DETAILED PROJECT REPORT
ON
FULLY MECHANISED (150 TPD)
(VARANASI BRICK CLUSTER)



Bureau of Energy Efficiency

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Making Infrastructure Happen

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ISTSL

FULLY MECHANISED
(150 TPD)

VARANASI BRICK CLUSTER

BEE, 2010

Detailed Project Report on Fully Mechanized Brick Kiln (150 TDP)

Brick SME Cluster, Varanasi, Uttar Pradesh (India)

New Delhi: Bureau of Energy Efficiency;

Detail Project Report No

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Feedback Ventures Pvt. Ltd.

Gurgaon

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List of Abbreviations

BEE	Bureau of Energy Efficiency
MoMSME-	Ministry of Micro Small & Medium Enterprise
BTK-	Bull's Trench kiln
IRR	Internal Rate of Return
DSCR	Debt Service Coverage Ratio
ROI	Rate on Investment
SIDBI	Small Industries Development Bank of India
TPD	Tonne per Day

Executive Summary

Bureau of Energy Efficiency (BEE) appointed Feedback Ventures Private Limited as the executing agency for brick cluster of Varanasi under BEE's SME programme. Under this project, the executing agency carried out studies in the brick cluster of Varanasi. Out of a total of 229 brick kilns, study was conducted in 67 units. Preliminary audits were undertaken in all the 67 units whereas detailed energy audits were conducted in 22 of these units.

Based on the energy audits, the executing agency submitted their report to BEE in form of a cluster manual with recommendations for energy conservation & savings potentials in the brick sector. Fully mechanized machine is one of the recommended technologies which can be installed in the unit and its installation will help in achieving the energy saving in brick industry.

Mechanized brick kilns utilize a number of machines along the brick manufacturing process to reduce the overall energy consumption, raw materials and labour used in the manufacturing process. Unit having production capacity more than 45 lakh brick per season are ideal for implementing the fully mechanized technique however, a fully mechanized machine of 150 TDP production capacity will save about 1200 tonne of coal per season.

This bankable DPR also found eligible for subsidy scheme of MoMSME for "Technology and Quality Upgradation Support to Micro, Small and Medium Enterprises" under "National Manufacturing and Competitiveness Programme". The key indicators of the DPR including the Project cost, debt equity ratio, monetary benefit and other necessary parameters are given in table below:

S.No	*Particular*	*Unit*	*Value*
1	Project cost	Rs. (in lakh)	505.00
2	Coal saving	tonne/year	1200
3	Monetary benefit	Rs. (in lakh)	147.69
4	Debit equity ratio	ratio	3:1
5	Simple payback period	Years	3.42
6	NPV	Rs. (in lakh)	143.31
7	IRR	%age	16.92
8	ROI	%age	18.91
9	DSCR	ratio	1.43
10	Procurement and implementation schedule	Month	10

The projected profitability and financial indicators shows that the project will be able to earn profit from inception and project is financially viable and technically feasible.

About BEE's SME Program

Bureau of Energy Efficiency (BEE) is implementing a BEE-SME Programme to improve the energy performance in 25 selected SMEs clusters. The brick cluster of Varanasi is one of them. The BEE's SME Programme intends to enhance the energy efficiency awareness by funding/subsidizing need based studies in SME clusters and giving energy conservation recommendations. For addressing the specific problems of these SMEs and enhancing energy efficiency in the clusters, BEE will be focusing on energy efficiency, energy conservation and technology up gradation through studies and pilot projects in these SMEs clusters.

***Major activities in the BEE -SME program are furnished below*:**

Energy Use and Technology Audit

The energy use technology studies would provide information on technology status, best operating practices, gaps in skills and knowledge on energy conservation opportunities, energy saving potential and new energy efficient technologies, etc for each of the sub sector in SMEs.

Capacity Building of Stake Holders in Cluster on Energy Efficiency

In most of the cases SME entrepreneurs are dependent on the locally available technologies, service providers for various reasons. To address this issue BEE has also undertaken capacity building of local service providers and entrepreneurs/ managers of SMEs on energy efficiency improvement in their units as well as clusters. The local service providers will be trained in order to be able to provide the local services in setting of energy efficiency projects in the clusters

Implementation of Energy Efficiency Measures

To implement the technology up gradation projects in clusters, BEE has proposed to prepare the technology based detailed project reports (DPRs) for a minimum of five technologies in three capacities for each technology.

Facilitation of Innovative Financing Mechanisms for Implementation of Energy Efficiency Projects

The objective of this activity is to facilitate the uptake of energy efficiency measures through innovative financing mechanisms without creating market distortion.

1 INTRODUCTION

1.1 Brief about the SME Cluster

About SME cluster

The Brick cluster selected under BEE's SME programme is located in Varanasi district. In Varanasi brick cluster, there are approximately 226 (Two hundred and twenty six) registered brick kilns operation within the greater Varanasi district. Out of these around 40% units are either closed or not in operation. These brick kilns have been classified into following clusters within the district:

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

Existing production process and technology

Although there are many brick production technologies existent but almost all the brick kilns in entire Varanasi cluster are of the traditional coal fired fixed chimney Bull's Trench Kilns (BTK) type, with fixed natural draft chimneys except a few kilns which are operating using induced draft fans for better airflow in the firing/ cooling zone.

Brick Production Process

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 1.1: Process flow chart of typical brick kiln 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.

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.

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.

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.

Firing and cooling

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

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.

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.

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.

Energy usage pattern

Bull's Trench Kiln is the only technology existent in the Varanasi brick cluster and coal is the main source of energy in this kind of technology. Majority of these kilns are using only coal as fuel however a few kilns are also using sawdust/ wood along with coal for firing of bricks. The consumption of other fuels is negligible as compared to the overall consumption of coal in the operation and energy usage of kilns in this cluster. Most of these units use a combination of coal types depending upon its availability and market price.

1.2 Energy performance in existing situation

1.2.1 Fuel and electricity consumption

The main fuel used for energy in brick industry is Coal. A few units within the cluster also use sawdust/ wood along 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 in brick kilns. Electricity is not used in the brick making process, although it is used for lighting purpose in the night in a few units. A typical unit in this cluster consumes approximately 558 tonne of Coal annually.

1.2.2 Average production

The brick production in a typical kiln depends upon firstly the size of the brick kiln and secondly the number of rounds completed within the season. The brick industry operates for around 7-8 months in a year (November to May) but it is highly dependent on the weather conditions. Cloudy or rainy conditions interrupt the process of brick making. On an average a typical unit in this Varanasi brick cluster produces 31 lakh bricks per annum.

1.2.3 Specific fuel consumption

Typically the energy consumption of brick manufacturing units is presented in terms of tonnes of fuel consumed for firing one lakh 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. The Specific Energy Consumption in this cluster is 1.1 to 1.5 MJ per kg of fired brick.

1.3 Identification of technology/equipment

The existing technology being used in this cluster is mainly the traditional coal fired fixed chimney Bull's Trench Kilns (BTK), with fixed natural draft chimneys. This main reason for the need of technology up gradation is that the existing technology a high coal consuming process. As per the results of the energy audits done in the cluster, a typical BTK consumes around 18 Tonne of coal for producing one lakh of bricks, which is very high compared to the other technology available.

1.3.1 Description of technology/equipment

A BTK is an oval or circular shaped brick kiln with its chimney usually in the centre. The trench is connected to the chimney by means of evenly spaced chambers along the trench. The outer wall has exit points for loading & Unloading of bricks. The firing & cooling process in a BTK comprises of three zones:

- Pre-heating zone
- Firing/ combustion zone
- Cooling zone.

Pre-heating zone is the area which is stacked with green bricks and utilizes the hot air coming from the firing zone for drying the green bricks by absorbing the moisture present in it.

Firing zone is the actual area where the firing takes place. In a straight line firing process, bricks are fired one line at a time at a temperature of around 900^0C - 1000^0C. The temperature is maintained by continuous feeding of coal at regular intervals until the bricks get ready. Once one line of brick is ready, its holes are closed and the firing is moved forward to the next line towards the pre-heating zone.

Cooling zone is the area where the firing has already taken place and the bricks are kept

for cooling before they are unloaded from the kiln. Since bricks are fired at a very high temperature, they take few days to cool down. Cooling time is lesser in the winter season compared to the summers due to the difference in the ambient temperature.

