln operated under an induced draught, which is provided by a fan of 60 hp installed. In this moving fire kiln the fire moves through the bricks, which are stacked in the annular space formed between the outer and the inner wall of the kiln. Green bricks are loaded in front of the firing zone, and cooled fired bricks are removed from behind. The kiln consists of series of chambers that are connected through underground radial flues to the chimney. In the arch of this barrel arched chamber, small feed -holes are provided that are used for firing of fuel (wood and coal) into the brick setting. In the outer wall of the chamber, wickets placed alternate with flues, for setting of green bricks and drawing out the fired bricks. After the kiln is lit, it is not allowed to go out and the sequence of operation is continued. The HHK installed is shown as below:

FIGURE 40 HHK AT FORTE BRICKS

FIGURE 41 TUNNEL DRYING AT FORTE BRICK

FIGURE 42 SHED DRYING AT FORTE BRICK

Key features of the Kiln

	Hybrid Hoffman at Fortes Bricks
Location	Village: Ayyapalli, Bettamangala, KGF, Kolar district, Karnataka
Description of company	➢ The owner is a second-generation brick maker ➢ Family business for last 25 years using Down draft kilns. Installed new technology of Hybrid Hoffman kiln form China, in 2019. ➢ Currently the company operates this HHK with 10,000 bricks per day and slowly it would be increased to the maximum capacity of 30,000.

Annual Production	➢ 3.0 – 3.5 million bricks/ year
Supplying Market	➢ In Kolar and Bangalore
Operational period	➢ Throughout the year
Kiln Description	➢ New technology of Hybrid Hoffman kiln ➢ Has a Tunnel dryer which uses the flue gases from the Hoffman Kiln ➢ Shunts are used to connect the flue gas duct of the kiln with the central duct which connect the tunnel dryer ➢ Induced draught fan is used to pull the flue gases form the HHK to the Tunnel Kiln.
Moulding	➢ Machine moulding o Solid Bricks o Accounts for 100% of production
Drying	➢ Shed drying o All the machine moulded bricks are dried in sheds o This would be followed by drying in the Tunnel dryer
Firing Fuel	➢ Only external fuel used and no internal fuel ➢ Primary fuel: Coal and wood • Indonesian Coal and wood • Contributes100% of total thermal energy input ➢ Other fuels: Wood
Draft system	➢ Induced draught system

Results

The reported specific energy consumption (SEC) of HHK of Forte brick industry is in the range of 1.1 – 1.3 MJ/kg of fired bricks, which is significantly lower than the DDK. Improvement in working condition was observed and the kiln owner is satisfied with the performance of the HHK and the quality of bricks produced from HHK.

Key learnings

HHK seem to be a promising option for efficient cleaner and efficient brick production. Key factors contributing to the better performance are

Waste heat recovery and utilization for drying: Freshly moulded green bricks (the unbaked bricks are referred to as green bricks) contain about 25% w/w moisture. The bricks are dried in shed drying and also using tunnel dryer. The combined action of the shed drying and tunnel dryer removes the moisture in the bricks. The moisture content in green bricks at the end of drying is range is less than 1% after the tunnel dryer. This consistently reduced the fuel requirement in the main kiln.

Mechanization in moulding- Machine moulding is followed in Fortes bricks. The automatic moulding machine is used to mould bricks. The mould boxes which are open at top and bottom and is made of steel. The moulded bricks using the automatic brick moulding machine is wire cut and stored in automatic trolleys which are moved to the tunnel dryer inlet.

FIGURE 43 MACHINE MOULDING OF CLAY AT FORTES BRICKS

Experience reported from Forte brick industry reveals that the hybrid Hoffman technology is very efficient compared to all other technology and can another positive feature is the kiln can be operated throughout the year and contribute to profit maximization.

Case study 5: Use of paddy straw pellets as fuel by the brick kilns in the state of Punjab

Background:
The Punjab State Council for Science & Technology (PSCST) has been working on techno-economically viable solutions to manage paddy straw and as the MoEFCC has also revised the emission standards for brick kilns to 250mg/Nm^3 from the earlier permissible limit of 750mg/Nm^3 in Feb 2022 which has led to evaluate the feasibility of using paddy straw as fuel in brick kilns. Loose biomass has been used in brick kilns for long time, but the emission and fuel consumption varied depending on the type of biomass, its calorific value and the operational practices in the kiln. Optimal use of biomass along with coal in Zig Zag kilns help in reducing coal consumption and emission reduction.

Intervention

As part of the evaluation led by PSCST a feasibility study was conducted where coal was partially replaced in induced draft brick kilns by paddy straw pellets. Typically, fuel is fed in the zig zag brick kilns in six chambers with temperature varying between 500-1025°C. The lower temperature zones are fed with mixture of sawdust and coal and it is in these chambers that paddy straw pellets are fed resulting in about 20-25% replacement of fuel in the process.
However, ensuring supply of paddy straw pellets to brick kilns has to be ensured. The first demonstration was carried out at M/s Gill Brothers, Village Jalalabad (East), District Moga. This unit is producing 5000 tonnes of briquettes per annum using 4000 tonnes of paddy straw from 6-7 villages in the vicinity. The briquettes are being used as replacement of coal in three brick kilns[5].

Results:
Overall, the study has indicated that replacing coal with paddy straw pellets is viable. The results also indicated a reduced emissions including of Sulphur Dioxide (SO2) in cases where the replacement was conducted. In summary, the use of paddy straw pellets has resulted in four pronged gains; reducing dependency on coal as fuel for brick kilns, better use of paddy straw pellets, meeting MoEFCC's new regulation for brick kilns and overall reduction of emissions. Based on these results,

[5] https://pscst.punjab.gov.in/en/paving-way-for-techno-economically-viable-solution-to-manage-paddy-straw

the Punjab State government has now mandated that all brick kilns in the state should use a minimum of 20% paddy straw pellets as fuel by 1st of May 2023[6]. The government notification is attached in Annexure 2.

