# MANUAL ON ENERGY CONSERVATION MEASURES IN BRICK CLUSTER VARANASI

## Bureau of Energy Efficiency (BEE)

*Ministry of Power, Government of India*

*Prepared By*

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# Contents

## LIST OF TABLES

## LIST OF FIGURES



## LIST OF IMAGES

## Acknowledgement

We express our sincere gratitude to the Bureau of Energy Efficiency, Ministry of Power for giving the opportunity to be a part of 'SME Programme'. We thankfully acknowledge the support and guidance provided by all concerned officials during the conduct of this exercise.

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We would also like to thank Int Nirmata Parishad and brick makers in the Varanasi Cluster for their support in undertaking this task of energy use and technology analysis within the brick making Industry. The field studies would not have been completed on time without their interaction and timely support. We are grateful for their co-operation, especially during field studies for their wholehearted support and hospitality. Their willingness to undertake energy efficiency measures was key in reducing the energy intensity of the brick manufacturing industry.

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# Executive Summary

**Objective of the SME Programme**

The mission of the SME Programme is to improve the overall energy efficiency of Small and Medium Enterprises. In quantitative terms, there is a general lack of record keeping with respect to energy consumption and energy saving opportunities within these Industries. The SME programme intends to enhance the energy efficiency awareness by funding/subsidizing need based studies in SME clusters and giving energy conservation recommendations.

The main project activities as stated by BEE under the SME program are:

- Energy Use and Technology Analysis
- Capacity Building
- Implementation of EE measures
- Facilitation of Innovative Financing Mechanism

**Brief Overview of the Varanasi Brick Making Cluster**

There are approximately 226 (Two hundred and twenty six) brick kilns in operation within the greater Varanasi district. The kilns are majorly located in clusters in the following areas of the district.

- Haruhua
- Sarnath
- Sindhora Road
- Rohania
- Munari
- Rameshwar
- Badagaon

**Varanasi Brick cluster snapshot**

| | |
|---|---|
| Classification of brick units within the Cluster | Bull Trench Kilns with natural draft |
| Raw Material used | • Sand<br>• Clay<br>• Water |
| Types of fuel | Coal |
| Specific Energy Consumption | 1.1 -1.5 MJ/kg of fired product |
| Manufactured Products | • Solid Bricks<br>• Perforated Bricks<br>• Half Bricks |

**Cluster Energy Consumption**

Based on site visits and the energy data of 226 brick manufacturing units in the greater Varanasi cluster the following table provides a snapshot of the Cluster energy consumption.

**Table 1: Cluster Energy Consumption**

| | | |
|---|---|---|
| Annual Cluster Production | 7,075.28 | Lac Bricks |
| Annual Cluster Coal Consumption | 1,26,880.77 | Tonnes |
| Annual Cluster Energy Consumption | 2907.994 | Terajoules |
| Annual Coal Consumption per unit | 561.42 | Tonnes |
| Annual Energy Consumption per unit | 12.867 | Terajoules |
| Average Coal consumption per lac bricks | 18.08 | Tonnes |
| Average Energy Consumption per lac bricks | 0.414 | Terajoules |

**Recommended Energy Conservation & Savings Potential**

On basis of field studies conducted in the Varanasi cluster and technology gap assessment of available technology/ process up-gradations, proposals for energy efficiency are listed in the tables below. The tables quantify and give tentative saving potentials within the cluster.
The entrepreneurs can be convinced to adopt one or more of the below mentioned technologies based on the information provided. Applying a generic ruling for adoption of technologies, the probability of low and medium investment technologies will be high as compared to high investment technologies.

**Table 2: Savings per typical Unit**

| S.No | Energy Efficient Technology/ Measure | Annual Coal Savings (Tonnes) | Annual Energy Savings (Terajoules) | Annual Monetary Savings (INR) |
|---|---|---|---|---|
| **1** | Process Change from straight line to Zigzag Firing | 140.85 | 3.228 | 7,04,250 |
| **2** | Best Practices in Coal Charging/ Feeding | 53.21 | 1.219 | 2,66,050 |
| **3** | Induced Draft Fan | 46.95 | 1.076 | 2,34,750 |
| **4** | Vertical Shaft Brick Kiln * | 128.33 | 2.941 | 6,41,650 |
| **5** | Hoffman Kiln | 125.2 | 2.869 | 6,26,000 |
| **6** | Manufacture of Perforated Bricks | 112.68 | 2.582 | 5,63,400 |

**Table 3: Total Cluster wide Savings (226 units)**

| S.No | Energy Efficient Technology/ Measure | Annual Coal Savings (Tonnes) | Annual Energy Savings (Terajoules) | Annual Monetary Savings (INR) |
|---|---|---|---|---|
| **1** | Process Change from straight line to Zigzag Firing | 31832.1 | 729.563 | 15,91,60,500 |
| **2** | Best Practices in Coal Charging/ Feeding | 12025.46 | 275.612 | 6,01,27,300 |
| **3** | Induced Draft Fan | 10610.7 | 243.187 | 5,30,53,500 |
| **4** | Vertical Shaft Brick Kiln * | 29002.58 | 664.713 | 14,50,12,900 |
| **5** | Hoffman Kiln | 28295.2 | 648.500 | 14,14,76,000 |
| **6** | Manufacture of Perforated Bricks | 25465.68 | 583.650 | 12,73,28,400 |

**Proposals 1&2, 4&5 are mutually exclusive. If one of them is implemented, the other cannot be implemented.*

**Zero Investment Energy Conservation Measures**

Apart from the proposals for reducing the energy intensity of the brick making industry in the Varanasi sector, alternatives/ zero and negligible cost measures were identified. There measures typically require minimal to zero investment and can be implemented almost immediately. Due to the nature of operation of Bull trench kilns it is not possible to quantify the actual energy savings from implementation of these measures/ practices.

1. Replacement of metallic lids with insulated lids in the firing zone
2. Increasing the top layer of fly ash on trench from a minimum of 4 to 6 inches
3. Timely feeding/standardization of coal charging in the combustion zone
4. Proper and timely housekeeping practices
5. Overall periodic maintenance of unit
6. Quality control of green bricks to reduce moisture below 3%
7. Use of powdered/ crushed coal for charging purposes

# 1. BEE SME Programme

The Bureau of Energy Efficiency (BEE) is a nodal agency set up under the Energy Conservation Act, 2001 with the primary objective of reducing energy intensity of the Indian Economy. BEE has identified the Small and Medium Enterprises (SMEs) like foundries, brass, textile, brick and ceramic manufacturing unites etc as having large potential for energy savings. BEE considers it useful to intervene in these SME clusters and build their energy efficiency awareness by funding/subsidizing need based studies in these clusters and giving energy conservation recommendations including technology up-gradation opportunities.

## 1.1 Project Objectives

The overall objective of the SME programme is to improve the energy intensity of the Indian economy by undertaking actions in the SME sector. The programme also specifies immediate/ short term objectives on accelerating the adoption of EE technologies and practices in the identified clusters through knowledge sharing, capacity building and development of innovative financing mechanisms.

The main project activities as stated by BEE under the SME program include:

- Energy Use and Technology Analysis
- Capacity Building
- Implementation of EE measures
- Facilitation of Innovative Financing Mechanism

## 1.2 Expected Project Outcomes

The expected project outcomes of the above mentioned activities are:

- Assessment of total energy usage and groundwork for undertaking further actions within the cluster
- Cluster manual to give an overview of the clusters
- List of 15 projects for the cluster to improve the current state of technology within the clusters
- Capacity building of the Local Service Providers to undertake implementation of EE measures in the clusters
- Facilitating arrangement between Financial institutions to enhance capacities of lead banks in the clusters
- Assessment of impact of the programme and roadmap for future action

### 1.3 Project Duration

| S.No. | Activity | Month | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 1 | Energy Use and Technology Gap Assessment Report | | | | | | | | | | | | | | | | | | |
| | Deliverable | | | | | | | | | | | | | | | | | | |
| a | Formats for Data collection and Field Measurement | | | | | | | | | | | | | | | | | | |
| b | List of Units where Energy Use & Technology Gap Assessment will be conducted | | | | | | | | | | | | | | | | | | |
| c | Energy Use and Technology Gap Assessment Report | | | | | | | | | | | | | | | | | | |
| d | 3 Case studies & Best Practices | | | | | | | | | | | | | | | | | | |
| e | Cluster Manual as per TOR | | | | | | | | | | | | | | | | | | |
| f | 750 printed copies of the Case studies | | | | | | | | | | | | | | | | | | |
| 2 | Information Dissemination Workshop | | | | | | | | | | | | | | | | | | |
| | Deliverable | | | | | | | | | | | | | | | | | | |
| a | Identification of 15 Projects in a cluster for preparing bankable DPRs | | | | | | | | | | | | | | | | | | |
| b | Presentation of Selected projects in workshop | | | | | | | | | | | | | | | | | | |
| c | Share Best practices in the Cluster | | | | | | | | | | | | | | | | | | |
| d | Distribute Cluster Manuals | | | | | | | | | | | | | | | | | | |
| 3 | Implementation of EE measures | | | | | | | | | | | | | | | | | | |
| | Deliverable | | | | | | | | | | | | | | | | | | |
| a | 15 DPR for the cluster | | | | | | | | | | | | | | | | | | |
| b | Detailed information for preparation of PINs | | | | | | | | | | | | | | | | | | |
| c | Details of Local Service Providers with CVs | | | | | | | | | | | | | | | | | | |
| d | Training Modules for the capacity Building of LSPs | | | | | | | | | | | | | | | | | | |

**Note: M = Month**

### 1.4 Identified Clusters in the Programme

The 18 clusters identified by BEE for the SME programme is listed below;

**Table 4: BEE identified clusters under the SME Programme**

| S. No | Cluster Location | Product | Units Surveyed (No.) | Total Units listed in the Cluster |
|---|---|---|---|---|
| **1** | Alwar | Oil Milling | 65 | 68 |
| **2** | Bangalore | Machine Tools | 54 | 62 |
| **3** | Batala, Jalandhar & Ludhiana | Foundry | 431 | 431 |
| **4** | Bhimavam | Ice Making | 28 | 33 |
| **5** | Bhubhneshwar | Brass | 33 | 44 |
| **6** | E&W Godavari | Refractories | 44 | 44 |
| **7** | Ganjam | Rice Milling | 205 | 231 |
| **8** | Gujrat | Dairy | 22 | 22 |
| **9** | Howrah | Galvanizing | 57 | 57 |
| **10** | Jagadhri | Brass & Aluminium | 91 | 392 |
| **11** | Jodhpur | Limestone | 78 | 78 |
| **12** | Jorhat | Tea | 60 | 60 |
| **13** | Kochi | Sea Food Processing | 35 | 35 |
| **14** | Muzaffanager | Paper | 18 | 26 |
| **15** | Orissa | Sponge Iron | 45 | 53 |
| **16** | Vapi | Chemical & Dyes | 180 | 227 |
| **17** | **Varanasi** | **Brick** | **69** | **226** |
| **18** | Vellore | Rice Milling | 49 | 66 |

## 2. Cluster Scenario

The Brick manufacturing cluster is located in the greater Varanasi district. Varanasi (Banaras) is one of the oldest cities of India. It is located along the left crescent- shaped banks of the river Ganges in the Eastern part of Uttar Pradesh. It is claimed to be the cultural and spiritual capital of India due to its diversity, temples, ashrams and mythologies. In addition to the tourist & religious aspect, Varanasi also hosts one of the biggest clusters of brick manufacturing industries in the country,

**Table 5: Varanasi at a Glance**

| | |
|---|---|
| Geographical Location | $83^{o}$E , $25^{o}$20’N |
| Geographical Area (2001) | 1535 Sq. Km. |
| Average Rainfall (2006) | 244 mm Actual |
| Temperature (2004) | Max. – 47, Min. – 4.5 |
| Population (2001) | 31,38,690 |
| Estimated Daily floating Population | 30,000 |
| Literacy (2001) | 16,94,400 |
| No. and Name of Tehsils | Total: 2<br>• Varanasi Sadar<br>• Pindra |
| No. and name of Development Blocks | Total: 8<br>• Kashi Vidyapeeth<br>• Cholapur<br>• Badagaon<br>• Chiraigaon<br>• Haruhua<br>• Pindra<br>• Arajiline<br>• Sevapuri |

Due its location on the banks of the river Ganges and its rich history Varanasi attracts tourists, devotees on pilgrimages and workers from nearby rural villages. It is estimated to have a floating daily population of around 30,000 and its riverfront and old city heritages zones are densely populated (above 500 people/per hectare).

**Image 1: Varanasi District Overview**


## 2.1 Overview of SME Cluster

### *2.1.1 Cluster Background*

There are approximately 226 (Two hundred and twenty six) brick kilns in operation within the greater Varanasi district. The kilns are majorly located in clusters in the following areas of the district:

- Haruhua
- Sarnath
- Sindhora Road
- Rohania
- Munari
- Rameshwar
- Badagaon

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. The late onset of spring has led to the currently functioning brick kilns to be operating at loss. This is due to the over consumption of coal in order to keep the brick kiln operating at capacity; With a number of units yet to start operations in February/ March 2010. The local market cost of 1st class bricks is in the range of Rs 3.8 – 4.2 per brick.

