Study Report

On

Evaluating Energy Conservation Potential of Brick Production in SAARC Countries: Bangladesh Country Report

Prepared by

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SAARC Energy Centre, Islamabad, Pakistan

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Abbreviations/Acronyms

BBMOA	Bangladesh Brick Manufacturing Owners Association
BMI	Brick Making Industry / Brick Manufacturing Industry
BTK	Bull's Trench Kiln
DALYs	Disability Adjusted Life Years
DOE	Department of Environment
EEK	Energy Efficient Kiln
ECA	Environment Conservation Act
ESMAP	Energy Sector Management Assistance Program
FCK	Fixed Chimney Kiln
ECR	Environment Conservation Rules
FY	Financial Year (July-June)
GSC	Gravity Settling Chamber
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse gas
HK	Hoffman Kiln
HHK	Hybrid Hoffman Kiln
ID	Induced Draft
IF	Internal Fuel
IFCK	Imported Fixed Chimney Kiln
KGOE	Kilogram of Oil Equivalent
MOEF	Ministry of Environment and Forestry
PDF-B	Project Development Fund – Block B
PM	Particulate Matter
SAARC	South Asian Association for Regional Cooperation
SEC	SAARC Energy Centre
SMEs	Small and Medium Enterprises
UNDP	United Nations Development Program
VSBK	The Vertical Shaft Brick Kiln
VSL	Value of Statistical Life
Xian	Xian Institute of Wall Building Material

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Engr. Anwar Hossain Khan

EXECUTIVE SUMMARY

1. Bangladesh has a total area of about 144,000 square kilometers which has population of about 153 million having a growth rate of 1.34% in 2011. Energy demand in the country is growing at a rate of 8 -10% in recent years although the per capita energy consumption in the country still very low - only about 250 KGOE only. Rapid urbanization rise in income level in the rural population has triggered a rapid growth of construction material including bricks.

2. However, brick-making is a significant economic activity in Bangladesh. However, brick manufacturing is not recognized as an industry in Bangladesh. The country's overwhelming dependence on bricks is due to its lack of stones in any sizable quantity or other alternative building materials at comparable cost. Trend data of the last decade show demand for bricks rising steadily at about 5.28% annually. Number of brick kilns operating in the country is estimated be 6000-6500 producing about 17 billion bricks annually with an estimated sale value of around US$450 million, almost 1% of Bangladesh's GDP.

3. After imposing ban by the government in 2004 on BTK, which used to be prevalent method of brick firing in the country, FCK has become most adopted technology. After the government notification of ban on FCK from September 2013, the number of Zigzag kilns started rising and by now has reached up to 1000. As a result of the efforts by some donor agencies with the objectives of reducing air pollution caused by the traditional kilns, energy efficient kilns like, Hoffman Kilns (Natural gas), HHK (coal), VSBK and IFCK have been introduced but their penetration level is very low because of high initial cost and requirement of skilled manpower for construction. Out of about 6,000-6,500 kilns in the country 81% kilns are FCK mostly using imported coal.

4. Economic and social benefit analysis conducted by the patronizing agencies has shown that the HHK is the most profitable technology for the entrepreneur, while the returns from the FCK, IFCK, and VSBK are lower. Despite the higher net returns, adopting the HHK is difficult for two major reasons (i) HHKs operate on high land, which is scarce and expensive and (ii) the adoption requires a substantial investment (TK60 million), which is unaffordable for most FCK owners, who operate on rented land that cannot be used as collateral. The Table 9 of this report shows the cost benefit analysis done by a UNDP sponsored study recently.

5. Coal consumption per 100, 000 bricks varies greatly for different technologies. FCK consumes the highest amount of coal (20-22 tonnes per 100,000 bricks) while VSBK requires the least amount of coal (10-12 per 100,000 bricks). It is clear that a huge energy saving potential, as high as nearly 50 %, is available through adoption of energy efficient technologies in the brick manufacturing. Country could save about 200 million US dollars from import of coal.

6. There is lack of government's brick sector strategy (policy), or other relevant energy efficiency guidelines to promote sustainable brick sector development. As a result, the legal and regulatory framework is poorly guided to address the underlying deficiencies in the brick sector development. The existing legislations are based on the Brick Burning Act (1989) and various amendments and circulars thereafter. Prior to 1989, brick making was an unregulated industry in Bangladesh. A summary of the legislations on brick burning and air pollution in Bangladesh is presented in the Table 16 under Section 8.