1.3.2 Role in process

The Combustion zone is the area where firing of bricks takes place. To achieve the desired properties of fired bricks the green bricks in this zone are heated at a temperature between 800 to1000 ^{0}C. 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.

1.4 Benchmarking for existing specific energy consumption

The baseline data has been established based in the energy audits conducted in a total number of 69 brick kilns out of which 47 were preliminary audits and 32 were detailed audits. These units were identified after conducting a meeting in November 2009 with the brick kilns owners with the cooperation of Int. Nirmata Parishad, the local brick makers association in Varanasi.

1.4.1 Design and operating parameters /specification

BTK has a circular or oval kiln circuit. The bricks to be fired are arranged in column setting. The fire is progressively moved round the kiln through the brick setting. Before entering the brick-firing zone, the air is preheated by exchanging heat with hot-fired bricks in the brick-cooling zone. Brick firing takes place in a narrow brick-firing zone; in which, coal is added manually from the holes provided in the roof of the kiln. The combustion products (hot flue gases) pass over the green bricks resulting in drying and preheating of bricks in the brick-preheating zone. The fire travel takes place in the direction of the airflow. Cooled fired bricks are removed from the brick cooling zone, while fresh green bricks are added in front of the brick preheating zone. A chimney stack provides the necessary draft. The below figure depicts the structure of a BTK.

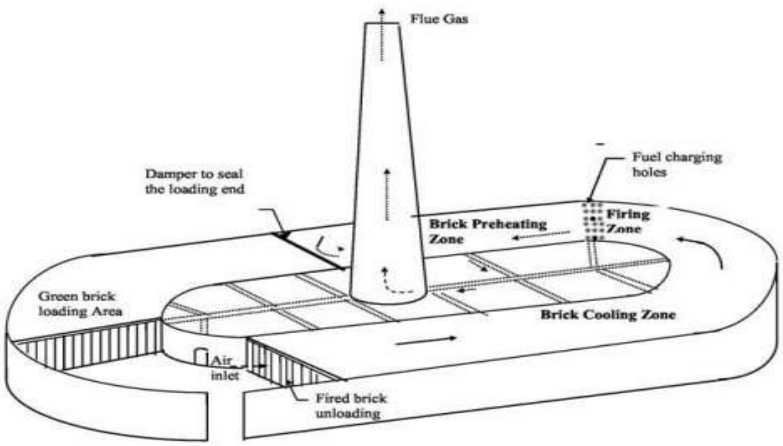


Figure 1.2: Typical structure of BTK

1.4.2 Operating efficiency analysis

To determine the Energy use and technical study, individual units were identified within different clusters in Varanasi district. 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 shown in Figure 3 below:



Figure 1.3: Energy auditing methodology

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. Preliminary energy studies were conducted at 47 brick manufacturing units in the Varanasi cluster and the time taken for each study was 45 - 90 minutes.

Detailed energy study

Detailed energy studies are conducted to get an in depth breaks 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. Since coal is the main source of fuel used, there are some guidelines which

need to be maintained while analyzing and measuring the coal consumption of the unit.

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.

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 labour for loading of the kiln during the course of the trials.

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.

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).

1.4.3 Specific fuel and electricity consumption

Based on the data collected from 79 units where the energy audits were conducted, the average specific fuel consumption in a typical brick kiln is being calculated to be 558 tonne of Coal for producing 31 lakh of bricks annually.

Electricity is not being consumed in operational process in a brick kiln, however it is used in some of the units for lighting purpose in the night for the coal feeders.

1.5 Barriers for adoption of proposed technology/equipments

1.5.1 Technological Barrier

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 the key to keep them abreast with international best practices in brick making.

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.

1.5.2 Financial Barrier

The greater part of the entrepreneurs in the brick community sites 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.

1.5.3 Manpower Skill

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.

1.5.4 Other losses (if any)

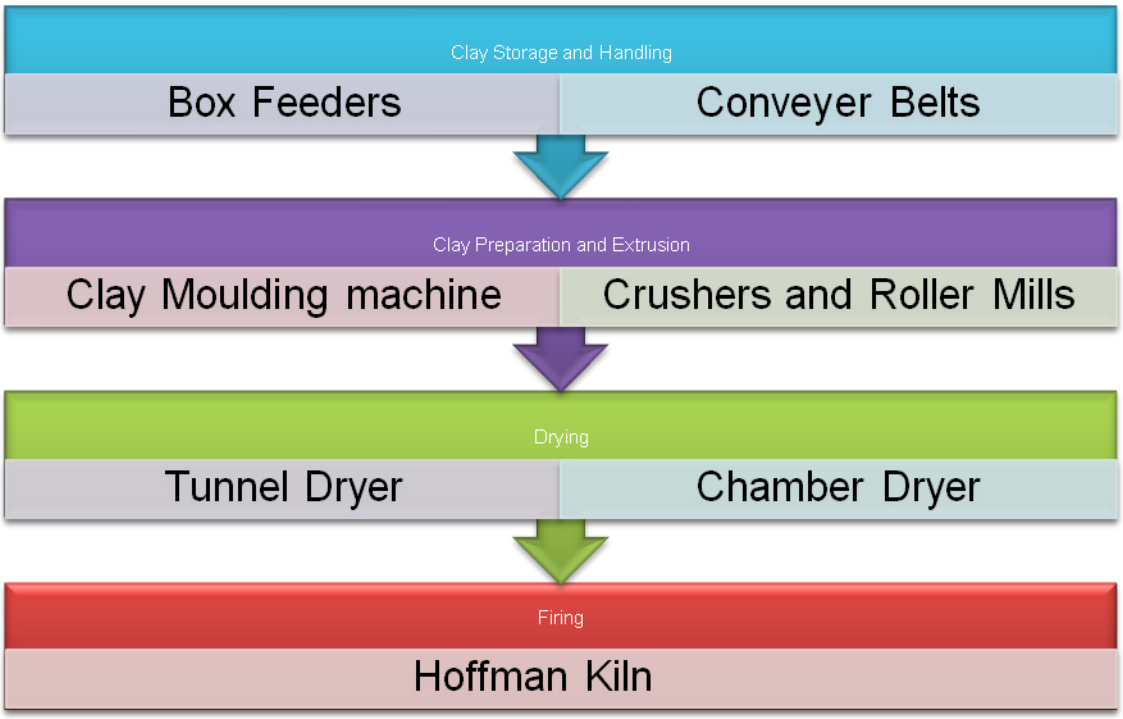
Brick industry is a labour intensive industry and major labour force working in Varanasi brick sector come from the neighbourhood states of Bihar, Jharkhand. The labour force goes back to their native places at the end of the season and their return to these brick kilns in the next season depends upon the financial deals given to them. Since there is no certainty about the labour coming back to the same kilns next season, labour remains a huge problem in the brick sector.

2 TECHNOLOGY OPTIONS FOR ENERGY EFFICIENCY IMPROVEMENTS

2.1 Detailed description of technology selected

2.1.1 Description of technology

Mechanized brick kilns utilize a number of machines along the brick manufacturing process to reduce the overall energy consumption, raw materials and labour used in the manufacturing process. The schematic diagram below illustrates the assortment of machines which may be used along the process value chain;



Integration of one or more of these machines in the brick manufacturing process yields visible benefits in the following areas:

- Significant energy consumption of the brick kiln
- Improved quality and quantity of the final product
- Reduction in raw materials and land degradation
- Greatly reduces the dependence on manual labour
- Significant increase in plant overall capacity
- Better working environment in the workplace and surrounding areas
- Significant reduction in pollution

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.

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.

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.

Brief descriptions of machines to be used along the process chain are given below:

Box Feeder

Box feeder is designed for even, continuous and controlled dosing and storage of material. Slat feeders are mainly used for handling wet material while rubber band feeders are more suitable for dry and dusty material. These box feeders are widely used not only in the ceramics industry but also in the chemicals and minerals sectors. An ideal range of sizes and configurations provides the flexibility and adaptability to suit all kinds of application. Their capacity can be as high as 142.5 m^3 with throughput of up to 130 m^3 hour.



Roller Mill

Roller mills are essential for grinding clays, but they can also be used for other minerals, a wide range of models allow for maximum adaptability to different applications, especially for secondary and tertiary grinding.



Grinding is accomplished by the combined forces of pressure and a tearing action created by the two rollers that turn in opposite directions at low operating and maintenance costs.