### *2.1.2 Product manufactured*

The two main product types manufactured in the Varanasi cluster are Bricks and Half Bricks. There is just one standalone unit which produces tiles/ perforated bricks in combination with bricks.

**Figure 1: Cluster Products Manufactured**

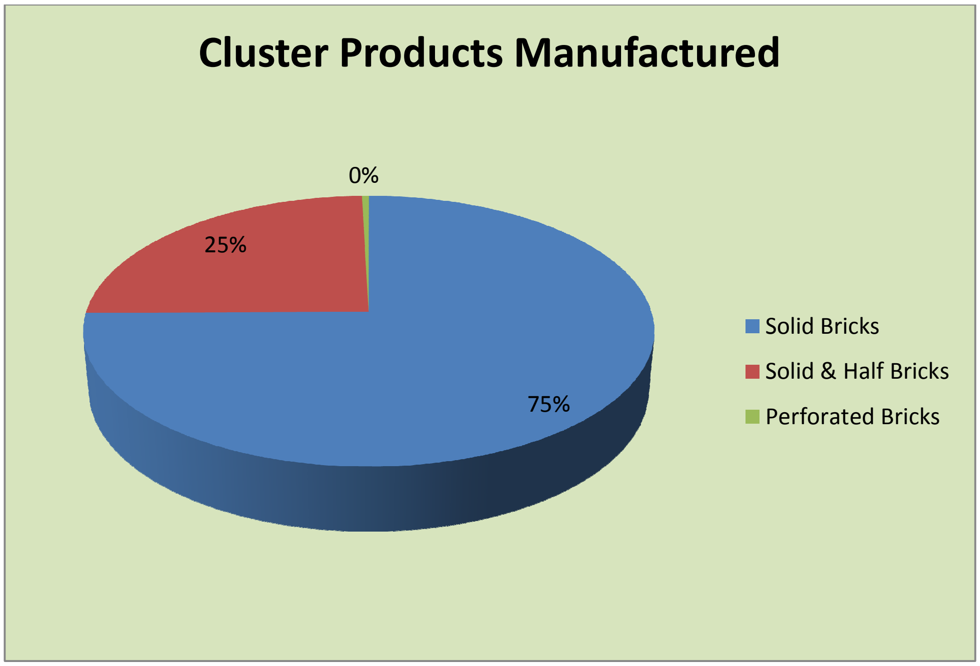



**Table 6: Cluster Product Manufactured Break Up**

| | |
|---|---|
| Total Number of units manufacturing Solid Bricks | 170 |
| Total Number of units manufacturing Solid +Half Bricks | 55 |
| Total Number of units manufacturing Perforated Bricks | 1 |

### *2.1.3 Classification of units*

The brick kilns in the entire Varanasi cluster are of the traditional coal fired fixed chimney Bull's Trench Kilns (BTK) type, with fixed natural draft chimneys. A minute percentage of the kilns in the area also operate using induced draft fans for better airflow in the firing/ cooling zones during summers.

**Image 2:Traditional Fixed Chimney BTK**

### *2.1.4 Production capacity (in tonnes or pieces per year) detail*

The capacities of these kilns vary between 2 – 9 lac bricks a round (approximately 30 days) with a minimum operation capacity of 15 thousand bricks per day. Kiln operations are highly dependent on weather/ seasons, with the kilns usually operating for a period of 6- 8 months from November - December to May - June. Therefore individual kiln production capacities vary greatly depending upon the seasonal operational of the kilns.

**Figure 2: Annual Brick Production**

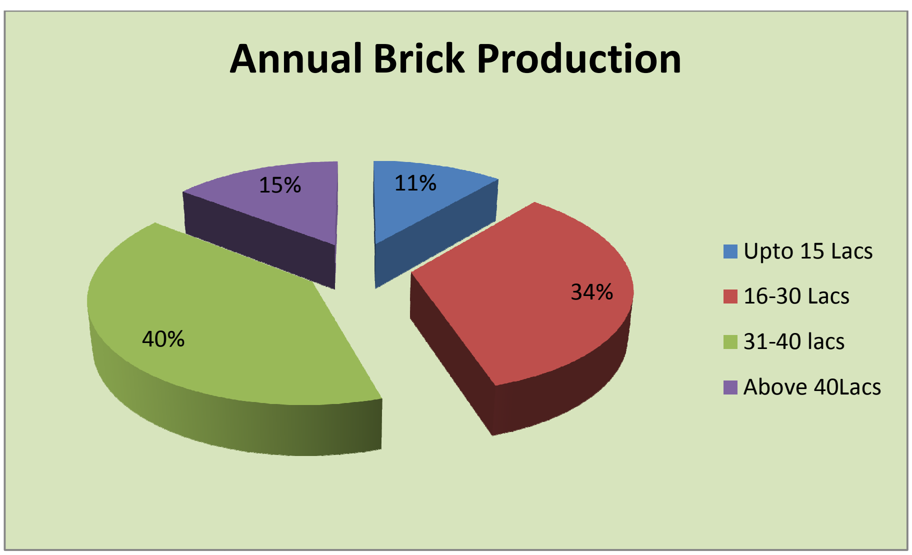


**Table 7: Annual Production Capacity**

| Annual Production Capacity | | | |
|---|---|---|---|
| Upto 15 Lacs | 16-30 Lacs | 31-40 Lacs | Above 40 Lacs |
| 25 | 75 | 89 | 32 |

### *2.1.5 Raw materials used*

The basic raw materials used for making bricks are; clay, sand and water. Due to the location of brick kilns around the vicinity of the Ganges valley the entire cluster has an abundance of good quality clay possessing near ideal chemical and physical properties. The soil is very suitable and create minimal to negligible difficulties while sun drying or while firing of burnt clay bricks.

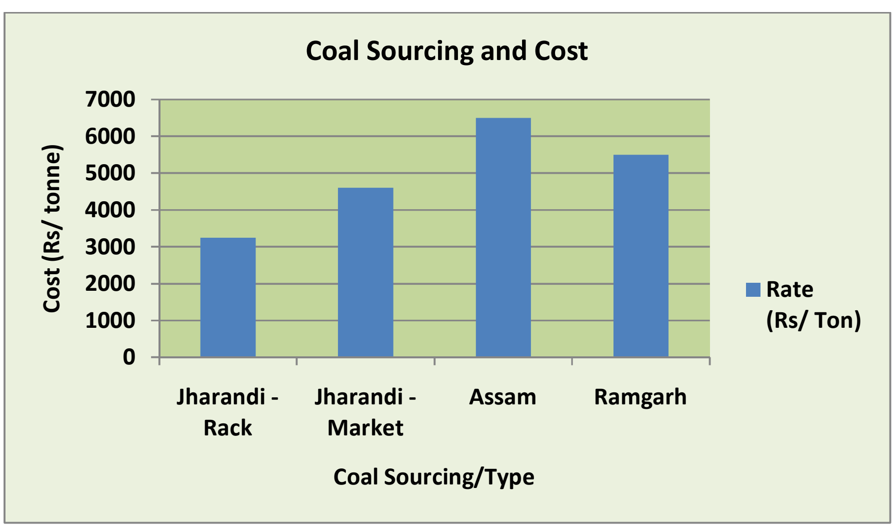
## 2.2 Energy Situation in the cluster

### *2.2.1 Types of fuels (fossils, biomass, waste, byproducts, etc) used and prices*

Coal is the main source of energy used in brick making. Very few units within the cluster are also using sawdust / wood in conjunction with coal for the firing of bricks. However the energy usage of these fuel sources is negligible as compared to the overall consumption of coal in the operation and energy usage of the kiln.

Many of the units use a combination of different coal types depending upon availability and market price fluctuations.

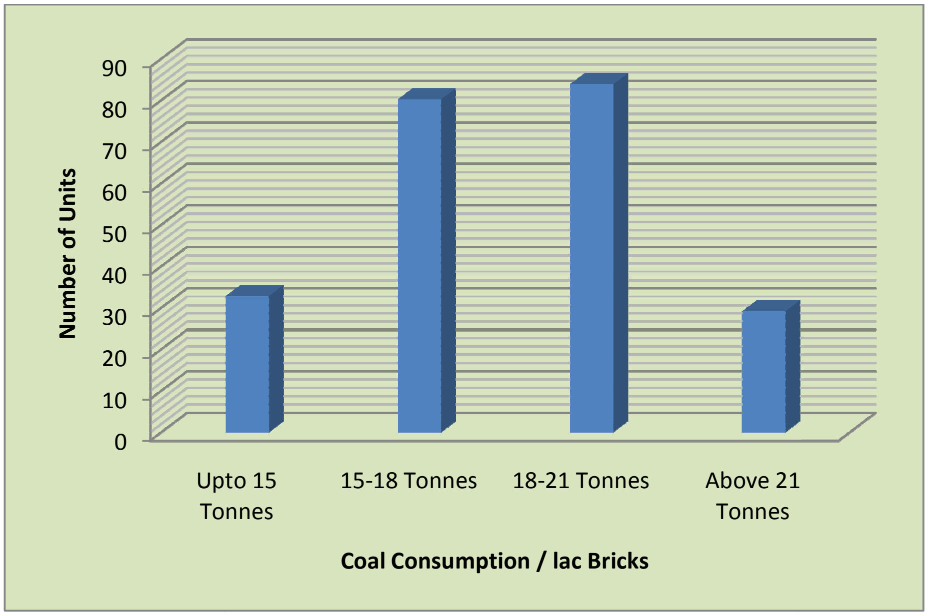
**Figure 3: Coal Source and Rate**



### *2.2.2 Fuels and electricity consumption in a typical unit*

The average coal consumption range in a BTK unit is shown as below:

**Figure 4: Coal consumption per lac bricks**




| **Coal Consumption (Tonnes/ Lac bricks)** | Upto 15 | 15- 18 | 18- 21 | Above 21 |
|---|---|---|---|---|
| **Number of Units in the Cluster** | 33 | 80 | 83 | 29 |

For night time operations, a small percentage of units use electricity for illumination purpose, with a majority using kerosene lamps or rechargeable lamps.

### *2.2.3 Specific energy consumption (in appropriate unit)*

Typically the energy consumption of brick manufacturing units is presented in terms of tons of fuel consumed for firing one lac bricks. This method of representation however is inaccurate in comparing the performance of brick kilns as:

- It does not account for the varying range of fired brick weight between units in the cluster
- Does not account for the difference in weight/dimensions of half bricks and full bricks
- It does not account for the quality/source of coal being used for the firing of bricks.

Therefore by calculating the specific energy consumption required for firing of one kilogram of fired brick, the performance and energy consumption of the brick kilns within the cluster can be accurately documented using this approach.

| | |
|---|---|
| Specific Energy Consumption (Mj/kg of final product) | 1.1 to 1.5 |
| Specific Energy Consumption per Fired Brick | 3.3 – 4.5 Mj |
| Specific Energy Consumption per lac Fired Bricks | 0.414 Tj |

**1 Lac bricks = 3,00,000 kgs of final products approx.*

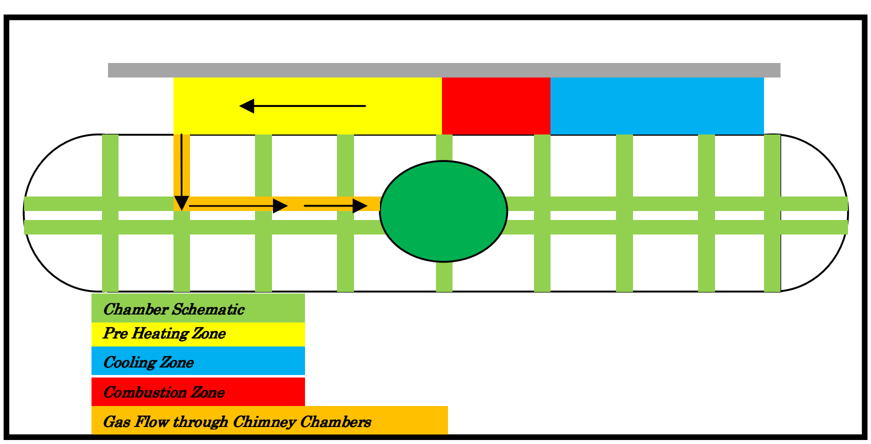
## 2.3 Manufacturing process/technology overview in a typical unit

In Varanasi, brick making is still a traditional process with minimal use of mechanization and technologies. Traditionally majority of the brick kilns in this area are moving chimney Bull Trench kilns. However after the minimum national emission standards for brick kilns under the prevention and control of Pollution Act 1996, it has seen the implementation of the more efficient fixed chimney BTKs replacing the moving chimney BTKs with a visible effect on the quality and quantity of brick produced.

### *2.3.1 Process technology*

The brick manufacturing process in a typical unit is centered around the Bull Trench Kiln (BTK) and the associated processes supplementing the firing and cooling within the BTK. The Bull Trench Kiln is the popular choice of brick manufacturing unit in the Varanasi cluster. It is an oval/circular shaped brick kiln with its chimney usually in the middle. The trench is connected to the chimney by means of evenly spaced chambers along the trench. A schematic of a BTK is shown below.

**Figure 5: Chamber Layout and Gas Flow through BTK**



### *2.3.2 Process flow diagram*

While the principles of brick manufacture in BTK's is fairly consistent, individual units may and sometimes do depart from these basics to fit their particular requirements, raw materials and mode of operations. The essential steps in brick making are shown in the diagram below.