4.2 Barriers in promoting Cleaner technologies for brick making in India

During the interactions with the brick industry associations, they highlighted few barriers which are hindering the adoption of clean brick making technology to transform the sector. The main barriers which need to be addressed are described below:

4.2.1 Technology Barriers

There are a variety of technical barriers impacting the transformation of Indian brick industry. For example, the use of extruders to produce resource efficient bricks require good quality lab testing facilities to test the clay and suggest the technical feasibility, similarly test lab facilities are required before taking a decision on adopting an advanced dryer or kiln technology. Such lab facilities are generally limited in India.

Another example is regarding the access to technologies such as Hybrid Hoffmann Kiln, Tunnel Kiln, Tunnel and Chamber dryers, extruders, etc. Most of the suppliers of these technologies are from Europe or China, which makes both the cost and access to these technologies difficult. There is a large variation in the clay, climatic and market conditions across the country and as these technologies have yet not been tested under different conditions, the perceived technology failure risk is very high among the brick kiln owners.

4.2.2 *Capacity & Knowledge Barriers*

The exiting brick enterprises mostly belong to small-scale unorganised sector. Most of the brick kiln owners and supervisors come from rural background and with limited formal education. Their exposure and knowledge about cleaner brick making technologies is low. There is no existing system for skill and vocational training for brick industry workers. Thus, the human resource capacity of the existing brick industry to absorb advanced technology is very limited. A programme to build the managerial and technical capacities including skill development programme for workers is essential for bringing a transformation in the brick industry.

4.2.3 *Policy & Regulatory Barriers*

One of the key barriers in the adoption of cleaner and resource-efficient technologies and attracting new investment in the clay brick sector are the policy risks associated with lack of clarity and uncertainty regarding environment policies and regulation. For example, while around 2500 brick kilns located in the National Capital region (NCR region) have adopted zigzag technology as per CPCB instructions to reduce air pollution, by investing Rs 20-50 lakh/kiln, their working season has been restricted due to an NGT order, thus severely impacting the viability of these enterprises. This is having a negative impact on adoption of zigzag kiln technology in the neighbouring states. The latest amendment in the fly ash regulation puts uncertainty over the use of clay bricks for building

---

[6] Directions u/s of the EPA, 1986 for usage of Paddy Straw Pellets as fuel by the Brick Kilns in the state of Punjab, 4 Nov 2022

construction in 300 km radius of coal/lignite based thermal power plants, which practically covers the entire country. This is even though the various studies have shown that even if all the remaining available fly ash is utilised for brick making, it will only meet a fraction of the demand for bricks. Large investments in technology upgradation would not materialise till the enterprises get assurance on their future operations. There is a need to have a holistic review of environment policies impacting the brick sector and bring synergies to promote resource efficient brick production in the country.

4.2.4 *Financial Barriers*

The current brick industry enterprises mostly belong to small-scale unorganised sector. A discussion with brick kiln owners shows that the adoption of zigzag kiln by more than 15,000 enterprises in the country. The conversion involved an investment of Rs. 20-50 lakh per kiln and this money was mostly raised through personal finance. The penetration of institutional finance (e.g. bank credit) to brick industry is very low. Also, as a large fraction of the brick enterprises belong to the unorganised sector, they do not have necessary financial documents and are not able to offer adequate collateral security (most of the kilns are located on leased lands and do not have much of fixed machinery) to avail credit from banks. It is shown that most of the measures required for bringing a transformation in the brick sector require investments ranging from Rs 2 to 50 crore. This level of investment requires access to finance from formal financial institutions. A better understanding of the financial needs of the brick industry and designing appropriate financial products is needed to improve access to finance to the sector.

CHAPTER 5 Recommendations and way forward

I. Moving from FCBTK into zig zag kiln will result in 15-20% energy savings; improvement in percentage of class I bricks; reduction in air pollution. The payback is attractive, the cost can be recovered within 2 brick season. However, it should be noted the performance of zig zag kiln depend on kiln construction, fuel used and more importantly operational practice. Poor operation may lead to high emission. Monitoring and validation of kiln performance in the field is required to ensure the performance of zig zag kiln in the field.

II. Adoption of Tunnel kin for brick manufacturing needs high investment (to the tune of crore rupees and more), the benefits can be reaped by producing value added products such as hollow and perforated bricks, tiles etc. Other benefits include increased production due to year-round operation; improvement in percentage of class I bricks and reduction in air pollution. Financial incentives can help in addressing the investment barrier.

III. Shift from solid to gaseous fuels yield more Class I bricks and reduce emission; yet financial viability is still to be proven for large scale adoption. Gas network and infrastructure need to be strengthened and use of natural gas for zig zag or VSBK are yet to be demonstrated. Considering these constraint, large scale adoption of gas for brick making is not a practical solution in near term.

IV. VSBK technology promotion requires further improvement in the technology to make it suitable for the soil which requires slow firing and firing temperature above 950 degree. Also process mechanisation in moulding and transfer of the green brick kilns will reduce the wastage.

5.1 International Experience of Brick Sector Transformation

5.1.1 Europe

The European brick and tile industry consists of around 1300 kilns owned by 700 companies, from SMEs to large international groups, which employ around 50,000 people across Europe and generate a production value of around €5.5 billion (Around INR 44,000 crore). Over the last decades, the sector has invested heavily in product and process innovations that have revolutionised the manufacturing process and delivered modern building solutions. This technological progress has profoundly modified the functioning of brick and roof tile plants. Today kilns are fully automated and heat recovery systems optimise the overall energy efficiency of the plant. Furthermore, modern process technology ensures that the environmental impact is minimal. There is a long history of technology modernization and transformation of European brick industry:

- Bricks were made by hand until about 1885, before the brickmaking machinery was introduced. With the introduction of the machinery the number of clays that could be made into brick was greatly increased which influenced the production capacity.
- Another major transformation took place after Second World War, when due to high demand and introduction of new labour laws, the focus was on mechanising the industry, during this time tunnel kiln technology was widely adopted, and the consolidation of the industry started taking place.
- Since 1960s, a shift from coal and liquid fuels to gaseous fuels started taking place and by 1990, natural gas became the dominant fuel, accounting for almost 80% of the total energy used in the European brick industry. In recent years along with natural gas, use of renewable biomass as fuel has also increased (Figure 15)
- Introduction of building energy conservation codes and emphasis on energy efficiency in

buildings which got introduced in 1970’s and 1980’s resulted in introduction of new hollow clay blocks which also had profound impact on the manufacturing process.