Primary Crusher

This equipment is suitable for the primary crushing of material from quarries and for reducing its original irregular size to uniform sizes of under 50 mm so that it may be properly batched and stored. Specially designed to accept non-ferrous material that contain moisture percentages of over 20%, which have a maximum hardness of 4 Months, and may even contain limited quantities of mineral of up to 5 Months.

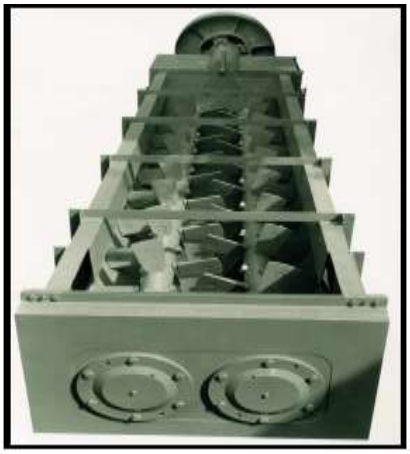
An ideal range of sizes and set-ups make them extremely flexible and adaptable to different applications and enabling production rates of up to 400 tonne per hour. These machines can be used in plants for treating clay, shale, bentonite, sepiolite, gypsum, coal, magnesite, phosphate, bauxite, and soft limestone, etc**.**



Mixer

Double shaft mixers are an important piece of equipment in the clay preparation process to help ensure uniformity between various types of clay, additives, and water. These mixers are available in different sizes that can achieve a throughput up to 180 tonne per hour.

These mixers achieve a high level of homogeneity due to their design. The arrangement of the mixing knives increases the blending effect by pressing the clay between the knives of both shafts.



Extrusion & Cutting

a. The extruder is built to minimise maintenance work and ensure perfect performance. They are manufactured using the most modern technology and design tools.

b. Some product highlights include:

- Independent drives for the mixer and extruder.
- A vacuum chamber that can be mounted at different positions.
- A high capacity mixer with easily accessible wear parts.
- Pre-compression mixing knives that are synchronized with the extrusion auger.
- Maximum accessibility to replace all wearable parts.
- An extrusion body with a self-supporting frame for direct installation onto the foundation.
- A mixing body with independent fastening support.



A wide range of sizes (auger diameters ranging from 400 to 750 mm) and arrangements allow for excellent flexibility and adaptability to different extrusion applications. The extruders can operate with the addition of water or steam and at low or high pressure.

2.1.2 Technology/equipment specification including fuel & electricity consumption

Details of fuel and electricity saving after adoption of proposed technology in a typical unit

of cluster having production capacity 150 TDP is shown in Table 2.1 below:

Table 2.1 Fuel & electricity saving

S.No.	Parameter	Unit	Value
	Existing scenario		
1	Coal consumption per lakh bricks	Tonne	25
2	Cost of brick	Rs. /brick	2.5
3	Total production capacity	Lakh	237
	Proposed scenario		
1	Coal consumption per lakh bricks	Tonne	20
2	Cost of brick	Rs. /brick	3.1
3	Total production capacity	lakh	237
4	Coal saving	Tonne/year	1200

2.1.3 Suitability or integration with existing process

Manual methods adopted for some processes in brick making can be easily replaced by fully mechanised techniques as the machines used are simple in operation and do not require any special training. The integration of these machines does not require any downtime in production and can be easily installed and set up during the months of in operation between July – November.

2.1.4 Superiority over existing technology/equipment

A fully mechanized technique is superior to the existing technique in multiple aspects from reduction in time and labour, to better homogeneity, standardization and quality of moulded bricks. A better quality green brick utilizes less energy to be fired into a manufactured brick and reduces losses and wastages. Fully – mechanised brick processes reduce the dependency on hired manual labour which are not always available and can be operated in the monsoon / winter season for stock-piling green bricks for the initial period leading to plant operation. Detail specific energy consumption is shown in Table 2.2 below:

Table 2.2 Specific energy consumption

S.No.	Kiln	Specific Energy Consumption (MJ/kg) fired product
1	Clamp (Biomass)	1.9
2	Clamp (Cole)	1.2 – 1.75
3	Moving chimney BTK	1.2 – 1.75
4	Fixed chimney	1.1 – 1.4
5	Zigzag	0.8-1.1
6	VSBK	0.7-1.0
7	Semi – Mechanised	1.1 – 1.25
8	Fully – Mechanised	0.3-0.5

2.1.5 Availability of technology/equipment

The technology and equipment for a fully - mechanized brick manufacturing process is available across India through vendor dealerships and stand alone manufacturers. Currently there is only one brick manufacturer in the Varanasi cluster employing this technology / equipment.

2.1.6 Source of technology/equipment for the project

The molding machine was invented by Gilbert, Barrie W. (Stonnall, GB2) in United States. This technique is widely popular in England since ages and other developed countries .It is being used in India sparsely usually in higher capacity kilns and in Plants manufacturing assortment of brick products using utilizing tunnel kilns and electric furnaces.

2.1.7 Service/technology providers

Neptune Industries is the local service providers in Varanasi and the neighbouring areas for implementation of this technology / process. They have a considerable experience in brick making utilizing mechanized equipment for brick manufacturing. Neptune industries have been forerunners in mechanization of brick manufacturing industry within India, they constantly review and research global technologies / equipments and their applicability in the Indian brick manufacturing scenario.

2.1.8 Terms of sales

Neptune industries would provide the necessary support required for sustainable implementation of technology and equipment in the existing brick kilns. They would also help the kiln owners and manufacturers in sourcing of equipment and details of transactions on case per case basis.

2.1.9 Process down time during implementation

The brick industry in Varanasi is not operational during the rainy season. In the months June to October, the operations related to manufacturing of bricks remain closed. This off season time can be utilized for retro-fitting works related to the installation of machinery

and training of workers to minimize the process downtime

2.2 Life cycle assessment and risks analysis

In case of a changeover from manually operated tasks to a fully - mechanized; there would be a singular change in operations and technology, thereafter the components may be replaced when required till the kiln is in operation. The risks associated as with any technological / equipment upgrade require training of machine operators, due diligence to equipment integration and after sale service from vendors.

2.3 Suitable unit/plant size in terms of capacity/production

The proposed technology cannot be integrated with previous brick kilns, use of this technology will result in production of 72000 bricks per day and 237 lakh per year with 330 working days, producing more than 6 times the capacity of BTK.

3 ECONOMIC BENEFITS DUE TO USAGE OF NEW EQUIPMENT

3.1 Technical benefits

3.1.1 Fuel savings per year

On the basis of field studies conducted in the Varanasi cluster and the technology gap assessment of available technology/ process up-gradations, the entrepreneurs can be convinced to adopt fully mechanized technology based on the information provided. Savings in a typical unit having production capacity about 150 TPD after adopting fully mechanized technique are tabulated in Table 3.1 below:

Table 3.1 Fuel saving per year

Energy Efficient Technology/ Measure	*Annual Coal Savings (tonne)*	*Annual Energy Savings (Tera joules)*
Technology change from manual to fully mechanised	1200	25.2

3.1.2 Improvement in product quality

A fully mechanized technique uses a moulding mill for the processes which are performed manually. A moulding machine provides brick of a sharper outline and more regular in shape. Overall using mechanized processes for brick preparation leads to better quality of brick output and less coal requirement for brick manufacture.

3.1.3 Increase in production

In a fully mechanized technique the production automatically improves since the work which was being done manually is replaced by machines. There is an increase in the quantity of bricks being manufactured and the quality of the end product.

3.1.4 Reduction in raw material consumption

The capacity of any machine is fixed at the time of its manufacturing and the quantity of the end product produced depends upon its capacity. So beyond the capacity it is not possible for a machine to work therefore the raw material required for manufacturing a specific product cannot exceed the capacity specification of the machine which reduces material loss.

3.1.5 Reduction in other losses

The major loss which is incurred in any manual process is the loss of energy of the workforce and the time that is consumed in the making process. These two losses are reduced to a great extent by the use of a fully mechanized technique. Another loss which

occurs in a manual process is the loss of a manufactured product due to the rejections, this type of loss is also mitigated in a fully mechanized operation since the processes done by a machine are subjected to least rejections.