**Figure 6: Brick Making Process**


The first three steps of the brick making process usually start around about 20-40 days before the actual firing of the kiln. This is done to build up a decent stockpile of dried green bricks for continuous operation of the brick kiln. The firing up process of the brick kiln takes 10-20 days to make the kiln reach its appropriate temperature for the bricks to solidify and acquire its pre requisite fired brick attributes. The entire process is continual and once the firing is initiated, very rarely is the kiln operation course halted.

**A. Clay Winning and Soil preparation**

Clay is usually dug from the local vicinity of the brick kiln. The clay is then processed as to be free from gravel, lime and other bio wastes/ matter. This soil once excavated is then watered and left over a period of 8 – 12 hours for weathering and processing. After aging the moistened soil is kneaded/ pugged as required.

**Image 3: Clay Winning & Moulding Area (Pathai)**

**B. Moulding / Brick formation**

The Plastic clay after been through the previous process is then moulded into the required brick shape and size with its makers mark using a metal/ wooden / PVC mould.

**C. Brick Drying**

Once the clay has been formed into the pre required green brick shape, it is then left out in the sun to dry and reduce its moisture content. Fast drying on extremely hot days may lead to creation of cracks in the green brick which is undesirable. Therefore to minimize crack creation and quick moisture loss, the drying process takes place over a period of 8 -12 days with the bricks left out in the Sun. The bricks are usually laid out in stacks with a horizontal vertical alignment as to maximize usage of space and Sun light.

**Image 4: Wet Green Brick drying**

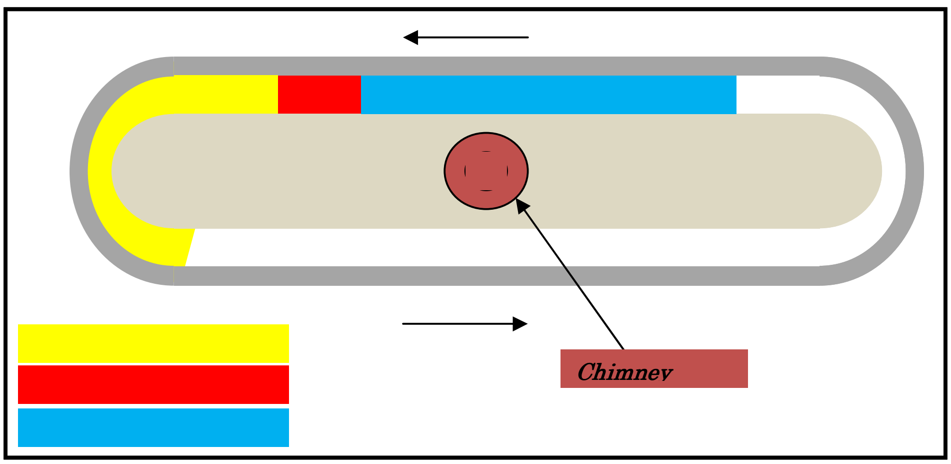
**D. Firing and cooling**

The firing and cooling is done in the bull trench kiln (BTK). Relative to combustion zone within the kiln, the trench can be divided into cooling, firing and pre heating zones.

**Figure 7: BTK zone Classification flow**


The cooling zone is the upstream region in which the fired brick extraction takes place. This area is also vital in the mechanics of the brick kiln functionality as it allows cool air to flow into the combustion zone. The cool air while flowing through the fired brick arrangement cools the brick arrangement while at the same time gaining heat from the previous lines of fired bricks.

**Figure 8: BTK operation and Zones**




The combustion zone is the area where the firing of bricks takes place. To achieve the desired/ required properties of fired bricks the green bricks in this zone are subjected to temperatures of 800 – 1080 degree Celsius. Holes are made in lines on the top layer of the brick arrangement through which coal is fed in regular intervals into the combustion zone. To minimize heat losses during feeding, these holes are covered with metallic lids. Coal feeding of a line within the combustion zone may take anywhere from 3 to 6 hours depending on the draft and temperature of the Pre heating line.

**Image 5: Combustion Zone with lines covered by metallic lids**

The pre-heating zone is located downstream to the combustion zone. Sufficiently dried green bricks are brought over from the *Pathai* (brick moulding area) and systematically stacked within this zone. This stacking arrangement is then covered with a top layer of fly ash (3 – 6 inches) to offer insulation and minimize heat losses. The hot air/gases coming from the combustion zone flow through these lines of bricks further reducing their moisture and heating these bricks. A hole connected to the chimney is opened at a suitable location downstream to allow for maximum heating of bricks in the pre heat zone before it is discharged through the chimney. The difference in temperature between the hot air in the chimney and the cold ambient air creates a draft which sucks in air from the cooling zone.

**Image 6: Green brick stacking pattern**

**E. Brick Extraction**

The extraction of bricks takes place in the beyond the cooling zone of the brick kiln. As the brick firing and cooling is a continuous process the brick discharge takes place daily in tandem with the position of the firing/cooling of the lines.

**Image 7: Fired Brick Extraction**

## 2.4 Current policies and initiatives of local bodies, if any

### A. *UDNP-GEF project: Energy efficiency improvements in Indian brick industry*

**Project objectives**

| Region | Cluster |
|---|---|
| North | Ludhiana |
| East | Varanasi (UP)/ Kolkata (West Bengal) |
| South | Bangalore (Karnataka) |
| West | Pune (Maharashtra)/ Gujarat |
| North East | Tripura |

With this background, UNDP–GEF is supporting a project on "Energy efficiency improvements in Indian brick industry" for a period of four years staring June 2009. The project is implemented by the Ministry of Environment and Forests (MoEF) and TERI is the responsible partner for implementation. The main objectives of the project include:

- Enhancing public sector awareness on resource-efficient products
- Facilitating access to finance for brick kiln entrepreneurs
- Improving knowledge on technology and marketing
- Demonstrating and making available the technologies and models for producing REBs in at least five brick producing clusters through its local resource centers;
- Improving capacity of brick kiln entrepreneurs, supervisors and workers.

**Advantages of Resource Efficient Bricks (hollow, perforated bricks)**

1. Lowering rate of consumption of top soil (about 30%)
2. Reduced fuel requirements (about 20%) for brick firing
3. Reduced $CO_2$ emissions
4. Improved crushing strength (more than 200 $kg/cm^2$) and reduced water absorption (around 10%) compared to handmade bricks
5. About 5–7% reduction in construction costs
6. About 5% saving in energy bill with reduced heating/cooling loads due to improved insulating properties.

**Key Stakeholders in the project**

- End-users such as builders, architects and government departments such as MES (Military Engineering Services), CPWD (Central Public Works Department), State PWD, etc
- Government organizations such as BIS (Bureau of Indian Standards) and BEE (Bureau of Energy Efficiency) for inclusion of the technical specifications of REBs in their standards
- Other government organizations such as HUDCO, CGCRI, MSME-DI, BMTPC, CPCB, state PCB
- Brick kiln entrepreneurs for technology adoption
- Banks and financial institutions for providing loans to brick kiln units for technology adoption

**Project outcome**

The resource efficient technologies are demonstrated in five different brick clusters in India, and the support system in place for technology adoption.

## *B.* Establishment of Testing Laboratory

**Int Nirmata Parishad**, the brick manufacturers association of Varanasi district, in an initiative along with TERI established a testing laboratory for the brick industry at the association's office in Varanasi through partial financial assistance from the Small Industries Development Bank of India.

This laboratory is being used by members of the association for various purposes. The laboratory is having the following equipments:

a. Bomb Calorie Meter – This instrument is used for testing calorific value of coal.
b. Muffle Furnace – This instrument is for testing firing temperature of soil to check suitability of the soil for making bricks.
c. Weighing Balance – It is used for weighing the coal which is to be tested in Bomb Calorie Meter.
d. Compressive Strength Testing Machine – It is used to check the compressive strength of fired brick.
e. Thermocouple and Temperature indictor– This instrument is used to measure the firing temperature in brick kilns.

## 2.5 Issues related to energy usage and conservation and barrier in technology up gradation

There are common widespread issues plaguing the brick industry in Varanasi which are creating barriers in implementation of new technologies, energy efficiency measures and up gradation of traditional age old processes. To reduce the energy intensity within the cluster, these issues need to be addressed collectively to overcome the barriers the unit owners/operators are currently facing.

### *2.5.1 Energy availability*

There are two main energy availability barriers which are prevalent in the Varanasi brick manufacturing cluster;

**I. Lack of fuel switching options**

Due to the nature of the brick making process technology in Bull trench kilns (BTKs), the energy options are limited. There are no available fuel alternatives to coal in this mode of process technology. Fuel switching alternative/ renewable fuel options can only be implemented successfully, if the current brick manufacturing process and the current state of technology is improved.

**II. Shortage of quality Coal**

The shortage of quality B grade coal and its high price required for brick manufacture poses another barrier in Energy Conservation within this sector.

Due to lack of quality coal, kiln owners resort to low quality and rack coal sources which have lower calorific value and carbon content. A lower quality fuel would be required a larger quantity to prepare the same amount of bricks as opposed to higher grade of fuel. Along with higher energy consumption, using lower grades of coal also results in increased air pollution.

### *2.5.2 Technological issues*

Technological barriers pose a very pertinent threat to adoption of Energy conservation, up gradation of current traditional process/operations and growth of the brick cluster in Varanasi. These issues can largely be attributed to:

**I. Traditional outlook of industry**

Majority of the kiln owners have a closed outlook, choosing to look at only the immediate future rather than long term benefits and improvements. There is a fairly dominant mindset of working it till it breaks and an unwillingness to look at repercussions of kiln operations in terms of land degradation, energy conservation and pollution control.

**II. Lack of Research and Development in this sector**

There is a definitive void in development and existing facilities for Research and Development in this sector. Institutes in the past have been integral in facilitating technology transfers and improvement in the brick manufacturing cluster all over India, However there is need for continuous Research and Development associated processes (Green brick moulding) other than the thermal firing/cooling to encounter the problems whenever they may arise. Providing Technical support to this industry is key to keep them abreast with international best practices in brick making.

### *2.5.3 Financial issues*

The greater part of the entrepreneurs in the brick community cite lack of financial support and access to credit from financial institutions. Due to the current technology of the brick manufacturing process; i.e. its dependence on weather conditions, constant relocations and its modulus operandi, financial institutions are hesitant to offer a line of credit to interested and progressive kiln owners. Such is the disposition of the brick manufacturing process in this cluster, any major technology upheavals are almost always at a high cost measure, making it inaccessible to be owners without suitable financial interventions.

### *2.5.4 Shortage of Trained Manpower*

Varanasi brick cluster faces shortage of trained manpower at every level. There is a void of competent consultants and qualified masons for planning & supervision of kiln improvements and kiln construction/renovations respectively. The current state of process technology is such that there are no formal training options available to the managers and coal feeders.

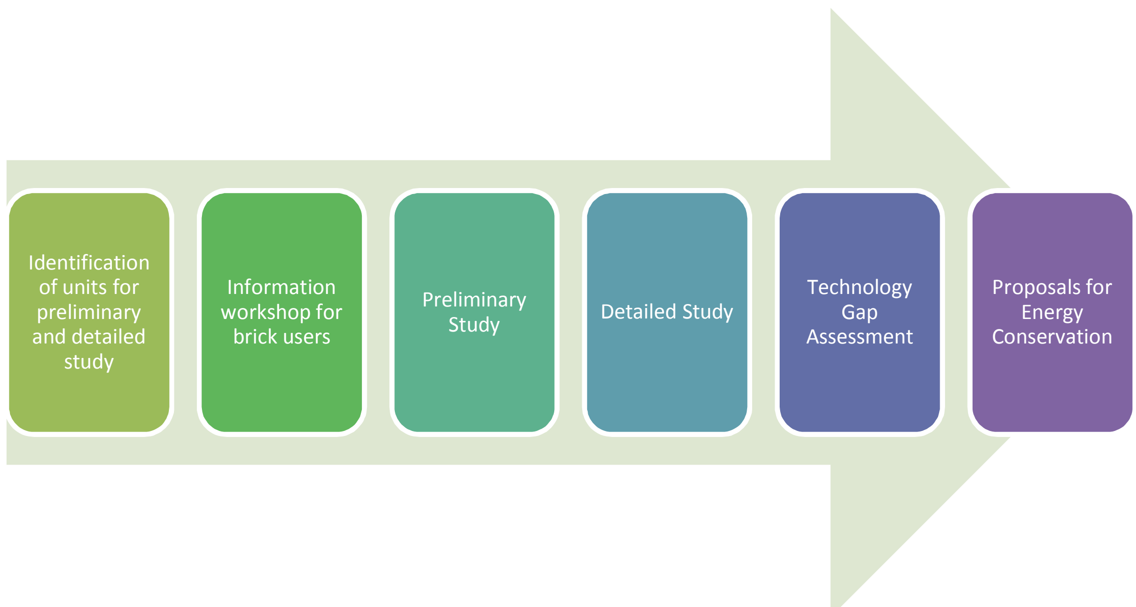
# 3. Energy audit and technology assessment

## 3.1 Methodology adopted for

### *3.1.1 Energy Use and Technical Study*

To determine the Energy use and technical study, individual units are identified within different clusters in the main Varanasi sector. It is integral to target different clusters as it accounts for deviations in soil properties, sourcing of raw materials, fuel, and variations in manufacturing and housekeeping operations. The overall step by step methodology followed for Energy use and technical study is as below:

**Figure 9: Methodology for Energy Use and Technical Study**




#### *3.1.1.1 Pre-Energy Audit Activities*

Before any activities take place at the brick manufacturing units within the cluster it is integral to create awareness and inform the brick owners associations about any proceeding goings on to be done within the cluster. This ensures cooperation from the individual brick manufactures and collective associations within the cluster.