FIGURE 44 EXAMPLES OF HOLLOW CLAY BLOCKS MADE IN EUROPE

5.1.2 China

In China, the work of introducing new technology in the brick industry started in 1960’s. Xi’an Research and Design Institute of Wall and Roof Materials was set up in 1965. Extrusion and tunnel kiln technologies were introduced during 1970’s and public sector enterprises for producing bricks were set up.

During 1980’s Chinese brick industry expanded rapidly. In 1994, brick production in China stood at close to 800 billion bricks/year. The bricks were produced in more than 84,000 small brickworks in rural areas throughout the country and about 1,200 large and medium-sized ones in the vicinity of cities and towns . Already most of the bricks were being produced through extrusion process. In terms of brick kiln technology, the Hoffmann Kiln was the most popular kiln, while a few of the large enterprises were also using Tunnel kiln technology. In the rural areas, intermittent "horse-foot" kiln and Vertical Shaft Brick Kiln (VSBK) were being used. The typical production capacity of the brick manufacturing units ranged from 5 to 65 lakhs bricks/year. Since then, the brick industry has undergone a transformation.

In 2018, the total production of bricks in China was estimated to be 980 billion bricks/ year. This consisted of:

- Fired Clay brick - 830 billion bricks, produced in around 3800 brick manufacturing units
- AAC blocks – 130 billion blocks, produced in around 3000 AAC block plants
- Concrete blocks – 20 billion blocks produced in around 350 manufacturing units.

The main resource efficiency strategies being promoted in China during this time has been:

- Use of internal fuel in bricks, particularly the use of coal gangue for brick making. Coal-gangue is the rock-type waste left over from coal mining and contains a variety of rock-type materials – including coal particles.
- Utilization of waste heat from tunnel kilns to use in tunnel dryers for drying of bricks. In case of coal-gangue based tunnel kiln, waste heat recovery system to produce steam and generate electricity
- Use of high efficiency motors and VFD drives to save electrical energy

- Using both process side measures and air pollution control device to reduce air pollution pf particulate matter, SO2, Nos, CO, HF, HCl, etc. As per the National Emission Standards for brick kilns (2016) the particulate matter in the chimney should not exceed 30 mg/Nm3.
- Preferred use of tunnel kiln and dryer system for firing of bricks
- Promoting the production of perforated and hollow bricks

FIGURE 45 TUNNEL KILN AND DRYER

Over 30 years (1990-2020), some of the key trends which can be identified in China are:

- Despite the introduction of non-fired products, clay brick remains the preferred walling material with 85% market share. In absolute terms also, the clay brick production remains almost at the same level ~ 800 billion bricks/year.
- Consolidation of brick manufacturing: The average production capacity has increased to 200 lakh bricks/ year or more and the number of brick manufacturing industries have come down to 3800, compared to around 85,000 in 1994. It seems that the number of small rural brick enterprises has reduced significantly.
- Shift to modern firing technologies like Tunnel and Rotary Tunnel kiln and year round production of bricks instead of seasonal production.
- Instead of depending on clay from agriculture fields as the main raw material, new sources of clay have been identified (e.g. coal-gangue) and instead of solid brick now the product mix has larger share of perforated and hollow bricks.

5.1.3 Vietnam

Vietnam is another major clay brick producing country in Asia. Similar to China, Vietnam has a strong government supported institutional set-up in the form of the Ministry of Construction, Vietnam Institute of Building Materials, public sector manufacturing units involved in the production of bricks and almost

50 years history of government supported interventions to mechanise the brick industry.

- In 2014, Government announced a master plan for development of construction materials in the country. The main aim of the master plan was to improve environment sustainability of the brick sector. Air pollution, CO_2 emissions and use of clay from agricultural fields were identified as the main environmental concerns. Some of the major provisions of the master plan were:
  - Ban on traditional kiln technologies: Due to air pollution concerns, government announced a ban on use of traditional intermittent kilns by 2016 and coal based VSBK and Hoffman kilns by 2018. After 2018, only Hoffmann kilns using biomass fuels, Tunnel kiln and Rotary Tunnel kilns were to be allowed.
  - Increase market share of non-fired bricks to at least 30% by 2020. To increase the production of non-fired bricks several incentives were announced, which included:
    - Reduction in corporate income tax
    - Exemption on import duties for importing machinery
- Exemption or reduction in land use tax and land rent.
- Training support
- Credit support

Making use of non-fired bricks mandatory in government construction depending on the categorisation of cities as well as making their use mandatory (80% of the total brick use) in private construction having height of more than 9 storeys.

Due to the implementation of the master plan, by 2018 the Vietnam had 800 tunnel kilns, 10 rotary tunnel kilns and 350 Hoffmann kiln using rice husk and straw.

In 2019, the average Specific Energy Consumption in fired clay brick industry was estimated to be:

- Thermal Energy: 1.63 MJ/kg
- Electrical Energy: 0.036 MJ/kg

As per the Vietnam Institute of Building Materials, Ministry of Construction, the target is to reduce the Specific Energy Consumption to:

- Thermal Energy: 1.50 MJ/kg
- Electrical Energy: 0.022MJ/kg

5.1.4 Bangladesh

Clay fired bricks are the main walling material in Bangladesh. In 2010, the Government of Bangladesh issued a circular that banned most polluting Fixed Chimney Kilns (FCKs) by 2012, to be replaced by more energy efficient and less polluting kilns, such as the Zig-Zag Kiln, Vertical Shaft Brick Kiln (VSBK), Hybrid-Hoffman Kiln (HHK) and Tunnel Kiln. The notification became an act in 2013 called the Brick Manufacturing and Kiln Establishment (Control) Act 2013. Bangladesh's brick sector consists of 7,859 operating kilns as of 30 June, 2018. The annual production is estimated at 33 billion bricks annually.

In Bangladesh, brick sector has been identified as one of the main energy consuming industrial sector and one of the key contributor to air pollution. During last 15 years, several internationally funded projects to improve the environment performance of brick kilns have been undertaken. During these programmes, HHK and tunnel kiln technology from China has been introduced in the country.