3.2 Monetary benefits

Monetary savings in a typical unit after adoption of fully mechanized process has been estimated based on both monetary saving due to quality improvement and due to decrease in coal consumption. Saving due to improve in quality would be about Rs. 87.69 and saving due to decrease in fuel consumption would be about Rs. 60 lakh per year. Hence, total monetary saving due to implantation of fully mechanised brick kiln would be Rs. 147.69 lakh. Details of monetary saving are furnished in Table 3.2 below:

Table 3.2 Details of monetary saving

S.No.	Parameter	Unit	BTK	FMBK
	Quality Improvement			
1	Coal consumption per lakh Bricks	Tonne	25	20
2	Cost of Brick	Rs. /brick	2.50	3.1
3	Selling Price per Brick	Rs. /brick	3.13	4.1
4	Production capacity	lakh	237	237
5	Total manufacturing cost of brick*	Rs. (In lakh)	592.5	734.7
6	Total selling cost of brick*	Rs. (In lakh)	741.81	971.7
7	Profit	Rs. (In lakh)	149.31	237
8	Actual profit	Rs. (In lakh)	87.69	
	Decrease in Fuel consumption			
9	Total fuel saving	tonne	-	1200
10	Cost of coal	Rs. / tonne	5000	5000
11	Saving due to fuel consumption	Rs. (In lakh)	60.00	
12	Total monetary benefit	Rs. (In lakh)	147.69	

Note- *the production capacity of 237.00 lakh bricks is used as a benchmark for both the technologies because it's the annual production capacity of a 150 TPD Fully Mechanized Brick Kiln.

3.3 Social benefits

3.3.1 Improvement in working environment in the plant

With the adoption of a fully mechanized technique the rate of coal consumption decreases which in turn reduces the amount of pollution caused. It also leads to a smooth working condition in the plant since the excess workforce which is involved in the manual process reduces. The machines employed are user as well as environment friendly. This technique offers a healthy environment to its workforce.

3.3.2 Improvement in skill set of workers

In a fully mechanized plant the machinery that is used requires specially trained people for its operation, especially for the purpose of feeding the raw material. Thus adoption of this technique involves capacity building of the workforce and thereby improving their skills.

3.4 Environmental benefits

3.4.1 Reduction in effluent generation

Since the process is mechanized therefore the use of fossil fuel that is coal is reduced. The less consumption of coal solves a number of problems related to the environment. Since the coal usage reduces therefore the particulate emission is also decreased to a great extent. The generation of the harmful gases like CO_2, NOx and SOx also reduces.

3.4.2 Reduction in GHG emission such as CO_2, NOx, etc

The GHG emission also comes down by the use of a fully mechanized technique which provides a healthy environment to its workforce. Reduction in coal consumption translates into GHG reductions roughly to the order of 1.4 tonnes of GHG per tonne of coal which is 1680 tonne of CO_2 reductions per year. On a large scale if it is seen then the reduction in emissions helps in saving the nature.

3.4.3 Reduction in other emissions like SOx

SOx are a major pollutant which can even lead to the deadly acid rain, it causes a number of health problems and like every pollutant does it also has a negative impact on the environment. With the adoption of a fully mechanized technology the emission of SOx will reduce due to reduction of coal consumption.

4 INSTALLATION OF NEW ENERGY EFFICIENT EQUIPMENT

4.1 Cost of equipment implementation

4.1.1 Cost of equipments

The costs of equipments that will be required after adoption of fully mechanized technique are provided in table 4.1 below:

Table 4.1: Cost of and equipments/technology

Commercial Proposal for Brick Plant	
Items (Code)	**150 TPD**
Box Feeder	Rs. 1.6 Crore
Crusher	
Roller mill	
Mixer	
Extruder	
Cutting Unit & Automatic Loading/ Unloading System (04)	Rs. 0.25 Crore
Chamber Dryer	Rs. 0.4 Crore
Hoffman Kiln	Rs. 1.7 Crore
Grinding Group Of Fuel Coke (56)	Rs. 0.65 Crore
Cost of Electrical Installation	Rs. 0.40 Crore
Cost of Consultancy	Rs. 0.05 Crore
Total (Rs. in Crores)	Rs. 5.05 Crore
Note: 5% Extra charge on Total amount for Engineering and Technical Assistance (85) (17)	

4.1.2 Other costs

Cost of civil work and consultancy

There is no such cost of civil work involved in this particular technique. It just involves a change in the technology used; installation of machines, no special structure is required to be constructed for this technique. The consultancy cost associated is almost negligible, there is only the cost incurred in procurement of the machinery from the vendor.

Arrangements of funds

Proposed financing for the Fully Mechanized system-150 T is made considering a debt equity ratio of 3:1, which is normally allowed by financial institutions for financing energy efficiency projects. On the basis of debt equity ratio of 3:1 the promoter's contribution

works out to 25% of the project cost and the balance would be term loan from the Bank / FIs.

4.2 Financial indicators

4.2.1 Cash flow analysis

Detail cash flow analysis is shown in Annexure 5.

4.2.2 Simple payback period

Payback Period is less than 3.4 years.

4.2.3 Net Present Value (NPV)

Net Present Value of new project would work out Rs. 143.31 lakh.

4.2.4 Internal rate of return (IRR)

Internal Rate of Return (IRR) would be 16.92%.

4.2.5 Return on investment (ROI)

The average return on investment of the project activity works out at 18.91%.

4.3 Sensitivity analysis in realistic, pessimistic and optimistic scenarios

In different situation fuel saving may increase or decrease due to market fluctuations, external and internal mechanisms, weather dependency etc. To correctly estimate savings potential relevance to changing market scenarios for financial feasibility of projects it is necessary to conduct sensitivity analysis in realistic, pessimistic and optimistic scenarios as illustrated on the parameters below.

- Fuel saving increase by 10%
- Fuel saving decrease by 10%

Particulars	*IRR*	*NPV*	*ROI*	*DSCR*
In normal Condition	16.92	143.31	18.91	1.43
Fuel saving increase by 10%	18.13	169.50	18.98	1.49
Fuel saving decrease by 10%	15.70	117.12	18.84	1.37

4.4 Procurement and implementation schedule

Procurement and implementation required for implementation of this technology is about 10 month and their detail brake up are shown in Annexure 6.

Annexure – 1: Energy audit reports used for establishing Baseline Parameters

The results of 22 kilns detailed energy audit with heat balance is given below

Audit No. 1

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	192	0.8
Energy in water vapour leaving the system	MJ/1000 brick	751	3.3
Heat required for chemical reactions	MJ/1000 brick	6494	28.2
Dry flue gas loss	MJ/1000 brick	2027	8.8
Unaccounted (mainly structure + surface)	MJ/1000 brick	13547.6	58.9
Total heat input	MJ/1000 brick	23011	100
Total heat input	MJ/1000 brick	23010.9	-
Kiln Efficiency	%age	%age -	31.5
Coal CV	MJ/kg	20.9	-
Specific Energy consumption	MJ/kg Brick	1.20133	-

Audit No. 2

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	411	2.0
Energy in water vapour leaving the system	MJ/1000 brick	1022	5.0
Heat required for chemical reactions	MJ/1000 brick	6125	29.9
Dry flue gas loss	MJ/1000 brick	1603	7.8
Unaccounted (mainly structure + surface)	MJ/1000 brick	11318.3	55.3
Total heat input	MJ/1000 brick	20480	100
Kiln Efficiency	%age	-	34.9
Coal CV	MJ/kg	19.3	-
Specific Energy consumption	MJ/kg Brick	1.13476	-

Audit No. 3

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	223	1.7
Energy in water vapour leaving the system	MJ/1000 brick	952	7.4
Heat required for chemical reactions	MJ/1000 brick	3119	24.4
Dry flue gas loss	MJ/1000 brick	620	4.8
Unaccounted (mainly structure + surface)	MJ/1000 brick	7888.2	61.6
Total heat input	MJ/1000 brick	12802	100
Kiln Efficiency	%age	31.8	%
Coal CV	MJ/kg	25.3	-
Specific Energy consumption	MJ/kg Brick	1.39302	-

Audit No. 4

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	265	2.1
Energy in water vapour leaving the system	MJ/1000 brick	1239	10.0
Heat required for chemical reactions	MJ/1000 brick	3438	27.8
Dry flue gas loss	MJ/1000 brick	987	8.0
Unaccounted (mainly structure + surface)	MJ/1000 brick	6452.1	52.1
Total heat input	MJ/1000 brick	12382	100
Kiln Efficiency	%age	-	37.8
Coal CV	MJ/kg	23.1	-
Specific Energy consumption	MJ/kg Brick	1.17193	-