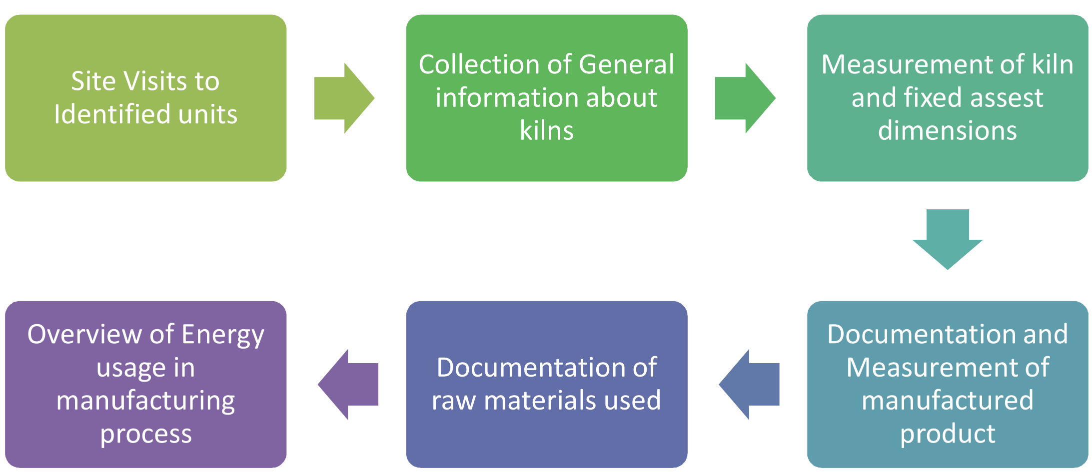
**Image 8: Pre Audit Workshop**

An Information and cooperation workshop was conducted in Varanasi, where invitations were extended to the brick owners/operators and the associations in the cluster to keep them abreast of the scheduled activities to take place in the cluster along with the programme outcomes, objectives and relevant stakeholders involved of the SME programme.

*3.1.1.2 Preliminary Energy study*

The preliminary study is the first stage in conducting an energy and technology assessment of the brick manufacturing units in the cluster. The aim of the preliminary study is collecting information relating to kiln operating and energy use to get an overview of energy sources, raw materials, processes involved, etc of the units within the cluster.

**Figure 10: Preliminary Audit Methodology**



Preliminary energy studies were conducted at 69 brick manufacturing units in the Varanasi cluster.

*3.1.1.3 Detailed Energy Study*

Detailed energy studies are conducted to get an in depth break up of energy usage of each of the associated processes in the operation of brick kilns. It covers the quintessential steps in preliminary study and provides a thorough analysis of the kiln functioning. Detailed Energy audits were conducted at 22 units with the team utilizing the following instruments:

- Flue-Gas Analyzer
- Thermocouple
- Basic dimension Measurement instruments
- Weighing Scale
- Laser Temperature Gun

To minimize errors in Measurement and Analysis, there are some guidelines which need to be maintained while analyzing and measuring the coal consumption of the unit.

a. Location of Combustion zone

The combustion/ firing zone should be in/along the straight position. If the fire is in the curved portion of the kiln the rate of fire travel is higher and therefore it adversely affects the accuracy of the results.

b. Regular loading of kiln during the study period

Ensure that the kiln has sufficient quantity of dry bricks (either already loaded or available for loading) and labor for loading of the kiln during the course of the trials.

c. Weekly off-day should not fall during the Study duration

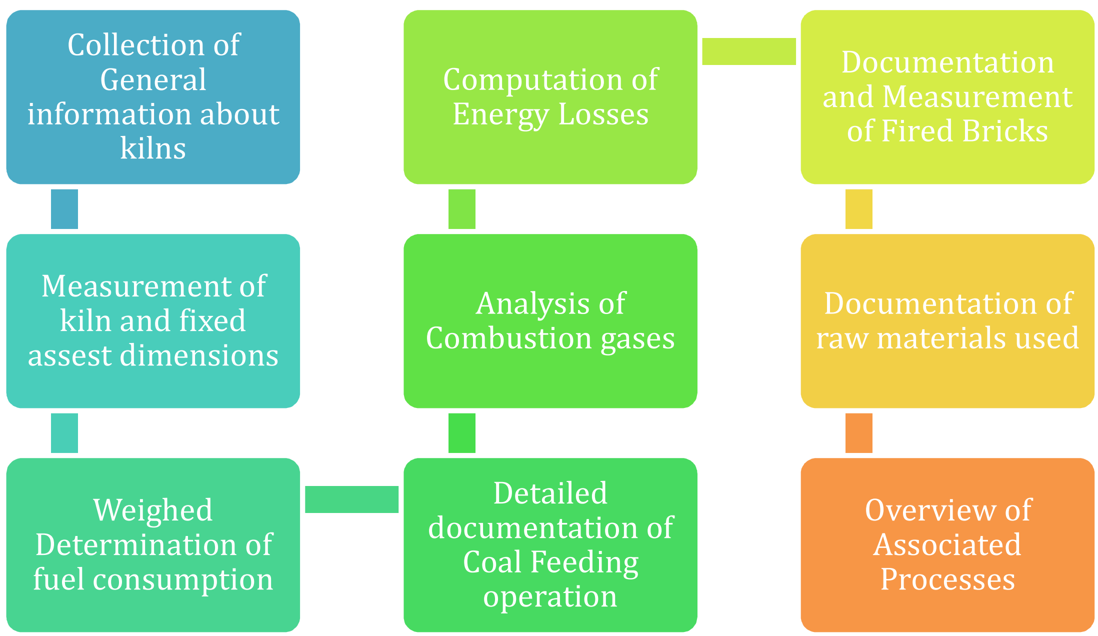
The kiln firing operation is a continuous process, taking place 24 hours, 7 days a week. The associated loading / unloading, moulding process workers are given a weekly day off. It is necessary to ensure the weekly off day does not fall during the study duration as it may affect the firing of the kiln.

d. Bad Weather

As the brick manufacturing operation in BTKs is open to weather, the precision of detailed study is affected by adverse weather conditions (rain, wind, storms, etc).

The methodology followed for conducting detailed energy studies at the brick manufacturing units in the Varanasi cluster is listed sequentially below.

**Figure 11: Detailed Audit Methodology**




## 3.2 Observations made during the energy use and technology studies carried out in the cluster

### *3.2.1 Manufacturing process and technology/equipments employed*

The bulk of the Manufacturing processes in a BTK are labor intensive with minimal mechanization. Observations made during on site studies are listed as per the process break up below:

**Figure 12: Process Observations**

**Clay Winning & Pugging**

- All operations (digging, mixing, etc) done manually using shovels.
- Very small percentage using excavators for digging
- Pathai Area approximately 60% of the Total Brick manufacturing area
- Approximately 10 people involved in this process
- Operation during early morning and late evenings

**Green Brick Moulding**

- Labor Intensive
- Done using PVC, Metal or Wooden moulds
- Manpower shared between Green Brick Moulding and Brick Drying Processes
- Operation during early morning and late evenings

**Brick Drying**

- Done in and around the Clay Winning and Green Brick Moulding area
- Stacked in horizontal and vertical stacks to maximise space utilization
- Process operation is continuous untill bricks are ready to be fired

**Firing and Cooling**

- Coal carried from storage to feeding area by 2-3 labors.
- Coal carried in baanks and used for filling typically 2 metal tubs, from which the coal feeders charge the coal in the combustion zone
- Baank and tub sizes vary by +/- 10-15 % in kilns within the clusters
- Coal feeders operate in 6 hour shifts
- Manual crushing/breaking of coal peices/ boulders
- Hand shovels used for coal feeding
- Hand shovel quantities vary from 0.5 - 1.5 kgs
- Feeding operation is carried out 24 hours

**Fired Brick extraction**

- Extraction process carried out in the morning and evenings
- Labor shared in loading and extraction process due to labor shortages
- Brick carried to and fro storage areas using mules, Rickshaws

Some of the deviations we observed during on site studies are listed below:

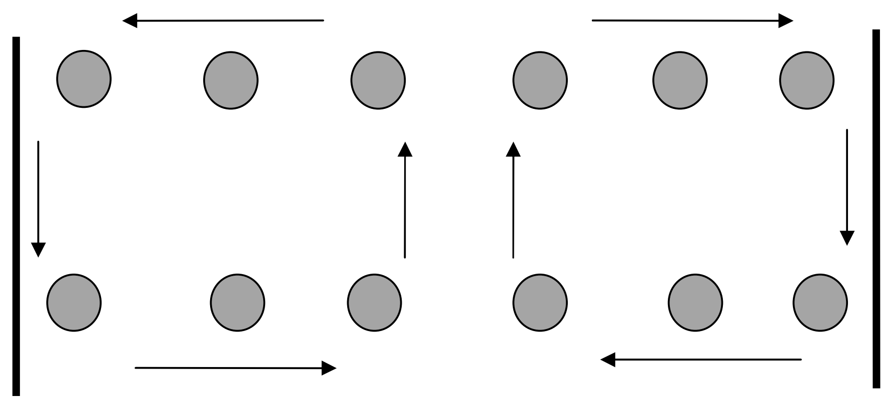
**Table 8: Deviations in Manufacturing Processes**

| S. No. | Deviations in Manufacturing Process / Technology/ Methodology | No. of units in the Cluster | Description |
|---|---|---|---|
| 1. | Clay Pugging Machine | 1 | • Mechanized operation<br>• Considerable Reduction in workforce<br>• Uniform mixture for green brick moulding<br>• Requires semi-trained workforce/ machine operators<br>• Efficient and streamlined operation with increased output |
| 2. | Induced Draft Fans | 4 | • Diesel Engine installed for Fan operation<br>• Longer cooling and pre heating zones<br>• Can be operated on Electricity |
| 3. | Zig-Zag Firing | 3 | • Requires continuous feeding of coal lines<br>• Smaller hand shovels used for feeding<br>• Smaller tub sizes and increase in the number of tubs by 2 per line fed. |
| 4. | Insulated Lids | 7 | • Insulated metal lids being used for covering feeding holes during coal feeding<br>• Reduction in Surface losses due to heat dissipation |
| 5. | Circular Brick Kilns | 7 | • Uniform Positioning of exhaust holes to lines being fed. |

### *3.2.2 Energy consumption profile & availability*

Over a 24 hour period the coal consumption is fairly uniform. Feeding operations take place intermittently at intervals of 30 – 90mins. The serving quantity of the hand shovels used for coal feeding is between 0.5 – 1.5 kgs and typically in one feeding operations about 5-10 feeding is done into a hole. The schematic below shows the coal feeding pattern in brick kilns using two man coal charging.

**Image 9: Coal Feeding Pattern**



To ensure the availability of coal in metal tubs for feeding operation in the combustion zone of the kiln, coal topped up regularly in the tubs by coal carriers using a *baank* (locally modified coal carrying containers).

### *3.2.3 Capacity utilization factor*

Individual unit capacity of the kiln depends upon the size of the kiln. Bull Trench Kilns are operated almost always at full capacity. It is not possible to alter the capacity of the kiln due to its unique process methodology i.e. if an unit has a capacity of 6 lac bricks per round; it is always operates at an maximum unit capacity.

Weather and labour conditions play a major role in the Annual capacity of brick manufacturing units. Annual capacity of individual units differ based on these two factors as it determines the duration the kiln is operated in one season. Currently only 60-70% of the units in this cluster are operating at full capacity; rest of the units are operating at 60% due to a late start this season.

### *3.2.4 Housekeeping practices*

Due to its characteristic disposition of the Bull Trench kiln, proper housekeeping practices are almost non-existent. This can be attributed largely to the brick kiln being open to environmental elements. The housekeeping practices typical to BTKs are listed below;

- Sealing of ducts, chimney and trench entrances during initial starting of kiln operations
- Daily laying of fly ash on top layer of brick stacking in the trench
- Timely sealing of firing holes in the combustion zones.

#### *3.2.5 Availability of data and information*

Information and data is not readily shared within this industry. Due to the closed and traditional outlook of greater majority of the kiln owners/operators, it takes some amount of persuasion to gain access to kiln operating information. There is also a widespread lack of recordkeeping within industry. This makes it hard to collect previous data regarding kiln operation and accurately form conclusions towards technology/ process upgrades and savings potential of these manufacturing units. It is tricky to verify the accuracy of actual coal consumption of these units due non prevalence of monitoring and verification documentation.