In spite of these efforts, the adoption of capital intensive HHK and tunnel kiln technology is lower than expected. The main barriers that have been identified are:

- Low levels of awareness of available modern technologies,
- Limitations regarding technological and operational capacity,
- High cost of financing
- Lack of financial assistance and attractive lending terms from local financial institutions.

In 2019, a roadmap document for brick industry has been prepared through support from the CCAC. The main recommendations of the roadmap are:

- Shut down all Fixed Chimney Kilns by the end of 2020, and 80% of Zig-Zag kilns by 2025
- Promote non-fired bricks so that by 2030, they contribute to almost 50% of the brick demand
- Provide a new line of credit for entrepreneurs who intend to establish new Tunnel kilns
- Build investment projects for R&D, raw material mapping and market demand generation for non-fired bricks
- Begin training programs to build technical expertise among brick sector workers (from labourers to senior design technicians) and lenders

Based on the above discussion, summary of the recommendations are as follows

i. Moving from FCBTK into zig zag kiln will result in 15-20% energy savings; improvement in percentage of class I bricks; reduction in air pollution. The payback is attractive, the cost can be recovered within 2 brick season. However, it should be noted the performance of zig zag kiln depend on kiln construction, fuel used and more importantly operational practice. Poor operation may lead to high emission. Monitoring and validation of kiln performance in the field is required to ensure the performance of zig zag kiln in the field.
ii. Adoption of Tunnel kin for brick manufacturing needs high investment (to the tune of crore rupees and more), the benefits can be reaped by producing value added products such as hollow and perforated bricks, tiles etc. Other benefits include increased production due to year-round operation; improvement in percentage of class I bricks and reduction in air pollution. Financial incentives can help in addressing the investment barrier.
iii. Shift from solid to gaseous fuels yield more Class I bricks and reduce emission; yet financial viability is still to be proven for large scale adoption. Gas network and infrastructure need to be strengthened and use of natural gas for zig zag or VSBK are yet to be demonstrated. Considering these constraint, large scale adoption of gas for brick making is not a practical solution in near term.
iv. VSBK technology promotion requires further improvement in the technology to make it suitable for the soil which requires slow firing and firing temperature above 950 degree. Also process mechanisation in moulding and transfer of the green brick kilns will reduce the wastage.
v. Financially viable, alternate solution is required to replace high number of clamp kilns

Annexure 1 MoEFCC Notification

रजिस्ट्री सं. डी.एल.- 33004/99 REGD. No. D. L.-33004/99

भारत का राजपत्र
The Gazette of India

सी.जी.-डी.एल.-अ.-22022022-233662
CG-DL-E-22022022-233662

असाधारण
EXTRAORDINARY

भाग II—खण्ड 3—उप-खण्ड (i)
PART II—Section 3—Sub-section (i)

प्राधिकार से प्रकाशित
PUBLISHED BY AUTHORITY

सं. 140] नई दिल्ली, मंगलवार, फरवरी 22, 2022/फाल्गुन 3, 1943
No. 140] NEW DELHI, TUESDAY, FEBRUARY 22, 2022/PHALGUNA 3, 1943

पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय

अधिसूचना

नई दिल्ली, 22 फरवरी, 2022

सा.का.नि. 143(अ).—केन्द्रीय सरकार, पर्यावरण (संरक्षण) अधिनियम, 1986 (1986 का 29) की धारा 6 और धारा 25 द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए, पर्यावरण (संरक्षण) अधिनियम, 1986 का और संशोधन करते हुए निम्नलिखित नियम बनाती है:, अर्थात्:-

1. संक्षिप्त नाम और प्रारंभ :

(1) इन नियमों का संक्षिप्त नाम पर्यावरण (संरक्षण) संशोधन नियम, 2022 है।

(2) वे राजपत्र में उनके अंतिम प्रकाशन की तारीख से लागू होंगे।

2. पर्यावरण (संरक्षण) नियम, 1986 में, अनुसूची-I में, क्रम सं. 74 पर प्रविष्टि के स्थान पर निम्नलिखित प्रविष्टि को रखा जाएगा, अर्थात्: -

74"	ईंट भट्टे	चिमनी से उत्सर्जन में विविकृत पदार्थ	250 मिलीग्राम/एनएम3
		निमनी की न्यूनतम ऊंचाई (भट्ठों की वर्टिकल साफ्ट) - भट्ठा क्षमता 30,000 ईंट प्रतिदिन से कम - भट्ठा क्षमता 30,000 ईंट प्रति दिन के बराबर या अधिक	14 मीटर (लोडिंग प्लेटफॉर्म से कम से कम 7.5 मीटर) 16 मीटर (लोडिंग प्लेटफॉर्म से कम से कम 8.5 मीटर)

1259 GI/2022 (1)

		चिमनी की न्यूनतम ऊंचाई (भट्टों की वर्टिकल शाफ्ट के अलावा)	
		- भट्टा क्षमता 30,000 ईंट प्रतिदिन से कम	24 मीटर
		- भट्टा क्षमता 30,000 ईंट प्रति दिन के बराबर या अधिक	27 मीटर

टिप्पणियां :