7. The major technical barriers to the adoption of energy efficient kiln technologies and in the way energy is utilized in making bricks are:
   - (i) lack of ability to design and construct brick making facilities that utilize energy in the most efficient way
   - (ii) lack of R&D and training facilities;
   - (iii) lack of capacity in terms of technical skills that could have made production more efficient and less polluting;
   - (iv) lack of worker and management capacity to enhance productive efficiency.
8. Approximately Taka 1.0 million is required as working capital for a BTK, FCK and Zigzag Kiln but for a HHK it can go up to Taka 7.5 million because of higher inventory, maintenance and overhead costs. Profitability in the current brick business largely depends on the sales volume as the profit margin per brick is low. Given limited capital resources, the manufacturers generally prefer to increase production capacity by setting up a new plant in a new location over investing in cleaner and efficient technologies. Institutional and Regulatory barriers include lack of supporting regulations, fiscal incentives and standards to encourage more energy efficient practices and technologies. Except for some sporadic efforts to regulate the industry, government has made little effort assist the brick industry to undertake comprehensive programs to transform the industry and make it less polluting and more profitable. Private entrepreneurs lack capacities in regard to modern practices in marketing, business opportunities and kiln management. There is also lack of trained manpower to cope with new technology changes. Besides, limited experience of commercial lending institutions with SMEs and in particular, brick SMEs is also hindering sustainable development of the brick industry.
9. The current status of brick industry is by no means sustainable. It is therefore imperative for Bangladesh to modernize/upgrade its brick sector in order to save valuable natural resources, reduce air pollution, and increase energy efficiency. The government has already established regulations that ban the use of fuel wood and FCKs, and has reconsidered the location and height of brick kiln chimneys. Donor agencies are also patronizing in introduction of energy efficient and less polluting technologies like VSBK and HHK through pilot projects and technical supports. VSBK seems to have failed to attract investors due to failure of the pilot project to produce bricks of desired quality. On the other hand, HHK did not show any technical constraint; however, relatively large investment requirement appears to be main impediment in fast propagation of this technology. Zigzag relatively cleaner than FCK, although not as good as VSBK or HHK, appear to be the choice of the industry in general. However, this transformation is not taking place at a pace that the government has targeted. The Brick Field owners leads by BBMOA are in favour extending time for conversion of existing FCK to Zigzag beyond 2013.

SECTION 1

INTRODUCTION, BACKGROUND, OBJECTIVES, SCOPES AND METHODOLOGY OF THE STUDY

1.1 Introduction to Country

1. Bangladesh emerged as an independent country in 1971. The country has a total area of about 144,000 square kilometers and bordered by India in the west and north, India and Myanmar in the east and by the Bay of Bengal in the south that is crisscrossed by numerous rivers. Most of the areas of Bangladesh lie within the broad delta formed by the Ganges and the Brahmaputra rivers. Lands are exceedingly flat, low-lying, and subject to annual flooding. Much fertile, alluvial soil is deposited by the floodwaters. The only significant area of hilly terrain, constituting less than one-tenth of the nation's territory, is the Chittagong Hill Tracts in the narrow southeastern panhandle of the country. Land distribution consist of 67% arable land, 16% forest and woodland, 2% permanent crops, 4% meadows and 11% others.
2. Bangladesh has a tropical monsoon-type climate, with a hot and rainy summer and a pronounced dry season in the cooler months. January is the coolest month of the year, with temperatures averaging near 26 deg C (78 d F), and April the warmest month, with temperatures ranging between 33 deg and 36 deg C (91 deg F and 96 deg F). The climate is one of the wettest in the world; most places receive more than 1,525 mm (60 in) of rain a year, and areas near the hills receive 5,080 mm (200 in). Most rain falls during the monsoon (June-September) and little during the dry season (November-February).
3. Bangladesh has population of about153 million having a growth rate of 1.34% in 2011. It has rate of literacy of 57.9% (male 61.1% and female 54.8%). About 31.5% people are living below the poverty line. Per capita GDP was 772 US dollars having a GDP growth rate of 6.32% in the year 2011-12. Bangladesh aims at turning it to a middle income country by 2021.
4. Energy demand in the country is growing at a rate of 8 -10% in recent years although the per capita primary energy consumption in the country still very low - only about 250 KGOE only. Traditional biomass accounts for about 35% of the primary energy consumption while commercial energy constitutes 65% of the national energy consumption. Indigenous natural gas supplying 75% of the primary commercial energy while imported oil, coal (indigenous plus imported) and Hydro are supplying 21%, 2% and 1% respectively. The country is suffering badly from the shortage commercial energy. However, use of the scanty energy resources is not efficient ones in many cases. The country needs urgent actions in the field of energy efficiency and conservation for sustainable development of the energy sectors as well as for environment.