### 3.3 Technology gap analysis

After Review of the operational processes and the current technology within the Varanasi brick Cluster, the following observations in regards to process and technology were noted;

#### *3.3.1 Technology up-gradation*

- Non-existent suitable model/machines for green brick moulding which can be replicated
- Need for improved kiln design (Hoffman kiln, Tunnel kilns etc)

#### *3.3.2 Process up-gradation*

- No standardization/ engineering for Energy saving practices (i.e. use of shunts, draft measurement, temperature measurement)
- Non-existent standard practices for soil preparation / pugging
- Need for standardized methodology for coal feeding quantity and duration
- Development of methodology for pre-heating, and cooling zoning lengths

## 3.4 Energy conservation measures identified

### *3.4.1 Proposals for energy conservation including technology up-gradation*

Based on the Technology gap assessment the following measures/ technologies are considered viable and proposed for reducing the overall coal consumption of kilns. These measures and technology upgrades are listed as below:

1. Process Change from Straight line firing to Zigzag Firing
2. Best Practices in Coal Feeding/ Charging
3. Installation of Induced Draft Fans
4. Vertical Shaft Brick Kilns
5. Hoffman Kilns
6. Manufacture of Perforated Bricks

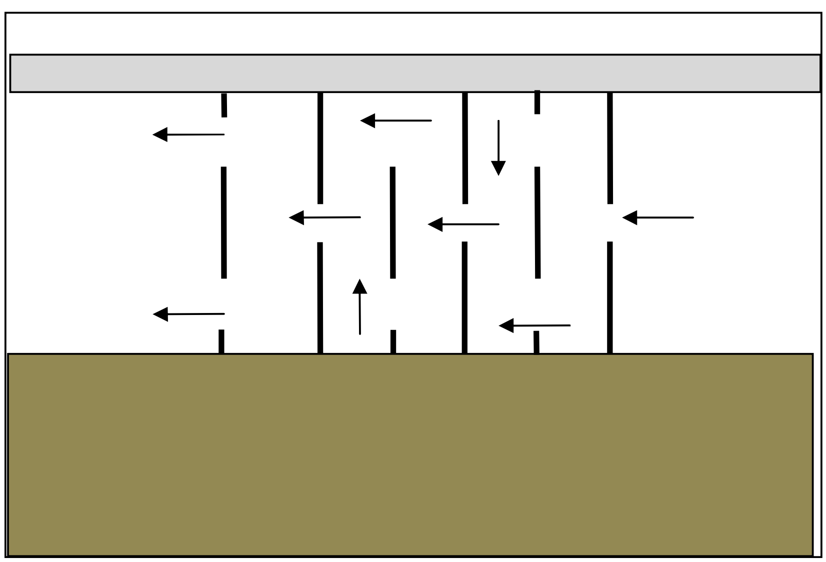
**Proposal 1: Process change from Straight line firing to Zig-Zag Firing**

**Description:**
During straight line feeding, coal is generally fed intermittently into 1-2 rows, with intervals between two successive feeding operations ranging from 30 – 60 minutes. The coal fed in each line is anywhere between 500grams – 1000grams per scoop. This type of coal feeding operation results in either or both of the occurrences listed below:

- Reduction in temperature of fuel bed, sometimes below ignition temperature
- Deepening of coal bed in the trench, and difficulties in diffusion of air in the fuel

In Zig-Zag mode of operation, the combustion zone is divided into 2-6 chamber (4 -12 lines) using partitioning green brick arrangement and the kiln is operated at a high draught for a fast rate of fire travel. The wall chamber runs along the width of the gallery except one end, where a space of 1.0ft is left for communication to the next chamber. The number of bricks per chamber depends upon the design capacity of the kiln and can vary anywhere from 5,400 – 10,000 bricks.
Zig-Zag firing kilns were at one time widely popular in developed countries like Australia and in Europe. These kilns are typically shorter in size (trench size, and overall kiln length) and have a longer combustion zone than straight line firing kilns.

**Image 10: Double Zig-Zag Firing Schematic**



**Benefits:**

1. Less Area Requirement
2. Typhoon Air circulation / higher turbulence in the air allows for better mixing of fuel and air resulting in better combustion
3. High firing rates results in shorter rounds of typically 15 days. This results in reduction in ground and structural losses
4. Reduction in surface heat losses.

**Table 9: Zig-Zag Firing Energy Savings Calculations:**

| Description | Value | Units |
|---|---|---|
| Average Annual Brick Production | 31.3 | Lac Bricks |
| Cluster Average Coal consumption Per Lac Bricks | 18 | Tonnes |
| Coal consumption Per Lac Bricks after adoption of Zig-Zag Firing | 13.5 | Tonnes |
| Kiln Average Annual Coal Consumption | 563.4 | Tonnes |
| Kiln Annual Coal Consumption after Zig-Zag Firing | 422.55 | Tonnes |
| Kiln Annual Coal Savings | 140.85 | Tonnes |
| Cluster Annual Coal Savings | 31,832.1 | Tonnes |
| Cluster annual Energy Savings | 729.5634 | Terajoules |

**Table 10: Zig-Zag Firing Cost Benefit Analysis**

| Description | Value | Unit |
|---|---|---|
| Cluster annual Coal Savings | 31832.1 | Tonnes |
| Average per tonne Cost of Coal | 5000 | INR |
| Annual Cluster Total Cost Savings | 159160500 | INR |
| Cost of Implementation per Unit | 721000 | INR |
| Recurring Costs | 36050 | INR |
| Cost of Implementation (Cluster) | 171093300 | INR |
| Simple Payback Period | 1.07 | Years |
| Typical lifecycle | 5-10 | Years |

**Table 11: Zig-Zag Firing Cost of Implementation**

| S.no. | Particulars | Cost |
|---|---|---|
| 1. | Cost of modification in Civil structure | Rs. 4.5 lack (Approx.) |
| 2. | Cost of Equipments | |
| a) | Feed hole covers – 100 nos. @Rs. 550/- | Rs. 55000/- (Approx.) |
| b) | Insulated Shunt – 2 nos. @ Rs. 25000/- | Rs. 50000/- (Approx.) |
| c) | Temperature gauge for Shunt – 2 nos. @ Rs. 1500/- | Rs. 3000/- (Approx.) |
| d) | Thermocouple – 1 set (includes 1 small and 1 big) | Rs. 10000/- (Approx.) |

| | | |
|---|---|---|
| e) | Temperature Indicator- 1 no. @3000/- | Rs. 3000/- (Approx.) |
| 3. | Cost of Consultancy and training to workers and supervisors | Rs. 150000/- |
| | Rupees Seven lack twenty one thousand only/- Total | Rs. 721000/- |

*Note: Proposals 1 with all its specifications can be adopted by majority of units in the cluster.*

**Issues /Barriers in Implementation**

1. Change in Stacking arrangement may not sit well with managers and labor used to traditional stacking methodology.
2. Bricks might remain too hot for handling at unloading point, due to fast firing of multiple chambers
3. Existing Brick kilns might have to be modified to accommodate Zigzag firing operation.
4. Lack of Consultants and technical support for implementation
5. Lack of Control Measures from Managers

**Environmental Benefits**

1. Reduction in fly ash due to incomplete combustion of coal
2. Reduction in GHG Emissions visible by reduction in black smoke coming out of chimney. (Typically 1.4 tonnes per ton of coal)
3. Reductions in CO emissions due to efficient combustion of the coal bed and diffusion with air.

**Proposal 2: Best Practices in Coal Feeding/ Charging**

**Description:**

During straight line feeding, coal is generally fed intermittently into 1-2 rows, with intervals between two successive feeding operations ranging from 30 – 60 minutes. The coal fed in each line is anywhere between 500grams – 1000grams per scoop. This type of coal feeding operation results in either or both of the occurrences listed below:

- Reduction in temperature of fuel bed, sometimes below ignition temperature
- Deepening of coal bed in the trench, and difficulties in diffusion of air in the fuel

Both the above cases result in incomplete combustion, signified by the distinctive black smoke observed coming out of the chimney. For achieving better combustion, following methodology for coal feeding should be adopted:

- Increase in number of fuel feeding lines from 1-2 to 3-5.
- Continuous charging/feeding of coal, instead of feeding intermittently
- Using smaller size spoons for feeding (500-700g/ scoop)
- Change in feeding pattern to single man feeding
- Use of Mechanized Coal Crusher to crush coal particle size to ~10mm
- Monitoring rate of fire travel and temperature profile within the combustion zone

**Benefits:**

Adoption of the above best practices in coal charging/ feeding would result in better/ efficient combustion of fuel in the combustion zone. This would lead to reduction in coal consumption. By monitoring the temperature of the pre heating lines and the current charging line, coal feeders are able to avoid overconsumption of coal, once the required temperature of 700 and 1000 degrees Celsius has been achieved in the pre heating and current feeding lines respectively.

**Table 12: Best Practices Energy Savings Calculations:**

| **Description** | **Value** | **Units** |
|---|---|---|
| Average Annual Brick Production | 31.3 | Lac Bricks |
| Cluster Average Coal consumption Per Lac Bricks | 18 | Tonnes |
| Coal consumption Per Lac Bricks after adoption of Best Practices | 16.3 | Tonnes |
| Kiln Average Annual Coal Consumption | 563.4 | Tonnes |

| | | |
|---|---|---|
| Kiln Annual Coal Consumption after adoption of Best Practices | 510.19 | Tonnes |
| Kiln Annual Coal Savings | 53.21 | Tonnes |
| Cluster Annual Coal Savings | 12025.46 | Tonnes |
| Cluster annual Energy Savings | 275.6128 | Terajoules |

**Table 13: Best Practices Cost Benefit Analysis**

| **Description** | **Value** | **Unit** |
|---|---|---|
| Cluster annual Coal Savings | 12025.46 | Tonnes |
| Average per tonne Cost of Coal | 5000 | INR |
| Annual Cluster Total Cost Savings | 60127300 | INR |
| Cost of Implementation per Unit | 100000 | INR |
| Recurring Costs | 5000 | INR |
| Cost of Implementation (Cluster) | 23730000 | INR |
| Simple Payback Period | 0.39 | Years |
| Typical Lifecycle | N/A | - |

*Note: Proposals 2 with all its specifications can be adopted by all units in the cluster.*

**Table 14: Best Practices Cost of Implementation**

| **S.no** | **Particulars** | **Cost (INR)** |
|---|---|---|
| 1. | Cost of modification in Civil structure | N/A |
| 2. | Cost of Equipment (shunts, insulated lids, etc) | 35,000 |
| 3. | Cost of Monitoring instruments (Thermocouple etc.) | 15,000 |
| 4. | Cost of Consultancy and training to workers and supervisors | 50,000 |
| | **Total** | **1,00,000** |

### Issues /Barriers in Implementation

1. Savings may vary kiln to kiln.
2. Lack of training at coal feeder/Manager level
3. Lack of awareness at Owner level
4. Lack of Training Facilities and Experts

### Environmental Benefits

1. Reduction in fly ash due to incomplete combustion of coal
2. Reduction in GHG Emissions visible by reduction in black smoke coming out of chimney. (Typically 1.4 tonnes per ton of coal)
3. Reductions in CO emissions due to efficient combustion of the coal bed and diffusion with air.

**Proposal 3: Installation of Induced Draft Fans**

**Description:**

At present majority of the brick manufacturing units operate with Natural draft within their chimneys. During the extreme hot summer season (March- June); the ambient air temperature is relatively similar to the temperature of the flue gases within the chimney. Due to the reduced temperature gradient between the chimney flue-gases and ambient air, there is a significant loss of pressure and slow propagation of fire travel within the kiln heating zones.

Installation of a Low hp Fan powered by an outside motor inside the chimney to increase the draft inside the firing zone ensures substantial exhaust gases draft within the kiln operational zones.

**Benefits:**

- Induced High Draft within the kiln increases the length of preheating zone and decreases the size of cooling zone, allowing for faster operation of kiln
- Increases Flue Gas heat recovery hence increasing the pre heating capacity of the kiln
- Reduction in coal consumption and structural losses due to better propagation of fire travel within the combustion zone.

**Table 15: Induced Draft Energy Savings Calculations:**

| Description | Value | Units |
|---|---|---|
| Average Annual Brick Production | 31.3 | Lac Bricks |
| Cluster Average Coal consumption Per Lac Bricks | 18 | Tonnes |
| Coal consumption Per Lac Bricks after installation of Induced Draft | 16.5 | Tonnes |
| Kiln Average Annual Coal Consumption | 563.4 | Tonnes |
| Kiln Annual Coal Consumption after Installation of ID Fan | 516.45 | Tonnes |
| Kiln Annual Coal Savings | 46.95 | Tonnes |
| Cluster Annual Coal Savings | 10610.7 | Tonnes |
| Cluster annual Energy Savings | 243.1878005 | Terajoules |

**Table 16: Induced Draft Cost Benefit Analysis**

| Description | Value | Unit |
|---|---|---|
| Average per tonne Cost of Coal | 5000 | INR |
| Annual Cluster Total Cost Savings | 53053500 | INR |
| Cost of Implementation per Unit | 170000 | INR |

| | | |
|---|---|---|
| Recurring Costs | 142200 | INR |
| Annual Cluster Net Savings | 20916300 | INR |
| Cost of Implementation (Cluster) | 38420000 | INR |
| Simple Payback Period | 1.836844949 | Years |
| Typical Lifecycle | <10 | Years |

*The Running cost of the ID fan is on basis of operation on Diesel Fuel and the current Tariff Rate of Diesel fuel in U.P. It is strongly recommended running the ID Fan on Electricity sourced from the Local/ State distribution agency.