1. सभी नए ईंट भट्टों को केवल ज़िग-ज़ैग तकनीक या वर्टिकल शाफ्ट के साथ होने की या ईंट बनाने में ईंधन के रूप में पाइप्ड प्राकृतिक गैस के उपयोग की अनुमति दी जाएगी और इस अधिसूचना में निर्धारित मानकों का पालन करना होगा।
2. विद्यमान ईंट भट्टे जो ज़िग-ज़ैग तकनीक या वर्टिकल शाफ्ट या ईंट बनाने में ईंधन के रूप में पाइप्ड प्राकृतिक गैस (पीएनजी) के उपयोग का पालन नहीं कर रहे हैं, उन्हें (क) गैर-प्राप्ति शहरों के 10 किमी के दायरे में स्थित भट्टों के मामले में एक वर्ष (जैसा कि केंद्रीय प्रदूषण नियंत्रण बोर्ड द्वारा यथापरिभाषित) (ख) अन्य क्षेत्रों के लिए दो वर्ष की अवधि के भीतर ज़िग-ज़ैग तकनीक या वर्टिकल शाफ्ट में परिवर्तित किया जाएगा या पीएनजी का उपयोग ईंट बनाने में ईंधन के रूप में किया जाएगा। इसके अतिरिक्त, ऐसे मामलों में जहां केन्द्रीय प्रदूषण नियंत्रण बोर्ड/राज्य प्रदूषण नियंत्रण बोर्ड/प्रदूषण नियंत्रण समितियां ने रूपांतरण के लिए अलग से समय-सीमाएं निर्धारित की हैं, वहां ऐसे आदेश प्रभावी होंगे।
3. सभी ईंट भट्टे केवल अनुमोदित ईंधन जैसे कि पाइप्ड प्राकृतिक गैस, कोयला, ईंधन लकड़ी और/या कृषि अपशिष्टों का उपयोग करेंगे। पेट कोक, टायरों/प्लास्टिक/ख़तरनाक अपशिष्टों के उपयोग की अनुमति ईंट भट्टों को नहीं दी जाएगी।
4. उत्सर्जन की निगरानी के लिए केन्द्रीय प्रदूषण नियंत्रण बोर्ड द्वारा निर्धारित मापदंडों/रूपरेखा के अनुसार ईंट-भट्टे स्थायी सुविधा (पोर्ट होल और प्लेटफार्म) का निर्माण करेंगे।
5. विविक्त सामग्रियों (पीएम) के निष्कर्ष 4% CO_2 पर प्रमामान्य किए जाएंगे जो निम्नलिखित हैं:

   पीएम (सामान्य) = (पीएम(मापित) X 4%)/ (चिमनी में मापित CO_2 का %, मापित CO_2 के मामले में ≥ 4% कोई प्रमामान्यीकरण नहीं। चिमनी की ऊँचाई (मीटर में) भी $H= 14\ Q^{0.3}$ सूत्र (जहां Q kg/hr में SO_2 उत्सर्जन दर है) द्वारा परिकलित की जाएगी, और अधिकतम दो को काम में ले सकेंगे।
6. ईंट भट्टों को आवासों और फलों के बागों से 0.8 कि.मी. की न्यूनतम दूरी पर स्थापित किया जाना चाहिए। राज्य प्रदूषण नियंत्रण बोर्ड/प्रदूषण नियंत्रण समितियां आवास, जनसंख्या घनत्व, जल निकायों, संवेदनशील रिसेप्टर्स इत्यादि की निकटता का ध्यान रखते हुए स्थापित मापदंडों को सख्त बना सकते हैं।
7. किसी क्षेत्र में भट्टों की अधिक संख्या से बचने के लिए मौजूदा ईंट भट्टों से कम से कम एक किलोमीटर की दूरी पर ईंट भट्टों को स्थापित किया जाना चाहिए।
8. ईंट भट्टों को संबंधित राज्य प्रदूषण नियंत्रण बोर्ड/प्रदूषण नियंत्रण समितियां द्वारा निर्धारित उत्सर्जन प्रक्रिया/पलायक धूल उत्सर्जन नियंत्रण दिशा-निर्देशों का पालन करना होगा।
9. ईंट भट्टों से निकलने वाली राख को ईंट बनाने में उसी परिसर के अंदर ही इस्तेमाल किया जाएगा।
10. ईंट भट्टे में ईंट बनाने के लिए उपयोग की जाने वाली मिट्टी को निकालने के लिए संबंधित राज्य/संघ राज्य क्षेत्र के खनन विभाग सहित संबंधित प्राधिकरणों से सभी आवश्यक अनुमोदन प्राप्त किए जाएंगे।
11. ईंट भट्टा मालिक यह सुनिश्चित करेंगे कि कच्चे माल/ईंटों के परिवहन के लिए उपयोग की जाने वाली सड़के पक्की सड़कें हैं।
12. कच्चे माल/ईंटों के परिवहन के दौरान वाहनों को ढका जाएगा।"

[फा. सं. क्यू-15017/35/2007-सीपीडब्ल्यू]

नरेश पाल गंगवार, अपर सचिव

टिप्पण : मूल नियम भारत के राजपत्र, असाधारण, भाग II, खण्ड 3, उप-खण्ड (i) में तारीख 19 नवंबर, 1986 के का.आ. 844 (अ) द्वारा प्रकाशित किए गए थे और 04 अक्तूबर, 2021 की अधिसूचना सा.का.नि. 724 (अ) द्वारा अंतिम बार संशोधित किए थे।

MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

NOTIFICATION

New Delhi, the 22nd February, 2022

G.S.R. 143(E).—In exercise of the powers conferred by sections 6 and 25 of the Environment (Protection) Act, 1986 (29 of 1986), the Central Government hereby makes the following rules further to amend the Environment (Protection) Rules, 1986, namely:—

1. Short Title and commencement: -

   (1) These rules may be called the Environment (Protection) Amendment Rules, 2022.

   (2) They shall come into force on the date of their publication in the Official Gazette.

2. In the Environment (Protection) Rules, 1986, in the SCHEDULE-I, for entry at Sl. No. 74, the following entry shall be substituted, namely: -

"74	**Brick Kilns**	Particulate matter in stack emission	250 mg/Nm^3
		Minimum stack height (Vertical Shaft Brick Kilns)	
		- Kiln capacity less than 30,000 bricks per day	14 m (at least 7.5m from loading platform)
		- Kiln capacity equal or more than 30,000 bricks per day	16 m (at least 8.5m from loading platform)
		Minimum stack height (Other than Vertical Shaft Brick Kilns)	
		- Kiln capacity less than 30,000 bricks per day	24 m
		- Kiln capacity equal or more than 30,000 bricks per day	27 m

Notes :

1. All new brick kilns shall be allowed only with zig-zag technology or vertical shaft or use of Piped Natural Gas as fuel in brick making and shall comply to these standards as stipulated in this notification.
2. The existing brick kilns which are not following zig-zag technology or vertical shaft or use Piped Natural Gas as fuel in brick making shall be converted to zig-zag technology or vertical shaft or use Piped Natural Gas as fuel in brick making within a period of (a) one year in case of kilns located within ten kilometre radius of non-attainment cities as defined by Central Pollution Control Board (b) two years for other areas. Further, in cases where Central Pollution Control Board/State Pollution Control Boards/Pollution Control Committees has separately laid down timelines for conversion, such orders shall prevail.
3. All brick kilns shall use only approved fuel such as Piped Natural Gas, coal, fire wood and/or agricultural residues. Use of pet coke, tyres, plastic, hazardous waste shall not be allowed in brick kilns.
4. Brick kilns shall construct permanent facility (port hole and platform) as per the norms or design laid down by the Central Pollution Control Board for monitoring of emissions.
5. Particulate Matter (PM) results shall be normalized at 4% CO_2 as below:

   PM (normalized) = (PM (measured)x 4%)/ (% of CO_2 measured in stack), no normalization in case CO_2 measured $\geq$ 4%. Stack height (in metre) shall also be calculated by formula $H=14Q^{0.3}$ (where Q is SO_2 emission rate in kg/hr), and the maximum of two shall apply.