1.2 Background of the Study

5. Economic development and raising the standard of living in the modern life is dependent on the use of commercial energy. Energy demand in the South Asian countries is increasing in faster rates than ever due to growth of economy and peoples' desire for living quality life keeping pace with technological development around the world. World is still immensely dependent upon the use of fossil fuel. South Asian

region is constraint with the supply of commercial energy. It has been a great challenge to ensure supply of commercial energy like oil, gas and coal for steady growth of the economy. However, by contrast, energy in the region is not being used efficiently. Almost in every sector there have been wastages of energy in the power sector or other sectors like industry and domestic. In Bangladesh, ample scope is there to save energy and supply the saved energy to the people who are starving for it, through appropriate policy and additional investment.

6. In Bangladesh people are migrating to the urban areas in search of jobs and better quality of living which is causing growth of urban population at a rate of 5% annually. This fact is triggering rise in the demand of bricks in the urban areas. Besides, due to rise in the income level and shortage of traditional housing materials in the rural area, the demand for bricks in the rural area is also in rise.

7. Brick industry within the SAARC region is the third largest consumer of coal after power and industry. There is hardly any technological advancement in the brick industry in the SAARC countries. SAARC Energy centre has undertaken a study to assess the brick industry in the region with particular attention to the efficient use of energy in the industry. This report is an effort to assist the SAARC energy centre to understating the brick manufacturing industry in Bangladesh by highlighting the opportunities and challenges in extensive introduction of energy efficient technologies in the country.

1.3 Objectives of the Study

8. SAARC Energy Centre (SEC) has a thematic program area titled “Program on Integrated Assessment of Energy Transport and Environment” (PETREN) that would lead towards cooperation based on transferring technologies, sharing expertise and knowledge between the public and private institutions in the region. Under this thematic area the SEC has undertaken a study to contribute and further understanding of the energy efficient techniques in order to reduce cost of production, efficient utilization of fuel and market in the region, assisting in the development and expansion of the market through the implementation of recommendations of the report. The aim of this report is to assist the SEC in attaining these objectives to the fullest extent.

1.4 Scope of Works

9. According to the terms of reference provided by the SEC, the Scope of Works for the expert pertaining to this study includes:
   - Introduction and Background of the Study
   - Objective of the study
   - Methodology
   - Economic and Industrial Condition
   - Social and Environmental Impact
   - Identification of relevant institution, activities for capacity building for promotion of energy efficiency in the sector
   - Mapping of active stakeholders in the market, covering financier /investors, technology providers
   - Identify and analyze barriers of the Private Sector for investment

- National Coal Policy and present situation of Coal Industry
- Environmental Policy for Brick Kiln (if any)
- Experiences, expertise and best available practices for Sharing with other member countries
- Energy, environment and economic comparison and status of prevalent technologies
- Economic and Cost Benefit Analysis
- Recommendations

1.5 Methodology

10. The expert reviewed available reports and literatures related to energy efficient brick field development to summarize what is currently known about Clean Technologies in the Brick Sector of Bangladesh. The expert discussed with the Bangladesh Brick Manufacturing Owner's Association (BBMOA), Brick Field Owners, Brick Industry Consultant, Environment Expert, Entrepreneurs and related Specialists to get views, opinion, suggestions, etc. in order to develop Energy Conservation Potential Strategy towards sustainable development of brick sector of the country. This report has been prepared collecting data and information from above mentioned literature review and discussions with key personnel.