The Table below encapsulates the Cost analysis of operating a ID Fan (15 Hp motor) on a LT electricity connection:

| **Description** | **Value** | **Unit** |
|---|---|---|
| U.P. Commercial Tariff Rate (Peak) | 5.4 | INR/ kWh |
| U.P. Commercial Tariff Rate (Off-Peak) | 4.3 | INR/kWh |
| U.P. Commercial Tariff Rate (Off-Peak other) | 3.45 | INR/kWh |
| Proposed load of ID Fan | 11.19 | kW |
| Other Demand Charges | Nil | |
| Yearly operating hours | 5040 | Hours |
| Yearly Units Consumed | 56,397 | kWh |
| Cluster Annual Units Consumed | 12745858 | kWh |
| Cluster Annual Electricity/Running Cost | 54807188 | INR |
| Cluster Annual Savings | 53053500 | INR |

**Table 17: Induced Draft Cost of Implementation**

| **S.no** | **Particulars** | **Cost** |
|---|---|---|
| 1. | Cost of modification in Civil structure (if Applicable) | INR 21500 |
| 2. | Cost of Fan Equipment | INR 98500 |
| 3. | Cost of Consultancy and training to workers and supervisors | INR 50000 |
| | **Total** | **INR 170000** |

**Issues /Barriers in Implementation**

1. Only suitable for kilns with low draft
2. May cause increase in Air leakages
3. Chimney modifications may be required

**Environmental Benefits**

1. Reduction in GHG emissions due to increase in combustion efficiency

**Proposal 4: Vertical Shaft Brick Kilns**

**Description:**

The brick manufacturing process in the Varanasi cluster is centered around the Bull Trench Kiln (BTK) and the associated processes supplementing the firing and cooling within the BTK. The Bull Trench Kiln is an oval/circular shaped brick kiln with its chimney usually in the middle. The trench is connected to the chimney by means of evenly spaced chambers along the trench. Brick Manufacture using Bull Trench kilns is an age old, traditional process, which is technologically outdated and kiln-owners encounter numerous problems due to inefficient operation of kiln including:

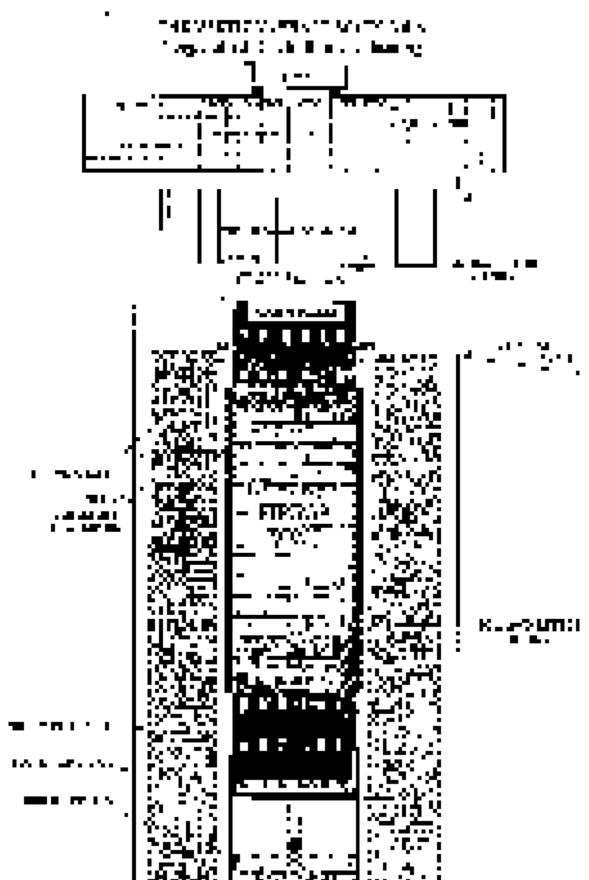
- Dependence on weather patterns
- Largely Labor intensive operations
- High pollutant emissions
- Fixed volume production

Vertical Shaft Brick kilns (VSBKs) consist of a vertical shaft of rectangular or square cross section. It works on the principle of counter current heat exchanger with, green bricks moving down (in intermittent movement) and air moving up (continuous flow).

Green bricks are loaded from the top with a powdered coal being put along the bricks on the top. The bricks move down the pre heating zone to the combustion zone which takes place in the middle of the shaft. Air for combustion enters from below through the cooling zone, where convective heat transfer takes place between the previously fired bricks and air. This hot air passes through the combustion zone in the middle and pre heats green bricks in the upper portion of the shaft (Pre Heating zone). Brick unloading is carried out from the bottom of the shaft using a trolley.

**Image 11: Vertical Shaft Brick Kiln**

**Image 12: VSBK Working Schematic**



Typically time between two unloading operations is 2-3 hours and the firing time varies between 20-30 hours.

**Benefits:**

- High energy efficiency
- Less polluting emissions
- Better and uniform quality of fired bricks compared to clamps
- Occupies less space - low land requirement
- Can work throughout the year subject to availability of green bricks
- Quick turnover; bricks are ready for sale after firing within two days of loading.
- Minimal maintenance requirements
- Flexibility in volume of production based on market demand
- Highly suitable where part of fuel is traditionally mixed with clay
- Construction and operation is easy to learn

**Table 18: VSBK Energy Savings Calculations:**

| Description | Value | Units |
|---|---|---|
| Average Annual Brick Production | 31.3 | Lac Bricks |
| Cluster Average Coal consumption Per Lac Bricks | 18 | Tonnes |
| Coal consumption Per Lac Bricks using VSBK | 13.9 | Tonnes |
| Kiln Average Annual Coal Consumption | 563.4 | Tonnes |
| Kiln Annual Coal Consumption after adoption of Best Practices | 435.07 | Tonnes |
| Kiln Annual Coal Savings | 128.33 | Tonnes |
| Cluster Annual Coal Savings | 29002.58 | Tonnes |
| Cluster annual Energy Savings | 664.713 | Terajoules |

**Table 19: VSBK Cost Benefit Analysis**

| Description | Value | Unit |
|---|---|---|
| Cluster annual Coal Savings | 29002.58 | Tonnes |
| Average per tonne Cost of Coal | 5000 | INR |
| Annual Cluster Total Cost Savings | 145012900 | INR |
| Cost of Implementation per Unit | 1446000 | INR |
| Recurring Costs | 72300 | INR |
| Cost of Implementation (Cluster) | 343135800 | INR |
| Simple Payback Period | 2.539 | Years |
| Typical lifecycle | 20 | Years |

*Note: Proposals 4&5 are mutually exclusive. Only one of them can be implemented at a time.*

**Table 20: VSBK Cost of Implementation**

| S.No. | Description | Cost (INR) | Remarks |
|---|---|---|---|
| 1 | Land | N/A | Lease / outright cost variable based on locality |
| 2 | Site Development | 50,000 | - Leveling/Filling<br>- Fencing/ Compound Walls<br>- Other/ Roads etc |
| 3 | Civil Works | 7,76,000 | - VSBK & chimney<br>- Site Office<br>- Hand Pump<br>- Water Storage tank<br>- Ramps & Others |
| 4 | Equipment | 1,20,000 | Mechanism w/ Kiln |
| 5 | Other Production Costs | 25,000 | Coal Crusher, etc |
| 6 | Running Costs | 5,00,000 | |
| | **Total Cost:** | **14,46,000** | |

**Issues /Barriers in Implementation**

1. Due to Fast Firing and Cooling, bricks do not produce the signature metallic sound or red color, typical of the bricks manufactured in this area. This may lead to difficulties in marketing and sales
2. VSBK was previously adopted by one entrepreneur. The manufacturing unit subsequently shut down due to the above reason.
3. Due to fast firing and cooling, strength of fired bricks is typically lower than those fired from BTKs

**Environmental Benefits**

1. Reduction in GHG emissions due to increase in combustion efficiency

**Proposal 5: Hoffman kilns**

**Description:**

The brick manufacturing process in the Varanasi cluster is centered around the Bull Trench Kiln (BTK) and the associated processes supplementing the firing and cooling within the BTK. The Bull Trench Kiln is an oval/circular shaped brick kiln with its chimney usually in the middle. The trench is connected to the chimney by means of evenly spaced chambers along the trench. Brick Manufacture using Bull Trench kilns is an age old, traditional process, which is technologically outdated and kiln-owners encounter numerous problems due to inefficient operation of kiln including:

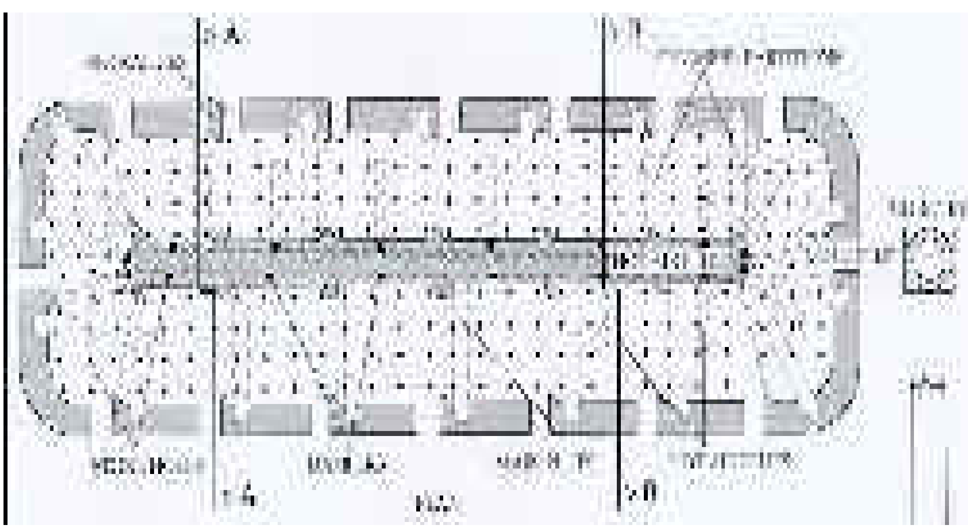
- Dependence on weather patterns
- Largely Labor intensive operations
- High pollutant emissions
- Fixed volume production

Hoffman Kilns are large oval shaped kilns built entirely of building bricks with a number of simple cast iron and steel non structural components. The kiln consists of a central chimney, approximately 150 – 200 feet high, connected to a main flue running the length of the kiln. On either side of the main flue there are anywhere between 16-24 barrel-arched firing chambers, each linked to the main flue via damper controlled under floor 'steam flues'. The capacity of individual chambers ranges between 20,000 – 30,000 bricks. These chambers are connected by small tunnels known as fire trace holes, through dividing walls just above ground level. Fuel (Coal) is added to each chamber through small opening in the roof. Larger opening allow control of temperature by introducing ambient air inflow.

**Image 13: Hoffman Kiln Side View**

Hoffman kilns are continuous kilns operating 24 hours a day and can be operated for 365 days provided enough stock of green bricks is maintained. Once Fired, the fire moves progressively from one chamber to another, with the bricks undergoing drying, pre-heating, firing and cooling in turn. The whole process is controlled manually by manipulating dampers and sliders. Thermocouples are also used to measure the temperature profile of the chambers.

**Image 14: Layout Plan of a Hoffman Kiln**



Sufficiently dried green bricks are set in a chamber and the entrance is bricked up and sealed. Hot air conveyed from cooling bricks in one chamber is used for pre heating the adjacent chamber. Once a temperature of 700 degree Celsius has been reached in the preheating chamber, caps in the roof are opened for subsequent coal charging in the chamber. Bricks are fired at temperatures of usually around 1000 degree Celsius for a period of 30 hours or until the next pre heating chamber is ready. These bricks are then allowed to cool before they are taken out and new green bricks are loaded in. This process cycle starts over again and takes about 10-15 days to complete.

The process methodology of a Hoffman kiln is very similar to a Bull Trench Kiln in relation to zoning and firing.