Audit No. 5

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	270	2.6
Energy in water vapour leaving the system	MJ/1000 brick	748	7.3
Heat required for chemical reactions	MJ/1000 brick	2966	29.0
Dry flue gas loss	MJ/1000 brick	583	5.7
Unaccounted (mainly structure + surface)	MJ/1000 brick	5647.3	55.3
Total heat input	MJ/1000 brick	10214	100
Kiln Efficiency	%age	-	36.4
Coal CV	MJ/kg	23.1	-
Specific Energy consumption	MJ/kg Brick	1.12068	-

Audit No. 6

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	232	2.4
Energy in water vapour leaving the system	MJ/1000 brick	991	10.1
Heat required for chemical reactions	MJ/1000 brick	2378	24.2
Dry flue gas loss	MJ/1000 brick	2314	23.6
Unaccounted (mainly structure + surface)	MJ/1000 brick	3908.6	39.8
Total heat input	MJ/1000 brick	9824	100
Kiln Efficiency	%age	-	34.3
Coal CV	MJ/kg	26.1	-
Specific Energy consumption	MJ/kg Brick	1.37874	-

Audit No. 7

Heat Balance			
Particulars	**Unit**	**Value**	**%age**
Sensible heat in Brick	MJ/1000 brick	146	1.3
Energy in water vapour leaving the system	MJ/1000 brick	1432	12.8
Heat required for chemical reactions	MJ/1000 brick	2973	26.6
Dry flue gas loss	MJ/1000 brick	1943	17.4
Unaccounted (mainly structure + surface)	MJ/1000 brick	4693.0	41.9
Total heat input	MJ/1000 brick	11188	100
Kiln Efficiency	%age	-	39.4
Coal CV	MJ/kg	21.2	-
Specific Energy consumption	MJ/kg Brick	1.25599	-

Audit No. 8

Heat Balance			
Particulars	**Unit**	**Value**	**%age**
Sensible heat in Brick	MJ/1000 brick	225	2.0
Energy in water vapour leaving the system	MJ/1000 brick	971	8.8
Heat required for chemical reactions	MJ/1000 brick	2945	26.7
Dry flue gas loss	MJ/1000 brick	448	4.1
Unaccounted (mainly structure + surface)	MJ/1000 brick	6429.8	58.4
Total heat input	MJ/1000 brick	11018	100
Kiln Efficiency	%age	-	35.5
Coal CV	MJ/kg	21.1	-
Specific Energy consumption	MJ/kg Brick	1.26851	-

Audit No. 9

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	809	3.3
Energy in water vapour leaving the system	MJ/1000 brick	1105	4.5
Heat required for chemical reactions	MJ/1000 brick	7545	30.8
Dry flue gas loss	MJ/1000 brick	899	3.7
Unaccounted (mainly structure + surface)	MJ/1000 brick	14176.0	57.8
Total heat input	MJ/1000 brick	24534	100
Kiln Efficiency	%age	-	35.3
Coal CV	MJ/kg	25.3	-
Specific Energy consumption	MJ/kg Brick	1.10234	-

Audit No. 10

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	2123	9.0
Energy in water vapour leaving the system	MJ/1000 brick	1323	5.6
Heat required for chemical reactions	MJ/1000 brick	6216	26.3
Dry flue gas loss	MJ/1000 brick	2305	9.8
Unaccounted (mainly structure + surface)	MJ/1000 brick	11675.3	49.4
Total heat input	MJ/1000 brick	23643	100
Kiln Efficiency	%age	-	31.9
Coal CV	MJ/kg	21.1	-
Specific Energy consumption	MJ/kg Brick	1.28942	-

Audit No. 11

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	476	1.8
Energy in water vapour leaving the system	MJ/1000 brick	1889	7.0
Heat required for chemical reactions	MJ/1000 brick	6440	24.0
Dry flue gas loss	MJ/1000 brick	921	3.4
Unaccounted (mainly structure + surface)	MJ/1000 brick	17158.8	63.8
Total heat input	MJ/1000 brick	26884	100
Kiln Efficiency	%age	-	31.0
Coal CV	MJ/kg	25.1	-
Specific Energy consumption	MJ/kg Brick	1.41533	-

Audit No. 12

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	532	1.7
Energy in water vapour leaving the system	MJ/1000 brick	2223	7.2
Heat required for chemical reactions	MJ/1000 brick	6623	21.5
Dry flue gas loss	MJ/1000 brick	1731	5.6
Unaccounted (mainly structure + surface)	MJ/1000 brick	19653.9	63.9
Total heat input	MJ/1000 brick	30764	100
Kiln Efficiency	%age	-	28.8
Coal CV	MJ/kg	25.6	-
Specific Energy consumption	MJ/kg Brick	1.48124	-

Audit No. 13

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	344	1.3
Energy in water vapour leaving the system	MJ/1000 brick	1723	6.5
Heat required for chemical reactions	MJ/1000 brick	5857	22.1
Dry flue gas loss	MJ/1000 brick	928	3.5
Unaccounted (mainly structure + surface)	MJ/1000 brick	17698.3	66.7
Total heat input	MJ/1000 brick	26550	100
Kiln Efficiency	%age	-	28.5
Coal CV	MJ/kg	21.2	-
Specific Energy consumption	MJ/kg Brick	1.50578	-

Audit No. 14

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	269	2.2
Energy in water vapour leaving the system	MJ/1000 brick	714	5.9
Heat required for chemical reactions	MJ/1000 brick	2935	24.2
Dry flue gas loss	MJ/1000 brick	419	3.4
Unaccounted (mainly structure + surface)	MJ/1000 brick	7816.5	64.3
Total heat input	MJ/1000 brick	12155	100
Kiln Efficiency	%age	-	30.0
Coal CV	MJ/kg	18.8	-
Specific Energy consumption	MJ/kg Brick	1.32041	-

Audit No. 15

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	189	1.6
Energy in water vapour leaving the system	MJ/1000 brick	811	6.7
Heat required for chemical reactions	MJ/1000 brick	3372	27.9
Dry flue gas loss	MJ/1000 brick	997	8.3
Unaccounted (mainly structure + surface)	MJ/1000 brick	6703.2	55.5
Total heat input	MJ/1000 brick	12071	100
Kiln Efficiency	%age	-	34.7
Coal CV	MJ/kg	21.4	-
Specific Energy consumption	MJ/kg Brick	1.15079	-

Audit No. 16

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	185	1.5
Energy in water vapour leaving the system	MJ/1000 brick	1081	8.7
Heat required for chemical reactions	MJ/1000 brick	2671	21.4
Dry flue gas loss	MJ/1000 brick	2016	16.2
Unaccounted (mainly structure + surface)	MJ/1000 brick	6516.5	52.3
Total heat input	MJ/1000 brick	12470	100
Kiln Efficiency	%age	-	30.1
Coal CV	MJ/kg	20.7	-
Specific Energy consumption	MJ/kg Brick	1.50059	-

Audit No. 17

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	177	1.7
Energy in water vapour leaving the system	MJ/1000 brick	770	7.5
Heat required for chemical reactions	MJ/1000 brick	2520	24.4
Dry flue gas loss	MJ/1000 brick	277	2.7
Unaccounted (mainly structure + surface)	MJ/1000 brick	6578.8	63.7
Total heat input	MJ/1000 brick	10322	100
Kiln Efficiency	%age	-	31.9
Coal CV	MJ/kg	25.2	-
Specific Energy consumption	MJ/kg Brick	1.31676	-

Audit No. 18

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	427	1.9
Energy in water vapour leaving the system	MJ/1000 brick	2270	9.9
Heat required for chemical reactions	MJ/1000 brick	6200	27.0
Dry flue gas loss	MJ/1000 brick	3044	13.3
Unaccounted (mainly structure + surface)	MJ/1000 brick	11018.7	48.0
Total heat input	MJ/1000 brick	22960	100
Kiln Efficiency	%age	-	36.9
Coal CV	MJ/kg	25.2	-
Specific Energy consumption	MJ/kg Brick	1.19035	-

Audit No. 19

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	348	1.3
Energy in water vapour leaving the system	MJ/1000 brick	2630	10.0
Heat required for chemical reactions	MJ/1000 brick	6684	25.3
Dry flue gas loss	MJ/1000 brick	4205	15.9
Unaccounted (mainly structure + surface)	MJ/1000 brick	12514.7	47.4
Total heat input	MJ/1000 brick	26382	100
Kiln Efficiency	%age	-	35.3
Coal CV	MJ/kg	20.9	-
Specific Energy consumption	MJ/kg Brick	1.3	-