SECTION 2

ECONOMIC AND INDUSTRIAL CONDITION

2.1 Present Economic Condition

11. Despite worldwide economic recession in recent years, Bangladesh has been able to maintain the trend of economic growth relatively unaffected. During last four years the country has persistently achieved GDP growth above 6%. According to a provisional estimate, the economy has posted a growth of 6.71% percent in FY2010-11 against that of 6.32% percent in FY2011-12. Although the agricultural sector has shown slightly downward trend in 2011-12 after growths of above 5% in two consecutive years, the growth in this sector is satisfactory. Side by side, the industrial and service sectors are playing important role in the GDP growth. It is estimated that GDP growths in agriculture, industry and service sectors would be 2.53%, 9.47% and 6.06% respectively compared to 5.13%, 8.20% and 6.22% in the 2010-11. Soaring global food and non-food prices have created inflationary pressure in the country pushing inflation rate to two-digit figure. During the ten months of the financial year 2011-12, the inflation rate was 10.99%.

12. Rapid and sustainable development and social progress essentially call for industrialization in any country. The industry sector has, therefore, got to play a critical role in this regard. The contribution of this important sector to Bangladesh economy has been on the increase. While in FY 1980-81, the contribution of the broad industry sector to real GDP was 17.31 percent, it increased to 30.38 percent in FY 2010-11. The contribution of industry sector to GDP has been estimated at 31.26 percent (BBS provisional estimate) in FY 2010-11. Among the fifteen sectors identified for computing national income, the broad industry sector includes five sub-sectors such as mining and quarrying, manufacturing, construction, electricity and gas, and water supply. Among these sub-sectors, the contribution of the manufacturing sector is the highest. According to the provisional estimate of BBS the contribution of manufacturing sector to GDP has been estimated at 19.01 percent *(BD Economic Review 2012).*

2.2 Long-term Perspective Plan

13. The Government of Bangladesh has formulated the first-ever long-term Perspective Plan 2010-2021 consistent with the Vision 2021 articulating its commitment to build a happy and prosperous Bangladesh. The overarching goal of the Perspective Plan is to accelerate national development process that embodies a shared view of all citizens and a dream supported by will and action to transform it into reality. The fundamental objective of the plan is poverty eradication through attainment of higher growth rates as well as achieving middle income country status in real terms by 2021, the Golden Jubilee Year of national independence. It envisioned equitable and inclusive growth process where poverty will be at its lowest level and regional disparities in development will be removed.

14. The vision of the Government is that Bangladesh will have, by 2021, a dominant industrial sector which will account for at least 40 percent of the gross domestic product (GDP) with a capacity to absorb 25 percent of the workforce. The Government, therefore, aims to take coordinated steps to accelerate the development of all important industrial sectors which should be environment-friendly and

technologically advanced.

2.3 Economic Aspects of Brick Manufacturing

15. Brick manufacturing is not recognized as an industry in Bangladesh. There are two main underlying reasons for lack of industry recognition. First, while Small and Medium Enterprises (SMEs) in Bangladesh are defined in terms of employment provided, brick kilns are seasonal operations that do not provide year-round employment. Second, most brick kilns are located on rented land and do not have fixed assets except for the chimney. Though not formally recognized as an industry, brick-making is a significant economic activity in Bangladesh. The country's overwhelming dependence on bricks is due to its lack of availability of stones in any sizable quantity or other alternative building materials at comparable cost. A snapshot of Bangladesh's Brick Sector prepared under the World Bank sponsored Study (June 2011) is placed below to show main economic aspects of the sector.

Table 1: Main Economic Aspects of Bangladesh's Brick Sector (2011)

Parameter	Value
Estimated total number of coal-fired kilns	5,000
Number of natural gas fired kilns	20
Annual brick production	17.2 billion
Value of output	TK 83 billion (~US$1.2 billion)*
Contribution to GDP	~1%
Coal consumption	3.5 million tons
Value of imported coal	TK22.6 billion (~US$322 million)
Firewood consumption	1.9 million tons
Emissions CO2	9.8 million tons
Clay consumption	45 million tons
Total employment (incl. supply of clay and coal, transport of bricks)	~1 million people
Growth rate of the construction industry (1995-2005)	5.6%
Estimated future growth rate of the brick sector over the next ten years	2-3%

[Report No. 60155-BD; June 2011; ESMAP, The World Bank]

SECTION 3

SOCIAL AND ENVIRONMENTAL IMPACTS

3.1 Background

16. Due to growth in population, uplift of standard of living, rapid urbanization and expansion of infrastructure facilities, there has been a construction boom in Bangladesh which has raised the demand for construction material in the country during the last 2-3 decades. Fired clay bricks are meeting major portion of demand for the aggregate materials used in the construction industry. They are literally, the major "building-blocks" for all infrastructure projects such as roads, bridges and buildings. Studies conducted in the 1990's show that out of 14.8 million households, 3.7 million or 25% used bricks as wall materials. Since then both number of households and the percentage of households using brick walls have increased. Preliminary results of 2011 census indicate that the number of households in the country increased to about 32 million. Until recently, demand for bricks were mainly urban based, but increasingly its use has spread to rural areas as incomes have risen there. High prices and/or scarcity of alternate building material such as, stones, iron sheets, wood, bamboo, and straw are driving the demand for bricks.