Annexure 2 Punjab Government Notification

GOVERNMENT OF PUNJAB
DEPARTMENT OF SCIENCE, TECHNOLOGY AND ENVIRONMENT
(STE Branch)

NOTIFICATION

Subject:- Directions u/s 5 of the Environment (Protection) Act, 1986 for usage of Paddy Straw Pellets as fuel by the Brick Kilns in the State of Punjab.

*****

No. 10/574/2022-STE1/443 **Dated, Chandigarh 04th November, 2022**

In order to protect and improve the environment and for prevention of hazards to human beings, other living creatures, plants and property and maintaining or restoring the wholesomeness of water and to preserve the quality of air, the Parliament of India has enacted the Water(Prevention and Control of Pollution) Act, 1974, the Air (Prevention & Control of Pollution) Act, 1981, the Environment (Protection) Act, 1986 and certain Rules under the provisions of the Environment (Protection) Act, 1986 and all these Laws are collectively and severally referred to as the Environmental Laws;

Whereas, Article 48(A) of the Constitution of India provides that the State shall endeavour to protect and improve the environment;

and whereas, in order to address the problem of air pollution, the Government of Punjab in consultation with the Punjab Pollution Control Board has declared the whole of the State of Punjab as 'Air Pollution Control Area' under Section 19(1) of the Air (Prevention and Control of Pollution) Act, 1981 vide notification no. SO21/CA14/81/S-19/88 dated 02.03.1988;

and whereas, the Government of Punjab in consultation with the Punjab Pollution Control Board and in coordination with various other departments is taking all such measures which are required for the reduction and control of air/environmental pollution in the State including the regulation and usage of such fuels which may have the potential to cause adverse impact on the quality of air and environment in the State;

and whereas, the subject matter of air pollution in National Capital Region, Delhi due to the cause of stubble burning in the States of Punjab, Haryana, Uttar Pradesh, Delhi is under continuous and constant consideration of the Supreme Court of India in Writ Petition (Civil) No. 13029 of 1985 titled as M.C Mehta vs Union of India and others, and Writ Petition (Civil) No. 1135 of 2020 titled as Aditya Dubey vs Union of India and others wherein directions for scientific usage of Paddy Straw are being issued from time to time ;

and whereas, the generation of huge quantity of paddy straw during the paddy harvesting season in the State of Punjab is a matter of concern due to its limited scientific usage;

Page 1 of 4.

and whereas, the Ministry of Environment Forest and Climate Change, Government of India vide notification no. G.S.R. 143 (E) dated 22.02.2022 has revised the emission standards for brick kilns and parameters have been made stringent @ 250 mg/Nm^{3}for particulate matter (PM) from the earlier permissible limit of 750 mg/Nm^3 ;

and whereas, with the twin objectives to make the scientific usage of Paddy Straw more prevalent and to investigate the emission levels with the usage of paddy straw as fuel in the brick kilns, on the directions of the State Government, the Punjab State Council for Science and Technology (PSCST) in collaboration with the Punjab Pollution Control Board (PPCB) has conducted a study to establish the usage of paddy straw pellets as replacement of coal in induced draft brick kilns with zig zag setting and the study has successfully revealed that paddy straw pellets can partially replace coal as fuel in the brick kilns without any structural modification and the usage of paddy straw pellets as fuel has resulted in compliance to meet the stringent standard of emissions notified by the Ministry of Environment, Forest and Climate Change vide notification dated 22.02.2022;

and whereas, apart from meeting with the stringent standards of emission as notified by the MOEF & CC vide notification dated 22.02.2022, the usage of paddy straw pellets as fuel in the brick kilns has further resulted in reduction of Sulphur Dioxide (SO_2) and emissions, which will resultantly improve and protect the environment from pollution arising from the operation of brick kilns in the State;

and whereas, in order to protect the environment from pollution arising from the usage of coal which contains higher Sulphur content, it is imperative to reduce the usage of coal and encourage the usage of paddy straw pellets as fuel in the brick kilns so that the environmental pollution is prevented and controlled ;

and whereas, the State Government in exercise of its powers and performance of its functions (as delegated by the Central Government in the Ministry of Environment and Forests Under/Section 23 of the Environment (Protection) Act, 1986 vide notification no. S.O. 327(E) dated 10.04.2001) under the Environment (Protection) Act, 1986 is empowered under Section 5 to issue directions in writing to any person, officer or any authority and such person, officer or authority shall be bound to comply with such directions ;

and whereas, for the avoidance of doubts, it has been explained and declared under Section 5 of the Environment (Protection) Act, 1986 that the power to issue directions u/s 5 includes the power to direct the closure, prohibition or regulation of any industry, operation or process or stoppage or regulation of the supply of electricity or water or any other service;