Audit No. 20

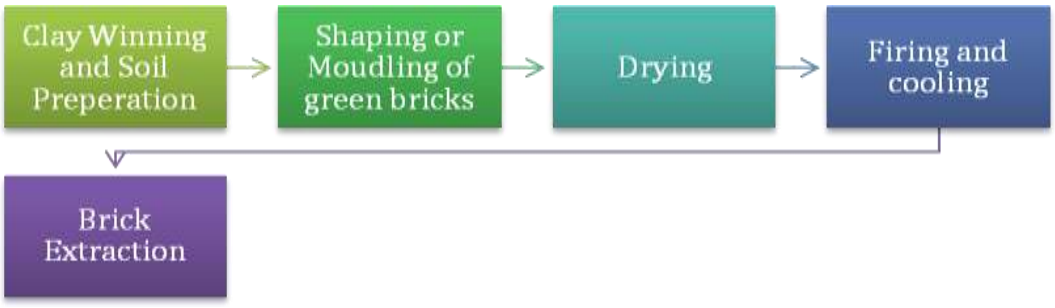
Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	485	1.6
Energy in water vapour leaving the system	MJ/1000 brick	2394	7.7
Heat required for chemical reactions	MJ/1000 brick	6213	20.0
Dry flue gas loss	MJ/1000 brick	2324	7.5
Unaccounted (mainly structure + surface)	MJ/1000 brick	19676.3	63.3
Total heat input	MJ/1000 brick	31092	100
Kiln Efficiency	%age	-	27.7
Coal CV	MJ/kg	25.2	-
Specific Energy consumption	MJ/kg Brick	1.60866	-

Audit No. 21

Heat Balance			
Particulars	***Unit***	***Value***	***%age***
Sensible heat in Brick	MJ/1000 brick	545	2.1
Energy in water vapour leaving the system	MJ/1000 brick	1433	5.6
Heat required for chemical reactions	MJ/1000 brick	5953	23.2
Dry flue gas loss	MJ/1000 brick	996	3.9
Unaccounted (mainly structure + surface)	MJ/1000 brick	16759.4	65.2
Total heat input	MJ/1000 brick	25687	100
Kiln Efficiency	%age	-	28.8
Coal CV	MJ/kg	22.9l	-
Specific Energy consumption	MJ/kg Brick	1.37827	-

Annexure– 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.



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.

Annexure – 3: Detailed Technology Assessment Report

The brick kilns technology in the entire Varanasi cluster are of the traditional coal fired fixed chimney Bull's Trench Kilns (BTK) type, where all the activities are performed manually.

Proposed Technology from manual work to fully mechanized

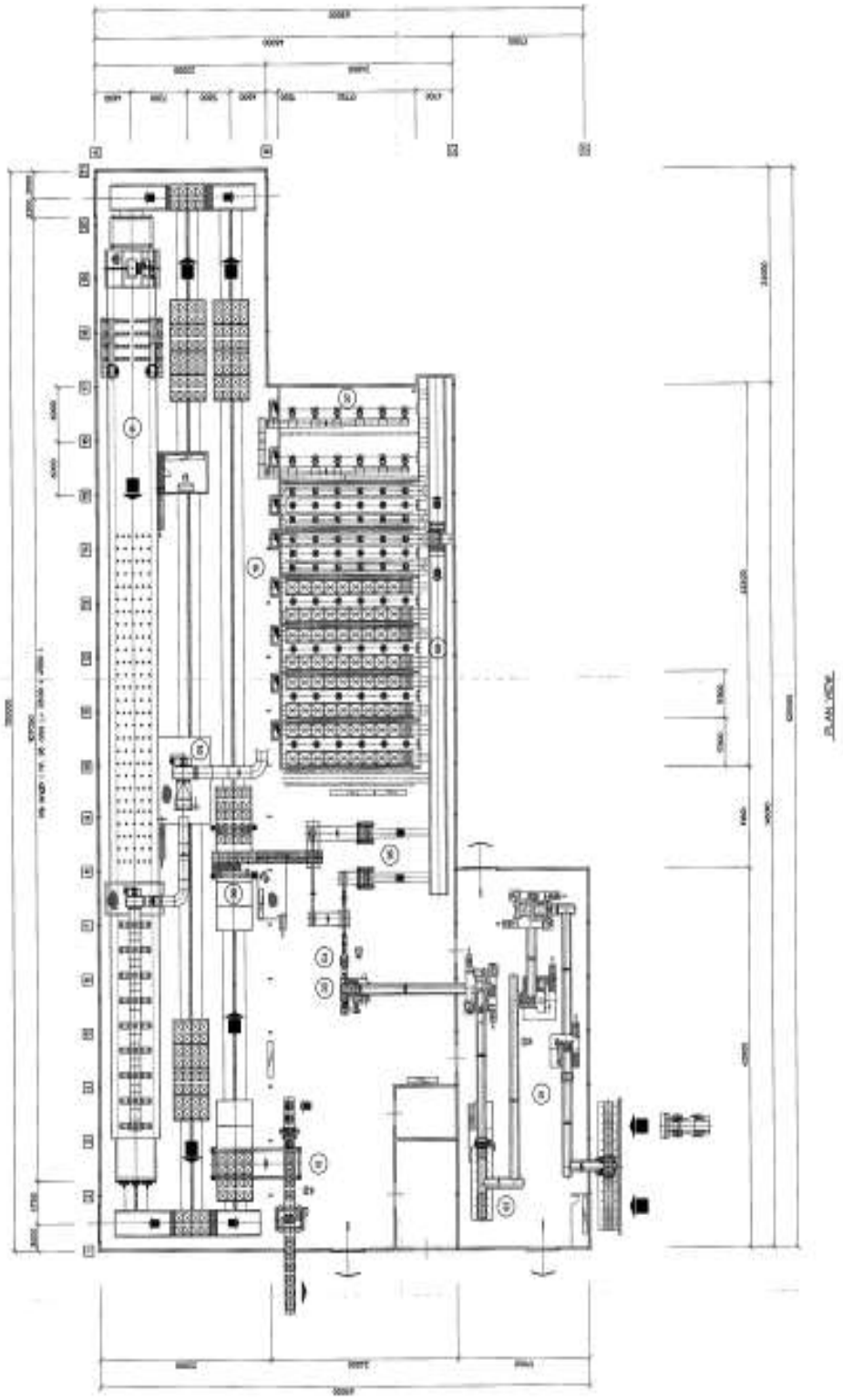
A fully mechanized process makes use of either a pugging machine or / and molding machine. The use of these machines significantly reduces the work done in the brick preparation process which is time consuming, labor intensive and weather dependent.

The first step in green brick molding involves tempering, which is done to produce a homogeneous plastic clay mass, and is carried out in a pugging mill. Additionally water is added to sand/ clay raw material in a pug mill, where a mixing chamber with one or more revolving shafts with blade extensions uniformly mixes the two ingredients. After pugging, the plastic clay mass is ready for formed in the desired final product output shape.

Molding the clay mass into the desired shape and dimensions is carried out using a molding machine also known as a soft mud process. It is used for clay containing a large amount of water. Once the clay has been tempered it is placed in the mold boxes where a pre decided pressure is applied on it through a plunger, to compact the green brick mold. The final product is almost obtained which after drying and firing processes are ready for shipping. The molds in the machine are lubricated with either sand or water to produce "sand-struck" or "water-struck" brick. With the use of these machines the production capacity increases in range of 3500-5500 bricks per hr.