17. Trend data of the last decade show demand for bricks rising steadily at about 5.28% annually. The main driver of this growth has been the construction industry, which has been growing above GDP rates. In the 1980's and 1990's while GDP grew at about 4%, the construction industry grew at 5.5%. Annual growth rate of the construction sector in Bangladesh has ranged from 8.1% to 8.9% in the last decade and this is expected to continue into the foreseeable future. Total brick production in Bangladesh is estimated to be over 17 billion bricks annually with an estimated sale value of around US$1.2 billion, almost 1% of Bangladesh's GDP. Like other industries BMI is also subjected to social and environmental issues which need to be addressed for the sake of the industry itself and the population in the adjacent areas.

3.2 Social Issues

18. Bangladesh brick manufacturing kilns usually operate 5–6 months of the year, from November to April, because most of them are located in low-lying areas, which experience flooding during the rainy season. Besides, operators depend on nature for drying green bricks in the sun under the open sky, which is not possible in the monsoon season. In addition, during the rainy season, dry green bricks cannot be made or stored at comparatively low cost as in the dry season and open-air kilns cannot operate. Most brickfields are on leased land with no permanent sites and fixtures. This along with the seasonal nature of production contributes to the 'footloose' nature of the industry.

19. The average brickfield employs about 150 skilled and unskilled workers. Apart from 6 to 10 permanent employees, most are employed for only six months during the production season. Migrants from northwestern Bangladesh comprise most of the kiln workforce due to the seasonality of kiln operations, their clustering, and lack of local workers. The workers are not organized and lack trade unions to promote their interests. Thus, the existing kilns involve many social issues related to migrant workers, gender and child, and health and sanitation.

3.2.1 *Worker safety and health concerns*

20. Except firemen who are skilled and better paid, the workforce usually perform unskilled, low-wage work, requiring hard physical labour for long hours (e.g., mud-pugging by foot, brick-molding by hand, and carrying head-loads of bricks), which can cause severe muscular and skeletal stress. In many cases, workers temporarily migrate with families and take up residence near kilns. These residences are usually self-made, ramshackle structures made of bamboo, wood, cardboard, and corrugated iron sheet. The sanitary conditions in such residences are not good. Moreover, the high level of air pollution in the kiln area is a health hazard for workers. Overall, the hard physical labour and unsafe conditions likely cause both short- and long-term health problems for workers.

Figure 1: Young children at a brick factory

3.2.2 *Child labour and gender issues*

21. While each kiln employs about 150 workers, migrant families usually bring some 30–50 children to live nearby. Although banned from working by law, older children often join in work to improve their family's income. Families, including children, often collect partially-burned coal to use for household cooking. Younger children play in unsafe conditions (e.g., mud, dirt and coal), and young girls sometimes perform domestic chores. Women are usually paid less than men, although they do equally arduous jobs; and children are paid even less. While children in villages can attend government primary school for free, kiln workers' children are deprived of this opportunity during the working season, as there are often no schools close to kiln sites.

Figure 2: : Children carrying bricks at a brick factory

3.2.3 *An opportunity for modernization*

22. In general, many of the shortcomings associated with work in the brick, for example, most loads are still carried on heads, wheel barrows are infrequently used, and green brick molding is primarily done by hand. However, in recent years, kilns have faced a supply shortage as older workers have become increasingly unwilling to do this arduous work (even when owners offer advance payment); this has led to a partial mechanization of the work (e.g., introduction of pug machines in kilns near Dhaka). The current supply shortage could be the opportunity for this change. Green-brick making, usually referred to as the "back process," needs to be mechanised in order to reduce the harsh involved and increase production efficiency. Any measure designed to improve the manufacturing processes in the existing kilns should consider all social and health problems.