5.11.22

and whereas, the State Government, with the delegated powers from the Central Government, is empowered under the provisions of the Environment (Protection) Act, 1986 to take all such measures as it deems necessary or expedient for the purpose of protecting and improving the quality of environment and preventing, controlling and abating environmental pollution ;

and whereas, the State Government with the delegated powers from the Central Government is further empowered to carry out planning and execution of programs for the prevention, control and abatement of environmental pollution under the provisions of the Environment (Protection) Act, 1986;

and whereas, in order to achieve the four fold objectives namely to reduce the usage and dependence on coal as fuel in the brick kilns; to manage and encourage the scientific usage of paddy straw in the form of paddy straw pellets as fuel in the brick kilns ; to make endeavor to achieve the stringent standard of emissions @ 250 $mg/Nm^3$for particulate matter (PM) in the brick kiln industry and to implement the planning for the prevention, control and abatement of environmental pollution, it is imperative that suitable directions are issued to the Brick kiln industry in the State ;

and whereas, it has been further decided by the Government that a reasonable period of six months for the implementation of the above directive and planning shall be given to all the stakeholders to adopt and accustom to the situation in a more professional manner;

and whereas, after consideration and detailed deliberations, the Government was satisfied that the planning and objectives aforementioned cannot be achieved except with the issuance of suitable directions under Section 5 of the Environment (Protection) Act, 1986;

and whereas, it was decided that brick kilns in the State in the initial phase shall replace at-least 20% coal with paddy straw pellets as fuel and accordingly, the comments and views of the brick kiln industry, associations and other stakeholders including the general public were invited through Public Notice published in various newspapers dated 21/06/2022 on the draft notification;

and whereas, the objections or comments received within the specified period from the stakeholders in respect of the draft notification have been duly considered by the Government and the Chairman, Punjab Pollution Control Board has held meetings with all the stakeholders to address their observations and objections;

and whereas, after consideration of all the facts and circumstances of the case including the technical and scientific aspects and the observations and comments of all the stakeholders, the Government of Punjab has decided to regulate the usage of paddy straw pellets as fuel in the brick kiln industry of the State by issuing directions under Section 5 of the Environment (Protection) Act, 1986,

Now, therefore, in exercise of the powers conferred u/s 5 of the Environment (Protection) Act, 1986, the Government of Punjab hereby issues the following directions:

Page 3 of 4.

1. That all the brick kilns in the State of Punjab shall replace at least 20% coal with paddy straw pellets.
2. That the Punjab Pollution Control Board being the prescribed authority under the Air (Prevention and Control of Pollution) Act, 1981 and the Department of Food, Civil Supplies and Consumer Affairs being the Licensing authority shall create awareness and mobilize the brick kilns to mandatorily replace at least 20% coal with paddy straw based pellets as fuel.
3. That the Department of Science, Technology and Environment through the Punjab State Council for Science and Technology shall provide and extend necessary technical assistance for implementation of the action plan aforementioned.
4. That the Deputy Commissioners of the all Districts shall monitor the progress of the activities performed under the aforementioned action plan at the District Level.

The directions aforementioned shall come into force with effect from 1st May, 2023. In case of failure to comply with the directions, action in accordance with the provisions of the Environment (Protection) Act, 1986 shall be taken against the violators.

(Rahul Tiwari, IAS)
Secretary to Government of Punjab
Department of Science, Technology
& Environment

Dated: 04.11.2012
Place: Chandigarh

Endst. No.10/574/2022-STE1/444 **Dated, Chandigarh: 04.11.2022**

A copy of the above is forwarded to the Controller, Department of Printing & Stationary Punjab to print the 100 copies of this notification.

Endst. No.10/574/2022-STE1/445-454 **Dated, Chandigarh: 04.11.2022**

A copy of the above is forwarded to the following for information and necessary action:-

1. Additional Chief Secretary, New & Renewable Energy, Punjab.
2. Additional Chief Secretary, Development, Punjab.
3. Principal Secretary, Power, Punjab.
4. Principal Secretary, Food, Civil Supplies & Consumer Affairs Punjab.
5. Chief Executive Officer, PEDA.
6. Director, Directorate of Environment & Climate Change Punjab.
7. Director, Agriculture Punjab.
8. All Deputy Commissioner Punjab (23)
9. Chairman PPCB.
10. Member Secretary PPCB.

4.11.22
Manjeet Singh Randhawa
Superintendent

Page 4 of 4.

Annexure 3. Key stakeholders working on energy efficiency and environmental aspects of brick kilns in India

Institutions

Issues related to brick making has several dimensions such as energy, environment, social and economic. Many agencies including ministries in the state and central Government, research institutes, Non-Governmental Organizations (NGOs), multinational organizations and other donor agencies are likely to have an interest in addressing issues related to brick kiln.

Ministry of Environment & Forest (MoEFCC):

Ministry of Environment & Forest (MoEFCC) is the nodal agency at the central Government responsible for formulating and implementation of policies and regulations relating to conservation of environment. Three different departments at MOEFCC are working on issues directly or indirectly related to brick making in India.

- Control of pollution department at MoEFCC coordinates with Central Pollution Control Board in developing emission norms and guidelines for brick kilns. The existing emission standards for brick kilns cover – a) Bull's trench brick kilns notified by MoEFCC in 1996 b) Vertical shaft brick kilns notified by MoEFCC in 2006 c) down draught brick kilns. The department currently is engaged in the process of revising the standards for brick kilns.
- Climate Change Division deals with issues related to for climate change cooperation and global negotiations. It is also the nodal unit for coordinating the National Action Plan on Climate Change.
- Clean Technology department at MoEFCC supports projects and initiatives to develop and promote clean technology and abatement of pollution through prevention strategies and waste minimization.

Central Pollution Control Board:

Central Pollution Control Board (CPCB) is statutory organization entrusted with power and functions to prevent and control pollution. They provide technical services to MoEFCC. The process of developing /revising emission norms for brick kilns is coordinated by CPCB, while the Gazette notification is issued by MoEFCC.

State Pollution Control Boards:

The role of the state pollution control board is to carry out investigations as may be directed by the Central/ state Government to lay down standards for the quality of environment and discharge of environmental pollutants, to monitor and enforce the standards laid down.

Building Materials and Technology Promotion Council (BMTPC):

BMTPC is an agency under the Ministry of Housing and Urban Poverty Alleviation and, among other things is also responsible for the promotion of alternate/new/sustainable building materials and construction technologies.

Punjab State Council of Science and Technology (PSCST):

PSCST is the Science and Technology department of the Punjab Government. It provides technical and advisory services for the promotion of cleaner technologies. PSCST is involved in the CPCB supported study on "Development of emission norms and best practice guidelines for Brick kilns". The study is expected to result in the revision of the emission standards from brick kilns. In the past it has played an important role in the dissemination of Fixed Chimney BTK in Punjab and Haryana.