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Annexure – 4: Engineering drawing



Annexure – 5: Financial analysis

Assumptions

Name of the Technology	**Fully mechanized**		
Rated Capacity	**150 TPD**		
Details	***Unit***	***Value***	***Basis***
Installed Capacity	TPD	150	Installed Capacity
No of working days	Days	330	No of working days
Proposed Investment			
Plant & Machinery	Rs. (in lakh)	460.00	
Cost of consultancy	Rs. (in lakh)	5.00	
Total cost	Rs. (in lakh)	465.00	
Misc. cost	Rs. (in lakh)	40.00	
Total Investment	Rs. (in lakh)	505.00	
Financing pattern			
Own Funds (Equity)	Rs. (in lakh)	126.25	
Loan Funds (Term Loan)	Rs. (in lakh)	378.75	
Loan Tenure	Years	7	Assumed
Moratorium Period	Months	6	Assumed
Repayment Period	Months	90	SIDBI Lending rate
Estimation of Costs			
O & M Costs	% on Plant & Equip	2.00	Feasibility Study
Annual Escalation	%age	2.00	Feasibility Study
Estimation of Revenue			
Coal savings	tons	1200	
Cost	Rs. / ton	5000	
Saving due to other benefit	Rs. (in lakh)	87.69	
St. line Depn.	%age	5.28	Indian Companies Act
IT Depreciation	%age	80.00	Income Tax Rules
Income Tax	%age	33.99	Income Tax

Estimation of Interest on term loan ***Rs. (in* lakh)**

Years	***Opening Balance***	***Repayment***	***Closing Balance***	***Interest***
1	378.75	21.00	357.75	34.33
2	357.75	42.00	315.75	33.86
3	315.75	48.00	267.75	29.39
4	267.75	54.00	213.75	24.32
5	213.75	60.00	153.75	18.69
6	153.75	65.00	88.75	12.45
7	88.75	69.00	19.75	5.66
8	19.75	19.75	0.00	0.33
		378.75		

WDV Depreciation ***Rs. (in lakh)***

Particulars / years	***1***	***2***	***3***	***4***	***5***	***6***
Plant and Machinery						
Cost	465.00	93.00	-	-	-	-
Depreciation	372.00	74.40	-	-	-	-
WDV	93.00	18.60	-	-	-	-

Projected Profitability ***Rs. (in lakh)***

Particulars / Years	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
Fuel savings	147.69	147.69	147.69	147.69	147.69	147.69	147.69	147.69	147.69	147.69
Total Revenue (A)	147.69	147.69	147.69	147.69	147.69	147.69	147.69	147.69	147.69	147.69
Expenses										
O & M Expenses	10.10	10.30	10.51	10.72	10.93	11.15	11.37	11.60	11.83	12.07
Total Expenses (B)	10.10	10.30	10.51	10.72	10.93	11.15	11.37	11.60	11.83	12.07
PBDIT (A)-(B)	137.59	137.39	137.18	136.97	136.76	136.54	136.32	136.09	135.86	135.62
Interest	34.33	33.86	29.39	24.32	18.69	12.45	5.66	0.33	0.00	0.00
PBDT	103.26	103.53	107.79	112.66	118.07	124.09	130.66	135.76	135.86	135.62
Depreciation	26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66
PBT	76.60	76.86	81.13	85.99	91.41	97.43	103.99	109.10	109.19	108.96
Income tax	-	9.90	36.64	38.29	40.13	42.18	44.41	46.14	46.18	46.10
Profit after tax (PAT)	76.60	66.96	44.49	47.70	51.28	55.25	59.58	62.95	63.01	62.86

Computation of Tax ***Rs. (in lakh)***

Particulars / Years	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
Profit before tax	76.60	76.86	81.13	85.99	91.41	97.43	103.99	109.10	109.19	108.96
Add: Book depreciation	26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66
Less: WDV depreciation	372.00	74.40	-	-	-	-	-	-	-	-
Taxable profit	(268.74)	29.13	107.79	112.66	118.07	124.09	130.66	135.76	135.86	135.62
Income Tax	-	9.90	36.64	38.29	40.13	42.18	44.41	46.14	46.18	46.10

Projected Balance Sheet

Particulars / Years	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
Liabilities										
Share Capital (D)	126.25	126.25	126.25	126.25	126.25	126.25	126.25	126.25	126.25	126.25
Reserves & Surplus (E)	76.60	143.56	188.05	235.75	287.03	342.27	401.86	464.81	527.82	590.68
Term Loans (F)	357.75	315.75	267.75	213.75	153.75	88.75	19.75	0.00	0.00	0.00
Total Liabilities (D)+(E)+(F)	560.60	585.56	582.05	575.75	567.03	557.27	547.86	591.06	654.07	716.93

Assets	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Gross Fixed Assets	505.00	505.00	505.00	505.00	505.00	505.00	505.00	505.00	505.00	505.00
Less Accm. depreciation	26.66	53.33	79.99	106.66	133.32	159.98	186.65	213.31	239.98	266.64
Net Fixed Assets	478.34	451.67	425.01	398.34	371.68	345.02	318.35	291.69	265.02	238.36
Cash & Bank Balance	82.26	133.89	157.04	177.41	195.35	212.26	229.51	299.37	389.05	478.57
TOTAL ASSETS	560.60	585.56	582.05	575.75	567.03	557.27	547.86	591.06	654.07	716.93
Net Worth	202.85	269.81	314.30	362.00	413.28	468.52	528.11	591.06	654.07	716.93
Debt Equity Ratio	1.76	1.17	0.85	0.59	0.37	0.19	0.04	0.00	0.00	0.00

Projected Cash Flow **Rs. (in lakh)**

Particulars / Years	***0***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
Sources											
Share Capital	126.25	-	-	-	-	-	-	-	-	-	-
Term Loan	378.75										
Profit After tax		76.60	66.96	44.49	47.70	51.28	55.25	59.58	62.95	63.01	62.86
Depreciation		26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66
Total Sources	505.00	103.26	93.63	71.15	74.36	77.94	81.91	86.25	89.61	89.68	89.52
Application											
Capital Expenditure	505.00										
Repayment Of Loan	-	21.00	42.00	48.00	54.00	60.00	65.00	69.00	19.75	0.00	0.00
Total Application	505.00	21.00	42.00	48.00	54.00	60.00	65.00	69.00	19.75	0.00	0.00
Net Surplus	-	82.26	51.63	23.15	20.36	17.94	16.91	17.25	69.86	89.68	89.52
Add: Opening Balance	-	-	82.26	133.89	157.04	177.41	195.35	212.26	229.51	299.37	389.05
Closing Balance	-	82.26	133.89	157.04	177.41	195.35	212.26	229.51	299.37	389.05	478.57

IRR **Rs. (in lakh)**

Particulars / months	***0***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
Profit after Tax		76.60	66.96	44.49	47.70	51.28	55.25	59.58	62.95	63.01	62.86
Depreciation		26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66
Interest on Term Loan		34.33	33.86	29.39	24.32	18.69	12.45	5.66	0.33	-	-
Cash outflow						-	-	-	-	-	-
Net Cash flow	(505.00)	137.59	127.49	100.54	98.68	96.62	94.36	91.91	89.94	89.68	89.52

IRR	16.92%

NPV	143.31

Break Even Point

Particulars / Years	1	2	3	4	5	6	7	8	9	10
Variable Expenses										
Oper. & Maintenance Exp (75%)	7.58	7.73	7.88	8.04	8.20	8.36	8.53	8.70	8.88	9.05
Sub Total*(G)*	7.58	7.73	7.88	8.04	8.20	8.36	8.53	8.70	8.88	9.05
Fixed Expenses										
Oper. & Maintenance Exp (25%)	2.53	2.58	2.63	2.68	2.73	2.79	2.84	2.90	2.96	3.02
Interest on Term Loan	34.33	33.86	29.39	24.32	18.69	12.45	5.66	0.33	0.00	0.00
Depreciation *(H)*	26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66
Sub Total (I)	63.52	63.10	58.68	53.66	48.08	41.90	35.17	29.89	29.62	29.68
Sales (J)	147.69	147.69	147.69	147.69	147.69	147.69	147.69	147.69	147.69	147.69
Contribution (K)	140.12	139.96	139.81	139.65	139.49	139.33	139.16	138.99	138.81	138.64
Break Even Point (L= G/I)	45.33%	45.08%	41.97%	38.42%	34.47%	30.07%	25.27%	21.51%	21.34%	21.41%
Cash Break Even {(I)-(H)}	26.30%	26.03%	22.90%	19.33%	15.35%	10.94%	6.11%	2.32%	2.13%	2.18%
Break Even Sales (J)*(L)	66.95	66.58	61.99	56.75	50.91	44.41	37.32	31.76	31.52	31.62

Return on Investment

Rs. (in lakh)

Particulars / Years	1	2	3	4	5	6	7	8	9	10	Total
Net Profit Before Taxes	76.60	76.86	81.13	85.99	91.41	97.43	103.99	109.10	109.19	108.96	706.06
Net Worth	202.85	269.81	314.30	362.00	413.28	468.52	528.11	591.06	654.07	716.93	3733.97
											18.91%

Debt Service Coverage Ratio

Rs. (in lakh)