3.3 Environmental Issues

23. Brick making in Bangladesh is a highly energy intensive and carbon emitting activity. Prior to 2004, most kilns in Bangladesh, about 95%, were based on the 150 year old Bull's Trench kiln (BTK) technology. In 2004, following a government order to raise smokestacks to 120 feet, BTK's were modified to accommodate taller chimneys and underground piping necessary to divert the flue gas to the fixed chimney. This required extending the width of the base. The taller chimney creates a stronger draft, which improves combustion to some extent and enables flue gas to be released at 120 feet, dispersing the pollution over a wider area. This 'new' kiln called the Fixed Chimney Kiln (FCK) is essentially the same Bull's Trench Kiln with a chimney

24. The baseline analysis indicates that GHG emissions from the brick industry are already at a high level and are expected to increase by at least 5.28% every year for the foreseeable future. This means that direct carbon emissions from kilns alone will rise to 8.7 million tonnes annually by 2014 or earlier depending on the growth rate of the industry. Fuel consumption, particulate emission and GHG emission from different kilns are given in the Table 2.

Table 2 : Energy Consumption, Particulate Emission and GHG Emission from Brick Kilns

Technologies	Coal per 100000 bricks (Tons)	Particulate(mg/m3)	CO2 per 100000 bricks (Tons)	GHG (CO2) Reduction
Baseline				
FCK	20-22	1000+	50	--
Zigzag (poor kiln design and poor management)	18-20	1000+	45	10%
Zigzag (poor kiln design and medium management)	16-18	500-800	40	20%
Hoffman (Natural Gas)	16,000 m3	< 100	30	40%
Alternatives				
Hoffman (Natural Gas)	16,000 m3	< 100	30	40%
FCK (+ GSC + IF)	16-18	< 500	40	20%
Zigzag (good management)	16-18	400-600	40	20%
Coal Hoffman	12-14	< 400	30	40%
VSBK	10-12	200-400	25	50%

Source: BUET 2007

25. It is clear from the above table that fuel consumption, particulate emission and GHG emission are highest for FCK. FCK releases the highest level of PM and SO2, primarily because of the high ash and sulfur content of the coal. Evidence is inconclusive on PM emissions of the Zigzag kiln. In terms of pollutants, the Hoffmann kiln, fired by natural gas, is considerably superior to all coal-burning kilns. Unfortunately, due to natural-gas supply constraints, the expansion of this technology stopped and existing kilns are facing closure.

26. The main environmental impacts of operating brick kilns, which are particularly evident for the FCKs, include health, CO_2 emissions and poor energy efficiency, Crop yields (from air pollution) and depletion of cropland.

3.3.1 *Health*

27. Pollutants from brick kilns (particularly PM and SO_2) contribute to health problems of the exposed population. These include: (i) adult mortality from cardiopulmonary diseases and lung cancer caused by long-term $PM_{2.5}$ exposure (Pope et al. 2002); (ii) infant and child mortality from respiratory diseases caused by short-term PM_{10} exposure (Ostro 2004); and (iii) all-age morbidity resulting from PM_{10} exposure (Ostro 1994; Abbey et al. 1995). Among existing technologies in Bangladesh, the FCK is likely to cause the worst health problems due to the highest level of particulate emissions.

3.3.2 *CO2 emissions and poor energy efficiency*

28. Burning coal emits CO_2, which contribute to global warming and climate change. In addition, low-quality coal is energy inefficient and produces further CO_2 emissions.

Similarly, poor insulation and heat losses require additional coal, whose use leads to further CO_2 emissions.

3.3.3 *Crop yields (from air pollution)*

29. Air pollution in the areas where brick kilns are located contributes to the decline of agricultural yields. Evidence of reduced yields from orchards and crops due to air pollution is well-documented. Dust deposition on leaves of plants (i.e., crops and orchards) hinders photosynthesis, which reduces productivity.

3.3.4 *Depletion of cropland*

30. The brick industry is contributing in various ways to growing carbon emissions from other sources. Most notable, is the impact of brick making on land degradation and deforestation. In a country where the pressure of population growth on a relatively small land mass is significant, farmland depletion can have alarming prospects for food security. Total farmland in Bangladesh is about 14 million hectares and this is depleting by about 80,000 hectares every year, a 0.05% depletion rate. Moreover, wood fuel is used as a secondary fuel for brick making accelerating the depletion of scarce carbon sinks in Bangladesh.