**Benefits:**

- Shorter Firing Cycles
- Can be operated all year round provided sufficient stock pile of green bricks
- Significantly lower Structural Heat losses due to absorbing roof on top of each chamber (Top structure losses account for 5-10% of heat losses in a BTK)
- Significantly reduced local air pollution due to reduced consumption of coal.
- Longer operational life ~20 years

**Table 21: Hoffman Kiln Energy Savings Calculations**

| Description | Value | Units |
|---|---|---|
| Average Annual Brick Production | 31.3 | Lac Bricks |
| Cluster Average Coal consumption Per Lac Bricks | 18 | Tonnes |
| Coal consumption Per Lac Bricks using Hoffman Kiln | 14 | Tonnes |
| Kiln Average Annual Coal Consumption | 563.4 | Tonnes |
| Kiln Annual Coal Consumption after adoption of Best Practices | 438.2 | Tonnes |
| Kiln Annual Coal Savings | 125.2 | Tonnes |
| Cluster Annual Coal Savings | 28295.2 | Tonnes |
| Cluster annual Energy Savings | 648.500 | Terajoules |

**Table 22: Hoffman Kiln Cost Benefit Analysis**

| Description | Value | Unit |
|---|---|---|
| Cluster annual Coal Savings | 28295.2 | Tonnes |
| Average per tonne Cost of Coal | 5000 | INR |
| Annual Cluster Total Cost Savings | 141476000 | INR |
| Cost of Implementation per Unit | 6000000 | INR |
| Recurring Costs | 300000 | INR |
| Cost of Implementation (Cluster) | 1423800000 | INR |
| Simple Payback Period ** | 18.40 | Years |
| Typical Lifecycle | 20 | Years |

*Note : Proposals 4&5 are mutually exclusive. Only one of them can be implemented at a time.*

*** Pay Back Period does not take into account additional revenue from increase in manufactured product*

**Table 23: Hoffman Kiln Cost of Implementation**

| S.No. | Description | Cost (INR) | Remarks |
|---|---|---|---|
| 1 | Construction Costs | 45,00,000 | - Leveling/Filling<br>- Fencing/ Compound Walls<br>- Other/ Roads etc<br>- Hoffman Chimney |
| 4 | Other Production Costs | 15,00,000 | Coal Crusher, Steel reinforcements for Air ducts, etc |
| | **Total Cost:** | **60,00,000** | |

**Issues /Barriers in Implementation**

1. Lack of supporting regulation, fiscal incentives and standards to encourage energy efficient practices and technology
2. Lack of skilled manpower
3. Cluster Industry absorption capacity to new technology is low
4. Financial Barriers due to very high investment costs
5. Lack of Consultants and Agencies within the cluster

**Environmental Benefits**

1. Reduction in GHG emissions due to increase in combustion efficiency

**Proposal 6: Manufacture of Perforated Bricks**

**Description:**
In the current Scenario there is only one brick manufacturer making perforated bricks in the entire cluster. Solid Brick products are gradually being replaced worldwide by perforated brick products. This is due to increasing awareness among consumers and manufacturers, along with technological advances in brick manufacture. The worldwide brick industry is looking towards reducing raw materials and wastages by means of developing and manufacturing perforated bricks. In developing countries like India, there is an ongoing debate and underlying effort to reduce land usage used for brick manufacture rather than use it for agriculture to feed our masses.

Perforated bricks are bricks with perforation made on the longer dimension face of the brick between 30 – 45% of total brick face area. These bricks are extruded by means of appropriate extruding machining tools and machinery.

**Benefits:**
1. Lowering rate of consumption of top soil (about 30%)
2. Reduced fuel requirements (about 20%) for brick firing
3. Reduced $CO_2$ emissions
4. Improved crushing strength (more than 200 kg/cm2) and reduced water absorption (around 10%) compared to handmade bricks
5. About 5–7% reduction in construction costs
6. About 5% saving in energy bill with reduced heating/cooling loads due to improved insulating properties.

**Table 24: Perforated Bricks Energy Savings Calculations**

| Description | Value | Units |
|---|---|---|
| Average Annual Brick Production | 31.3 | Lac Bricks |
| Cluster Average Coal consumption Per Lac Bricks | 18 | Tonnes |
| Coal consumption Per Lac Bricks using Hoffman Kiln | 14.4 | Tonnes |
| Kiln Average Annual Coal Consumption | 563.4 | Tonnes |
| Kiln Annual Coal Consumption after adoption of Best Practices | 450.72 | Tonnes |
| Kiln Annual Coal Savings | 112.68 | Tonnes |
| Cluster Annual Coal Savings | 25465.68 | Tonnes |
| Cluster annual Energy Savings | 583.650 | Terajoules |

**Table 25: Perforated Bricks Cost Benefit Analysis**

| Description | Value | Unit |
|---|---|---|
| Cluster annual Coal Savings | 25465.68 | Tonnes |
| Average per tonne Cost of Coal | 5000 | INR |
| Annual Cluster Total Cost Savings | 127328400 | INR |
| Cost of Implementation per Unit | 4100000 | INR |
| Recurring Costs | 205000 | INR |
| Cost of Implementation (Cluster) | 972930000 | INR |
| Simple Payback Period | 11.439 | Years |

*Note Proposal 6 can be adopted by all the units in the cluster.*

*** Pay Back Period does not take into account additional revenue from increase in manufactured product*

**Table 26: Perforated Bricks Cost of Implementation**

| S.No. | Description | Cost (INR) | Remarks |
|---|---|---|---|
| 1 | Extrusion machine including Civil Works | 29,50,000 | - *Weathering Tank<br>- Loading Platform<br>- Machinery Shed<br>- Water storage tank<br>- Office etc |
| 2 | Preliminary and Pre-operative Studies | 4,50,000 | • Personnel training<br>• Feasibility Studies<br>• Start up expenses etc |
| 3 | Others including Running costs | 7,00,000 | |
| | **Total Cost:** | **41,00,000** | |

### Issues /Barriers in Implementation

1. Under developed market for perforated bricks
2. Present Technologies favor production of solid bricks
3. Lack of technical support for adoption of perforated bricks

### Environmental Benefits

1. Reduction in GHG emissions

### *3.4.2 Availability of technology/ product in local/national/international market*

**Table 27: Technology Availability**

| S. No. | Technology | Availability in Local Market | Availability in National Market | Availability in International Market |
|---|---|---|---|---|
| **1** | Process Change from straight line to Zigzag Firing | Available<br>• Being used in 3 units in within the Cluster | Available<br>• Widely used in different Brick Clusters all over India | Readily Available |
| **2** | Best Practices in Coal Charging/ Feeding | Available<br>• Being used in varying capacities in multiple units within the Cluster | Available<br>• Widely used in different Brick Clusters all over India | Readily Available |
| **3** | Induced Draft Fan | Available<br>• Being used in four units within the cluster<br>• Lack of Vendors for technology Implementation | Available<br>• Vendors available for technology Implementation | Available<br>• Vendors available for technology Implementation |
| **4** | Vertical Shaft Brick Kiln | Not Available<br>• Currently not being operated within the cluster | Available<br>• Operated in varying capacities along nationwide clusters | Available<br>• Widely operated in brick manufacturing units worldwide |
| **5** | Hoffman Kiln | Not Available<br>• Not being operated within the cluster<br>• Lack of Consultants and Vendors | Available<br>• Popular mode of operation in Southern Indian | Available<br>• Operated in brick manufacturing units in South East Asia and Oceania |
| **6** | Manufacture of Perforated Bricks | Available<br>• Currently operated in One unit within the | Available<br>• Operated in varying capacities | Available<br>• Popular mode of manufacture |

| S. No. | Technology | Availability in Local Market | Availability in National Market | Availability in International Market |
|---|---|---|---|---|
| | | cluster | multiple units in Brick Cluster | of bricks |

### *3.4.3 Availability of local service providers who can take up abovementioned proposals*

The following Local Service Providers were identified to implement the abovementioned proposals to reduce the energy consumption in the Varanasi brick cluster

**A. Technical Local Service Providers**

**I. Bhagwat Technologies and Energy Conservation Pvt. Ltd**

Bhagwat Technologies and Energy Conservation is a leader in providing expert consultancy services in implementation of Vertical Shaft Brick kilns and technological step upgrades in the brick industry nationwide. They have a proven record of carrying out pollution control, and Energy Efficiency interventions in brick kilns.

**Company profile**

Bhagwat Technologies and Energy Conservation Private Limited (BTECON) is incorporated in 2002 as a Private Limited Company with registered and principal offices in Delhi.

BTECON's aim it to promote new and innovative ideas in the field of renewable energy, energy conservation and to educate the general public and other stakeholders about the economic benefits of using energy efficient products and renewable energy systems. Awareness generation is an important prerequisite, however, much more needs to be also done at implementation level. Our motto is thus not only to spread the ideas but also to contribute in the practical implementation of the ideas and help in solving the problems faced in technical and commercial development of energy conservation devices and technologies.

BTECON is an ISO- 9001: 2000 company working with following objectives and areas of operation:

- Energy conservation and management through energy planning in industrial, commercial, institutional, agricultural and domestic sectors.

- Energy audit for load management.
- Technology/Industry/Market analysis of Renewable Energy Products and systems.
- Consultancy in designing, developing and implementing energy efficient measures.
- Adoption and promotion of alternative/ renewable energy sources.
- Organizing seminars and conservation campaigning for energy and resource thrift.
- Conducting training program on energy management for educating and motivating the end users.
- Demand Side Management for energy economics and environment improvements through retro-fittings and re-engineering.
- PDD for CDM project

**Projects completed**

- Training cum Orientation Programme on Energy and Environment Performance Monitoring of Brick Kilns, Semi-Mechanization and Zigzag Firing conducted at Varanasi in association with Green tech Knowledge Solutions Varanasi( 2009)
- Energy audit of Jindal Mechno Bricks , Badali, Jhajhar, Haryana (2008)
- Training program for brick kiln operator in eastern UP in association with TERI.(2007)
- Technical feasibility study of Thermact-BR and energy audit of brick Kiln in Gaziabad (2007)
- Baseline development for CDM implementation in SW pipe (Priya klay ) factory. (2006)
- Energy efficiency Improvements in the Indian Brick Industry (NCR and Eastern UP Cluster) prepared for TERI/ MOEF. (2005)
- Energy audit and study of emission in production of Fal-G brick and burnt brick production for CER computation Sponsored by Neptune Clean Technology, Mehsana Gujarat. (2005)
- R&D on suitability of mixing fly ash with clay available in Haryana State for brick making in association of Punjab State council for Science and Technology (2004).
- Energy and Environment Audit of Priya Brick Co, Raghavpur, West Bengal (2003)
- Priya Klay Products, Electrical and Thermal Energy Audit (2002) and energy conservation study.

**Contact Details:**
*Anil Kumar*
*Chief Operating Officer*
Bhagwat Technologies & Energy Conservation Pvt. Ltd.
5,Millenium Business Centre, 34 Corner Market
Malviya Nagar, New Delhi-110017
**Web: www.btecon.com E-mail : ak@btecon.com**
**Tel: 26680036, 64513006 Mobile: 9891584175**

## II. Neptune Engineering

Neptune Engineering provides technical expertise and expert support in all aspects of Brick Manufacturing improvements in manufacturing processes. They offer retrofit and complete upheaval solutions in Energy Efficiency and Product management incorporating existing international technologies to the local industries.

**Company Overview**

Neptune Industries is a leading engineering and manufacturing company delivering Engineering Project Solutions to various industry segments. Neptune offers the world class designs, concepts & technologies with indigenous & economical proven solutions to provide client satisfaction through best quality service and timely delivery.

**Neptune's** engineering and manufacturing solutions are known for performance, innovative and economical production technologies and high reliability.

**Neptune** offers engineering project solutions along with Technical Services to diverse fields as:

- Ceramics Industry
- Fly Ash Technology
- Waste Recycling
- Agro-waste Panel Board
- Solar base Equipment Solutions
- Contract Manufacturing Services

**B. Managerial Local Service Providers**

**I. Int Nirmata Parishad (Varanasi brick association)**

Int Nirmata Parishad is the local association of Brick Manufacturers in Varanasi with National associations and partnerships. Previously the Association has been a driving force to implement Energy Efficiency in the brick manufacturing industry with emphasis on socio-environmental benefits.

**Organization Profile**

**Int Nirmata Parishad (INP)** is an association of brick makers of Varanasi district having its registered office at F-2(1), Ananta Colony, Nadesar, Varanasi. This association is formed by owner of brick kilns in Varanasi and has around 75 members. The association helps in facilitating its members with distribution of subsidized coal supplied under quota by the Government. The association act as a bridge between brick kiln owners and the government. INP played a major role in getting the "Samadhan Yojana" implemented which is a sale tax scheme only for brick kilns where the brick kiln owners pay a fixed amount of sales tax depending upon the capacity of their kilns.

They also facilitate any Govt. / Non Govt. agency working for brick sector development. In past they assisted TERI in implementation of Vertical Shaft Brick Kiln (VSBK) in Varanasi and organized Training/Workshops for owners of kilns. Int Nirmata Parishad also organizes technical events and seminar for energy efficiency in brick kilns sector.

The key members of the Int Narmata Parishad are:

A. Shri Kamla Kant Pandey – President
B. Shri Om Prakash Badlani – Vice President
C. Shri Hira Lal Yadav – Treasurer
D. Shri Shiv Prakash Singh – General Secretary
E. Shri Hiranand Lacmani – Secretary

**II. Prayag Bricks (Mr. O. P. Badlani)**

Prayag Bricks promoted by Shri O. P. Badlani is headquartered at S-4/32, A-1, Orderly Bazar, Varanasi – 221002, Uttar Pradesh. It is a 30 year old organization and has established it as one of Uttar Pradesh's leading manufacturers of high quality bricks (hand made & machine made) & decorative tiles. Prayag Bricks is the only company in the

Varanasi district which is producing perforated bricks and decorative tiles.

Its products stand apart from rest in the states on account of different factors which are:

- Latest brick kiln technologies
- Exclusive firing techniques & practices.
- Quality maintenance & upgradation
- Latest manufacturing machinery
- Assurance of best services

Prayag Bricks makes bricks with trade marks "Prayag & Puja", which are now proven names in quality bricks. According to the market requirements and trends, Prayag Bricks has changed its manufacturing strategies & design to suit the needs of time as well as customers

Prayag Bricks manufactures latest and wide range of decorative roofing and wall tiles of high quality. These tiles prove true to the expectation of the customers. Prayag Bricks makes use of best quality raw material and latest manufacturing technology.