Bureau of Energy Efficiency (BEE):
Bureau of Energy Efficiency (BEE) is the nodal agency involved in developing and promoting strategies on energy efficiency in the country. BEE's activities on energy efficiency enhancement in brick and other small and medium enterprises include

- Analysis of technology and energy use
- Capacity building
- Implementation of energy efficiency (EE) measures and
- Facilitation of innovative financing mechanism for adoption of energy efficient technologies.

BEE has conducted an analysis of energy use in Varanasi brick cluster. At present, BEE is actively involved in undertaking energy efficiency activities in the brick industry which includes Energy and Resources mapping done through Enzen Global Solutions Pvt Ltd and Greentech Knowledge solutions Pvt Ltd . Energy Efficient Enterprise (E3) Certification is BEE's initiative to recognize burnt clay brick manufacturers who adopt energy-efficient manufacturing and encourage customers to source bricks from such E3 certified manufacturing units.

The Energy and Resources Institute (TERI):
TERI is an NGO and was one of the organisations involved in transfer and promotion of Vertical Shaft Brick Kiln (VSBK) technology to India as a part of Swiss Agency for Development Cooperation (SDC) program. It also developed the emission norms for Vertical Shaft Brick kilns for CPCB and MoEFCC. TERI was also the implementation organization for the UNDP-GEF project on resource efficiency in Indian brick industry.

Development Alternatives (DA):
Development Alternatives (DA) an NGO and has a long history of working on alternate/eco- building materials in India as well as several other Asian and African countries. It has been involved in promotion of VSBK technology since 1996. In addition it also provides technology for industrial waste utilization in brick making as well as manufactures machinery for brick industry.

Greentech Knowledge Solutions Pvt Ltd (GKSPL):
GKSPL carries out energy& environment monitoring of brick kilns and provides consulting and training services for cleaner brick production. Greentech is considered one of the premier consulting agencies in this sector in the developing world and has been providing consulting and training in India, Nepal, Vietnam and South Africa under projects supported by UNDP, UNEP, Swiss Agency for Development and Cooperation, Shakti Sustainable Energy Foundation, etc.

Central Building Research Institute (CBRI):
CBRI is the CSIR laboratory, responsible for promoting building science and technology. The institute carried out pioneering research work to develop technology for brick industry in 1960's and 1970's. It provides consultancy and design assistance to the industry primarily for High Draught Kiln.

All India Brick and Tiles Manufacturers Federation (AIBTMF):

AIBTMF is the national federation of brick makers, with over 7000 members. The primary activity of AIBTMF is to lobby with the Government to protect the interests of brick entrepreneurs.

State and Cluster level brick associations:

Most of the states have state level associations of brick makers; there are several district/cluster level associations also. Like, AIBTMF, the primary activity of these organizations is to lobby with the Government to protect the interests of their members.

Academic Institutes:

Some of the Academic Institutes such as Indian Institute of Sciences (IISc), Bangalore and Indian Institute of Technology, Bombay are also involved in research aspects of brick making and building materials.

Multilateral and bi-lateral Funding Agencies:

Multilateral and bi-lateral Funding Agencies such as United Nation Development Program (UNDP), Swiss Development Cooperation (SDC), and GIZ have been involved in brick kiln programmes in India. In recent years, Shakti Sustainable Energy Foundation has been supporting activities for cleaner brick production.

Bibliography

1. Factsheets about Brick Kilns in South and South-East Asia https://www.gkspl.in/wp-content/uploads/2018/10/REBM3.pdf
2. Rajarathnam, U., Athalye, V., Ragavan, S., Maithel, S., Lalchandani, D., Kumar, S., Baum, E., Weyant, C. and Bond, T., 2014. Assessment of air pollutant emissions from brick kilns. Atmospheric Environment, 98, pp.549-553 https://www.academia.edu/35900622/Assessment_of_air_pollutant_emissions_from_brick_kilns
3. Roadmap for Promoting Resource Efficient Bricks in India: A 2032 strategy https://www.gkspl.in/wp-content/uploads/2018/10/REBM5.pdf
4. Design Manual for Improved Fixed Chimney Brick Kiln https://www.gkspl.in/wp-content/uploads/2018/10/REBM9.pdf
5. Zigzag Brick Kiln Performance Assessment (2013) https://www.gkspl.in/wp-content/uploads/2018/10/Report-Monitoring-2013_25sep2013_final.pdf
6. Manual on Cleaner Brick Kiln Technologies:Design, Construction and Operation https://www.gkspl.in/wp-content/uploads/2018/10/REBM10a.pdf
7. Towards Cleaner Brick Kilns in India https://www.gkspl.in/wp-content/uploads/2018/10/REBM1e.pdf
8. Learnings from Bihar's Experience of Implementing Cleaner Brick Kiln Directive: A Case Study https://www.gkspl.in/wp-content/uploads/2019/01/Learnings-from-Bihar-Experience-of-Implementing-Cleaner-Brick-Kiln-Directive-A-Case-Study.pdf
9. Lakshmi Singh, A., and Md. S. Asgher. 2005. "Impact of brick kilns on land use/landcover changes around Aligarh city, India." Habitat International 29 (2005) 591–602. https://www.researchgate.net/publication/353849264_Impact_of_brick_kilns_on_land_uselandcover_changes_around_Aligarh_city_India
10. Techno economics of retrofitting FCBTK into Zig Zag technology, CSE, 2017 https://shaktifoundation.in/wp-content/uploads/2018/01/Zig-Zag-Kilns-A-Design-Manual-English-2017-1.pdf
11. Nivit Kumar Yadav and Rahul Kumar 2017, Zigzag Kilns: A Design Manual, Centre for Science and Environment, New Delhi https://cdn.cseindia.org/attachments/0.15498400_1520395734_zig-zag-kilns-design_manual.pdf
12. Brick Kilns Performance Assessment & A Roadmap for Cleaner Brick Production in India – Enzen validation https://www.ccacoalition.org/sites/default/files/resources/Brick_Kilns_Performance_Assessment.pdf