3.4 Way forward

31. Transforming the currently energy-intensive brick industry to cleaner-burning, less carbon intensive technology will have significant long term impacts on GHG emissions. An estimate made by a UNDP study indicated a direct reduction of 1.319 million tonnes over the expected 15-year service life (2009-2024) of the energy efficient kilns (EEKs), as the proposed interventions begin to take hold. The CO_2 savings calculations assume emissions from internal combustion to be the same as free burning fuel. At the Global Environmental Facility (GEF) incremental cost of US$3,000,000, the cost of avoided CO_2 emission will be about US$2.27 per tonne over the 15-year period (*IKEBMI 2009*).

SECTION 4
BRICK MANUFACTURING INDUSTRY IN BANGLADESH

4.1 Introduction

32. In Bangladesh, bricks are the predominant building material in urban areas. They have also become a significant building material in the rural areas. High prices and/or scarcity of alternative building materials, such as stones, iron sheets, wood, bamboo, and straw are very rapidly increasing the demand for bricks. To meet the increasing demand, brickfields are mushrooming all over the country with heavy concentrations on the outskirts of urban area. In our country, there are nearly 4500 brick manufacturing companies producing about 17 billion bricks per year. The brickfields are situated all over the Bangladesh. As shown in the Figure 1, brickfields are more frequent around the big cities. The region around capital Dhaka has the biggest cluster of brickfields.

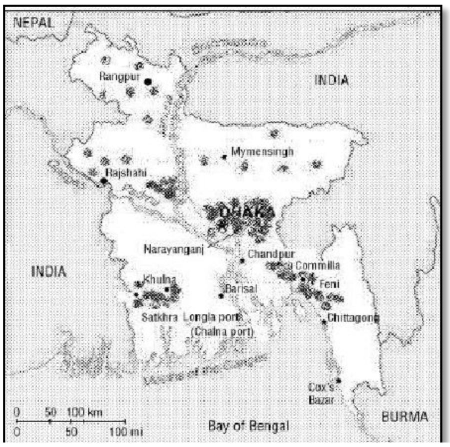

Figure 3: Distribution of brickfields in Bangladesh

33. There are five steps to manufacturing of bricks:
    i. Preparation of clay
    ii. Pugging or tempering of clay
    iii. Moulding of bricks
    iv. Drying bricks
    v. Burning or firing bricks

4.2 Preparation of Clay

34. Preparation of clay involves operation like un-soiling the top loose earth, then digging, cleaning, weathering and blending of the earth. The top layer soil about 30 cm thick contains lot of impurities and as such unsuitable for brick making. After removing the top unsuitable soil, the clay is dug out either with manual or with the help of power excavator. An analysis of the clay available in Bangladesh by Xian

Institute indicates that the locally available clay is given in the Table 3. Dugout clay spread on the level ground. Height of the heap of clay may vary from 80 to 150 cm. After weathering, the earth is chemically analyzed any deficiency of any ingredient it is spread on the heap of the weathered earth and mixed with it with the help of phorah.

Table 3 : Chemical Properties of Clay

SiO_2	55~70%
Al_2O_3	10~20%
Fe_2O_3	3~10%
Cao	<5%
MgO	<3%
SO_3	<3%
Ignition Losses	3~15%
Physical Properties	
Particle size:	
<0.005 mm	~30%
0.005~0.05 mm	~50%
0.05~0.25 mm	~20%
Linear drying shrinkage	~4%
Sintering Temperature	~950^{0}C

The quantity of clay that would be required to produce the target output of 16.5 million bricks is 3.35 million cu.ft. of clay.

4.3 Pugging or tempering of clay

35. Pugging of the clay means breaking up the prepared clay; watering and kneading till the earth become a homogeneous mass. Nowadays in Bangladesh pug mill is widely used for manufacturing of bricks (Figure 4).

Figure 4: Manual pugging & Pugg Mill

Large brickfields use jaw crusher for

36. Crushing and grinding the materials as shown in the Figure 5. First, each of the

ingredients is conveyed to a separator that removes oversize material. A jaw crusher with horizontal steel plates then squeezes the particles, rendering them still smaller. After the raw materials for each batch of bricks have been selected, a scalping screen is often used to separate the different sizes of material. Material of the correct size is sent to storage silos, and over-sized material goes to a hammer mill, which pulverizes it with rapidly moving steel hammers. The hammer mill uses another screen to control the maximum size of particle leaving the mill, and discharge goes to a number of vibrating screens that separate out material of improper size before it is sent on to the next phase of production.