Prayag Bricks also manufactures extruded wire cut **Sewer Bricks (IS Code: 4885)** as per the Indian Standards specifications laid down by the government of India

## 3.5 Identification of technologies/equipments for DPR preparation

### *3.5.1 Justification (e.g. potential, replicability, etc. in the cluster) for technologies/equipments identified for DPR preparation*

**Table 28: Justification and Replicability of identified Measures**

| S.No. | Technology | Availability | Potential for Energy Savings | Cost of Implementation | Environmental Benefits | Implementation Time | Replicability |
|---|---|---|---|---|---|---|---|
| **1** | Process Change from straight line to Zigzag Firing | High | Medium | Low | Medium | Low | Medium |
| **2** | Best Practices in Coal Charging/ Feeding | High | Medium | Low | Medium | Low | High |
| **3** | Induced Draft Fan | Medium - High | Low | Low - Medium | Low- Medium | Low | Medium |
| **4** | Vertical Shaft Brick Kiln ** | Medium - Low | High | Medium - High | High | Medium - High | Low |
| **5** | Hoffman Kiln | Low | Medium - High | High | Medium - High | Medium - High | Low |
| **6** | Manufacture of Perforated Bricks | Low - Medium | Medium | Medium - High | High | Medium - High | Low - Medium |

** Previously Implemented in Varanasi Cluster, operations shut down after 2 years of running in loss due to brick not having characteristic metallic sound and red color typical to bricks in the cluster

# 4. Environmental Benefits

## 4.1 Reduction in waste generation (if applicable)

During the initial firing at the start of the season, there is usually 30% wastage in manufactured brick product. In the subsequent firing rounds of the kiln this wastage in 5% till the end of the season. This wasted brick products is largely made up of broken or melted bricks which are not fit for market sale. This broken brick waste can be crushed into fine particles and used for concrete construction by means of a Crusher.

Additional waste from Bull trench kiln operation includes fly ash from incomplete combustion. This is recycled in the operation of Bull Trench Kilns by spreading and covering the top layer of the stacking arrangement in the trench for insulation purposes.

There is also the issue of degradation of land by digging up of top soil making it unsuitable for agriculture after the kiln operations cease. This is a very a very important concern in India where poverty is widespread.

Adoption of abovementioned proposals would reduce the amount of fly ash formed due to incomplete combustion and significant reduction in wasted fired bricks. Additional advantages are reduction in land degradation by reduction in un-usable brick wastage.

## 4.2 Reduction in GHG emission such as CO2, NOx, etc

There are significant reductions to be achieved in Green House Gas emission by adoption of the above proposals. Reduction in coal consumption translates into GHG reductions roughly to the order of 1.4 tonnes of GHG per ton of coal. The other benefits include, decrease in particulate pollution levels in kiln and surrounding area.

# 5. Conclusion

## 5.1 Summary of proposals for energy saving

**Table 29: Summary of Proposals for Energy Savings**

| S. No. | Proposal for Energy Savings | Technology Gap Assessment | Techno - Economics | | | | Barriers in Implementation | Shortli for DP |
|---|---|---|---|---|---|---|---|---|
| | | | Cost of Implementation including Running Costs(Cluster wide) (INR) | Cluster Annual Energy Savings (Thermal Tera joules) | Cluster Annual Monetary Savings (INR) | Simple Payback period (Years) | | |
| **1** | Process Change from straight line to Zigzag Firing | Manually operated process can be upgraded to automated/ mechanized process | 17,10,93,300 | 729.563 | 15,91,60,500 | 1.074 | 1. Change in Stacking arrangement may not sit well with managers and labor used to traditional stacking methodology.<br>2. Bricks might remain too hot for handling at unloading point, due to fast firing of multiple chambers<br>3. Existing Brick kilns might have to be modified to accommodate Zigzag firing operation.<br>4. Lack of Consultants and technical support for implementation<br>5. Lack of Control Measures from | Yes |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Managers | |
| **2** | Best Practices in Coal Charging/ Feeding | Manually Operated, can be upgraded to Automated/ Mechanized Process | 2,37,30,000 | 275.612 | 6,01,27,300 | 0.394 | 1. Savings may vary kiln to kiln.<br>2. Lack of training at coal feeder / Manager level<br>3. Lack of awareness at Owner level<br>4. Lack of Training Facilities and Experts | Yes |
| **3** | Induced Draft Fan | N/A | 3,84,20,000 | 243.187 | 5,30,53,500 | 1.83 | 1. Only suitable for kilns with low draft<br>2. May cause increase in Air leakages<br>3. Chimney modifications may be required | Yes |
| **4** | Vertical Shaft Brick Kiln ** | Capacity Limitations | 34,31,35,800 | 664.713 | 14,50,12,900 | 2.539 | 1. Due to Fast Firing and Cooling, bricks do not produce the signature metallic sound or red color, typical of the bricks manufactured in this area. This may lead to difficulties in marketing and sales<br>2. VSBK was previously adopted by one entrepreneur. The manufacturing unit subsequently shut down due to the above reason.<br>3. Due to fast firing and cooling, strength of fired bricks is typically | No |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | lower than those fired from BTKs | |
| **5** | Hoffman Kiln | Mechanization in Clay Preparation, and Coal Feeding. | 1,42,38,00,000 | 648.500 | 14,14,76,000 | 18.40 | 1. Lack of supporting regulation, fiscal incentives and standards to encourage energy efficient practices and technology<br>2. Lack of skilled manpower<br>3. Cluster Industry absorption capacity to new technology is low<br>4. Financial Barriers due to very high investment costs<br>5. Lack of Consultants and Agencies within the cluster | Yes |
| **6** | Manufacture of Perforated Bricks | Up-gradation to Automated Process Line | 97,29,30,000 | 583.650 | 12,73,28,400 | 11.439 | 1. Under developed market for perforated bricks<br>2. Present Technologies favor production of solid bricks<br>3. Lack of technical support for adoption of perforated bricks | Yes |

Note: Proposals 1 & 2, and 4 & 5 are mutually exclusive. If one of them is implemented, the other cannot be implemented in the same unit.

### 5.2 Summary of level of awareness on energy efficiency and energy efficient products in the cluster

The level of awareness on Energy Efficiency and Energy Efficient products is very low within this cluster. Brick kiln owners have a traditional outlook in this industry, and have a short term view of operations. There is also a lack of technical support and knowledge base for the unit owners to broaden and keep them abreast of National and International technologies/ improvements in the Brick industry.

## Pictorial Acknowledgements

*Image 1: Varanasi District Overview: Image accessed from http://www.topnews.in/law/varanasi-s-pandit-channulal-mishra-elated-receiving-padma-bhushan-award-25011 on 31/05/10*

*Image 11: VSBK: Image Accessed from http://www.cosmile.org/images/inside/brick4.jpg*

*Image 12: VSBK Schematic: Image Accessed from http://nzdl.sadl.uleth.ca/cgi-bin/library?e=d-00000-00---off-0hdl--00-0----0-10-0---0---0direct-10---4-------0-1l--11-en-50---20-about---00-0-1-00-0-0-11-1-0utfZz-8-00&a=d&c=hdl&cl=CL3.3&d=HASH01cf3c2f552f4f1812ac4ce9.2.4*

*Image 13: Side view of Hoffman Kiln: Image Accessed from http://www.lowtechmagazine.com/2009/10/hoffmann-kilns-brick-and-tile-production.html*

*Image 14: Layout of Hoffman kiln; Image accessed from http://www.cd3wd.com/cd3wd_40/GATE_DL/BUILDING/HK/EN/HK_FILES/FIGURE2B.GIF*

**Annexure–1: Detailed technology/equipment assessment report including the design technical specifications, in the format provided by BEE.**

Kiln Summary Report

**Heat balance**

| | MJ | % |
|---|---|---|
| Sensible heat in Brick | 348 | 1.1 |
| Energy in water vapor leaving the system | 2630 | 8.3 |
| Heat required for chemical reactions | 6684 | 21.1 |
| Dry flue gas loss | 4205 | 13.3 |
| Unaccounted (mainly structure + surface) | 17854.4 | 56.3 |
| Total heat input | 31722 | 100 |

| | | |
|---|---|---|
| Total heat input | 31721.6 | MJ |
| Kiln Efficiency | 29.4 | % |
| Coal CV | 6012 | 25.2 |
| Moisture in GB | 6 | % |
| Specific Energy consumption | 1.525547 | MJ/Brick |

(a)CALCULATION OF SENSIBLE HEAT LOSS IN FIRED BRICKS WITHDRAWN FROM THE KILN:

| | | |
|---|---|---|
| Total weight of fired Bricks (Kg) | 20794 | kg |
| Specific heat of clay bricks | 0.000836 | MJ/kg-oC |
| Average temperature of the fired bricks when withdrawn | 49.0 | oC |
| Average ambient temperature | 29 | oC |
| total sensible heat loss in unloaded pipesin MJ/dayi.e(Mfp*Cp,fp*(Tfp-Ta)) | 347.7 | MJ |
| % contribution | 1.1 | % |

(b)CALCULATION OF HEAT IN VAPOUR LEAVING THE SYSTEM:

(I)Energy in water vapour due to mechanical moisture in green bricks:

energy leaving with water vapour due to mechanical moisture=Weight of moisture* Cp,water *(100-Tload)*4.18KJ/Kg]+[weight of moisture*Lvap ]+[Weight of moisture * Cp,steam(Tfluegas-100)*4.18KJ/Kg]

weight of mechanical moisture removed per day from the pipes :(moisture %present *weight of green pipes loaded in the kiln(Kg/day)

| | | |
|---|---|---|
| Average % of moisture present | 4 | |
| loss on ignition(%) | 3.37 | |
| Weight of green Brick (Kg) | 20794 | kg |
| weight of mechanical moisture removed per day from the pipes | 831.74 | **Kg** |
| Average temperature of brick when loaded(Tload)(oC) | 29 | |
| Average temperature of flue gas at the exhaust(oC) | 197.0 | |
| Cp,water(1kcal/kg) | 1 | |
| Lvap(latent heat of vap)KJ/Kg | 2257 | |
| Cp,steam(Kcal/Kg) | 1.5 | |
| Energy leaving with water vapour due to mechanical moisture(kJ/day) | 2629949.6 | kJ |
| Energy leaving with water vapour due to mechanical moisturein MJ/day | 2629.9496 | MJ |
| % contribution | 8.2907196 | % |

Heat required for reaction

| | | |
|---|---|---|
| % of pure clay (^)=(Loss on ignition*100)/13.96 | 24.14 | |
| Specific heat of clay(Kcal/Kg) | 0.502 | |
| specific heat of silica(Kcal/Kg) | 0.264 | |
| Specific heat of green brick=[^ *0.502] +[(1-^)* 0.264] | 0.321 | |

| | | |
|---|---|---|
| Maximim temperature(Tmax)(oC) | 1020 | |
| Ambient temperature(Tamb)(oC) | 29 | |
| Cp of fired Bricks(kcal/Kg) | 0.2 | |
| Heat requited for reaction in MJ | 6684.189 | |
| % contribution | 21.071 | |
| Flue gas lossess | | |
| Approximate method (for O2%) | 0.95 *O2/(21-O2) | |
| O2% measured | 16.3 | |
| Exess air | 329.47 | % |
| Amount of fuel burned | 1260 | |
| Stociometric air equred | 6 | Kg/kg of coal |
| Amount of air flow in the kiln | 24907.787 | Kg |
| Average exit flue gas temperature | 197.0 | C |
| Specific heat of flue gas | 1.005 | kJ/kg-K |
| Dry flue gas loss | 4205.43 | MJ/day |
| % contribution | 13.26 | % |

## Annexure– 2: Details of technologies/services providers for the cluster

Details of Technology/ Service providers provided in Section 3.4.3 of Cluster Manual.

## Annexure–3: Quotations or techno-commercial bids from service/technology providers (Sample)

To,

Date:- 27-05-2010

Mr. Sanjay Rawat
Assistant Manager Energy Division
Feedback Ventures (Pvt.) Ltd.
Gurgaon.

Please find the Quotation for conversion of brick kiln from straight firing line to Zig-Zag Firing.

# Quotation

| S.NO. | Particulars | Cost |
|---|---|---|
| 1. | **Cost of modification in Civil structure** | Rs. 4.5 lack (Approx.) |
| 2. | **Cost of Equipments** | |
| a) | Feed hole covers – 100 nos. @Rs. 550/- | Rs. 55000/- (Approx.) |
| b) | Insulated Shunt – 2 nos. @ Rs. 25000/- | Rs. 50000/- (Approx.) |
| c) | Temperature gauge for Shunt – 2 nos. @ Rs. 1500/- | Rs. 3000/- (Approx.) |
| d) | Thermocouple – 1 set (includes 1 small and 1 big) | Rs. 10000/- (Approx.) |
| e) | Temperature Indicator- 1 no. @3000/- | Rs. 3000/- (Approx.) |
| 3. | **Cost of Consultancy and training to workers and supervisors** | Rs. 150000/- |
| | **Rupees Seven lack twenty one thousand only/- Total** | **Rs. 721000/-** |

**Note:-**

**1)** Cost of modification in Civil structure may be vary , its depend on kiln condition.
**2)** If modification required in chimney that's cost will be extra.

Thanking you,

Yours truly

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