Particulars / Years	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*Total*
Cash Inflow											
Profit after Tax	76.60	66.96	44.49	47.70	51.28	55.25	59.58	62.95	63.01	62.86	276.76
Depreciation	26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66	26.66	133.32
Interest on Term Loan	34.33	33.86	29.39	24.32	18.69	12.45	5.66	0.33	0.00	0.00	61.44
Total (M)	137.59	127.49	100.54	98.68	96.62	94.36	91.91	89.94	89.68	89.52	471.51

DEBT

Interest on Term Loan	34.33	33.86	29.39	24.32	18.69	12.45	5.66	0.33	0.00	0.00	61.44
Repayment of Term Loan	21.00	42.00	48.00	54.00	60.00	65.00	69.00	19.75	0.00	0.00	267.75
Total (N)	55.33	75.86	77.39	78.32	78.69	77.45	74.66	20.08	0.00	0.00	329.19
	2.49	1.68	1.30	1.26	1.23	1.22	1.23	4.48	0.00	0.00	1.43
Average DSCR (M/N)	1.43										

Annexure – 6: Details of Procurement and Implementation Plan

S.No	Activity	Month									
		1	2	3	4	5	6	7	8	9	10
1	Service Contract										
2	Civil and infrastructure Modification (as										
3	Installation of Pugmill and Moulding										
4	Process integration and Training										
6	Trail operation										

Annexure – 7: Details of Technology/equipment and service providers

Name	*Organization*	*Contact No.*	*E-mail*
Mr. Shakti Swarup	Neptune Industries	+91 - 9909966776	Shakti@neptune-india.com

Annexure– 8: Quotations or Techno-commercial bids for new technology/equipment

Neptune Industries Limited
Marketing & Business Development Center
F1, Ankur Complex, Opp. X-Ray House B/H Town Hall,
Ellisbridge Ahmedabad - 380006 Gujarat, India.
Mobile: +91 - 98792 06991 Phone: +91 - 79 - 2657 6234
Email: info@neptune-india.com / sales@neptune-india.com

150TPD Brick Plant Owning & Operationg Cost

COST OF PROJECT			
S NO	PARTICULARS		Cost in Lac Rs.
1	LAND:		
2	BUILDING:		60.00
A	Raw Material storage area approch roads & Dyke		
B	Production Machinery Shed		
C	Drying & Kiln Area		
d	Storage Area		
3	PLANT & MACHINERIES	→	460.00
a	PLANT & MACHINERIES FOR GREEN BRICK PROD		
b	DRYER & KILN		
4	ELECTRICAL INSTALATION	→	40.00
6	CONTINGENCY		50.00
8	MARGIN FOR WORKING CAPITAL		100.00
7	Other required material handling equipments Fork lift - 2 nos , tractor mounted front end loader		40.00
8	Pre Operative Expense (expence + interest)		50.00
	TOTAL		800.00

MEANS OF FINANCE		
		Lac RS
1	CAPITAL RAISED BY PROMOTER (30%)	240.00
2	BANK / STATE FINANCE CORP.LOAN (70%)	560.00
	TOTAL	800.00

Tentative Owning & Operating Cost Calculation for 150 TPD Brick Plant 1 of 5

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150 tpd , 50 k brick plant

Clay Brick Plant - Capacity & Equipment matrix

BRICK SIZE (Perforated) 230X115X75 & 400 x 200 x 200

Plant Specification

Plant Capacity

Bricks / Year	23,760,000	
Bricks / Day	72,000	
Bricks / Shift	36,000	36000 (Rated Output PER SHIFT)

Say min output	61,000	Bricks per day	153 TPD
			50,325 TPA

Assumptions

No. Of Production Lines	1

Brick / Hr		4500
Hrs / Shift		8
Shift / Day		2
Day / year (%)	82.25%	330
PLF		85%

Rate of Raw material	Rs/ Ton	
Fly Ash	100	
Clay 1	100	
Clay 2	100	
Additive	1500	
Coal as fuel	2500	(Coal + Rice Husk)

Rate of Utility Supply	Rs	
Water	5.00	Rs per Ton
Power	5.00	Rs per Kwh
Steam		Rs per Ton
Natural Gas		Rs per M3

% Waste in Raw material in entire Process	5%

Sales Price Rs/ Brick	4.10
Sales Price Rs/ Block	32.00

% PLF Effective on the basis of rated output		98%
Effective No. of Bricks for sale in a year		19,727,400
	So say bricks sold/ year	19,000,000
	Stock (bricks on hand)	1,130,000

Tentative Owning & Operating Cost Calculation for 150 TPD Brick Plant 2 of 5

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Brick Specification

Size	230X115X75 & mm		User defined size possible
Wt of Brick	2.50 Kg		
Wt of Block	14.50 Kg		

Sales Realisation

100%	19,000,000					
100%	19,000,000	Bricks/year	@ Rs/ Brick	4.50	=	85,500,000
0%	-	Block/year	@ Rs/ Block	35.00	=	-

Profitability

(A)	Sales Realisation				85,500,000
(B)	Total Production Cost				62,312,914
					3.0955
				%	Rs per Brick
	(B/1)	Raw Material	5,350,177	9%	0.27
	(B/2)	Power & Utility	24,585,938	39%	1.22
	(B/3)	Man Power	11,270,000	18%	0.56
	(B/4)	Interest	11,652,000	19%	0.58
	(B/5)	Depreciation	2,154,800	3%	0.11
	(B/6)	Total Maintenance	2,300,000	4%	0.11
	(B/7)	Office & Admn. Expenses + salary	2,500,000	4%	0.12
	(B/8)	Marketing / Travelling Expense	2,500,000	4%	0.12
		Total	62,312,914	100%	3.10
*	PBT				23,187,086
*	PBDT				25,341,886
	PBDIT				36,993,886

Tentative Owning & Operating Cost Calculation for 150 TPD Brick Plant 3 of 5

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Raw Material Requirement

	Material	%	Tons/ Day	Tons/Year	Cost/day Rs	Cost/year Rs	Per Brick Rs
	Fly Ash	10%	15.25	5032.5	1525	503,250	0.03
	Clay 1	50%	76.25	25162.5	7625	2,516,250	0.13
	Clay 2	40%	61.00	20130.0	6100	2,013,000	0.10
	Additive	0%	0.00	0.0	0	-	0.00
	Total RM	100%	152.50	50325.0	15250	5,032,500	0.25
	Water	25%	38.13	12581.3	190.625	62,906	0.00
							0.00
	SUB Total					5,095,406	0.25
	Wastage	5%				254,770	0.01
							0.00
							0.00
(B/1)	Total Raw Material Cost					5,350,177	0.27
				RM Cost Rs/Brick		0.27	

Power

Power	HP	KW	Load	P.F.	Rs / day	Rs / year	
	500	0.75	0.5	0.75	11250	3712500	0.18
	Reqd (Kcal per kg of brick)		Required (Kg of coal per Day)		Rs / day	Rs / year	
GAS	450		22,875		57187.50	20973437.5	1.04
CV of coal	3000	Kcal/Kg of coal		TOTAL		24685937.5	1.22

MANPOWER- PER DAY

		Nos.	Rs/ day/person	Rs / Day	Rs/year	
O & M						
	Supervisor	2	1000	2000	730000	
	Skilled Worker	10	800	8000	2840000	
	Unskilled Workers	50	400	20000	6800000	
Admin - Fin - Other Support - Mktg						
	Manager	1			500000	
	Sr officers	1			300000	
	Jr officers	1			200000	
	Off Staff	3			300000	
(B/3)	TOTAL	68			11270000	0.56

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Total Investment In Plant And Machineries (Lac Rs)				**460.00**
Total Investment In Project (Lac Rs)				**800.00**
	Int %	**Amt For Int**	**Rs per Year**	
Term Loan (70 %)	12%	56,000,000	6,720,000	
Promoter's contribution	12%	24,000,000	2,880,000	
Interest on working capital	12%	17,100,000	2,052,000	20 % of Sales
(B/4) TOTAL		97,100,000	11,652,000	

	Cost	%	Per Year	
Building (WDV basis)	6,000,000	10%	600,000	
Plant & Machinery (SLM basis	46,000,000	3.38%	1,554,800	
(B/5) TOTAL			2,154,800	

Cap. Investment	24,000,000

Fixed Cost (Total)	21,106,800	
Variable total	41,206,114	
Break Even Point		
Production	8,604,485	Brick
Price	3.279627056	Rs per Brick

Tentative Owning & Operating Cost Calculation for 150 TPD Brick Plant 5 of 5

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