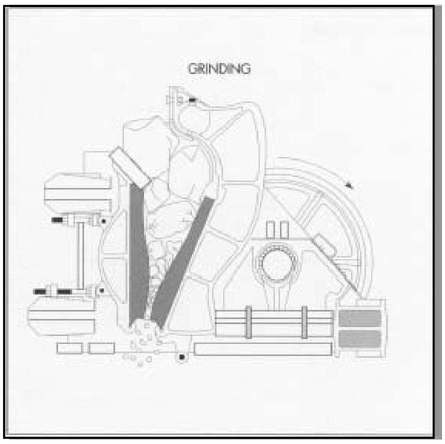

Figure 5: Jaw Crusher

4.4 Moulding of bricks

37. Moulds are made in size slightly greater than the standard size of the brick. It can be made by timber or steel. There are two method usually applied-

(i) Hand moulding

(ii) Machine moulding

4.4.1 *Hand moulding*

38. In Bangladesh most of the brick manufacturing company uses the hand moulding. It is economical and it is great helpful for our national economy. Sizes of moulds are usually 200mm x 100mm x 80mm (Figure 6)

39. A lump of prepared clay is thrown manually into the mould. Excess clay is wiped out by a wooden or metallic wiper, the mould with clay in it is turned upside down, finally the mould is pulled upward to expel the brick from the mould. Each time before throwing clay into the mould, the mould is lubricated with sand for sooth expelling of the fresh brick.

Figure 6: Hand Moulding

4.4.2 *Machine moulding*

40. In some modern brick manufacturing factories, extrusions are used to mould the bricks. These bricks are normally used for ornamental purposes in the country. In extrusion, the pulverized ingredients are mixed together with water, passed into a de-airing chamber (which removes the air to prevent cracking), compacted, and extruded out of a die of the desired shape.

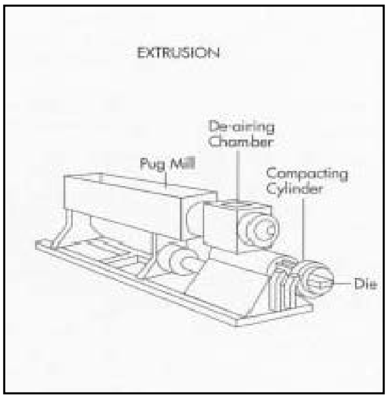

Figure 6 a: Machine Moulding

4.5 Drying of Bricks

41. Before the brick is fired, it must be dried to remove excess moisture. If this moisture is not removed, the water will burn off too quickly during firing, causing cracking. Drying also saves time and fuel during firing. Apart from some modern brick manufacturing factories for special purposes, bricks are in general dried in Bangladesh in the direct sun. The following steps are

considered to drying bricks:

(i) the drying period should be 9 to 12 days (Figure 7).

(ii) should be stalked leveling sufficient space for free air circulation.

(iii) should not be subjected to the direct sun light and wind

Figure 7: Drying of bricks in the sun

42. In modern factories dryers are also used. Two types of dryers are used. Tunnel dryers use cars to move the brick through humidity-controlled zones that prevent cracking (Figure 8). They consist of a long chamber through which the ware is slowly pushed. External sources of fan-circulated hot air are forced into the dryer to speed the process. Automatic chamber dryers are also used, especially in Europe. The extruded bricks are automatically placed in rows on two parallel bars. The bricks are then fed onto special racks with finger-like devices that hold several pairs of bars in multiple layers. These racks are then transferred by rail-mounted transfer cars or by lift trucks into the dryers.

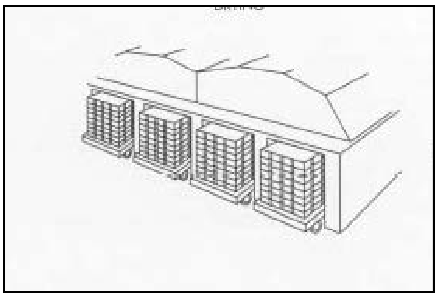

Figure 8: Tunnel dryers

4.6 Burning of Bricks

43. Burning is the most important step in manufacturing of bricks. This process removes water of crystallization from the bricks. The brick should not burn more than 1100 degree centigrade. Bangladesh uses four main types of kiln

technology namely Fixed Chimney Kiln (FCK), Zigzag Kiln, Hoffman (gas) and Hybrid Hoffman Kiln (HHK). A list of brick firing technologies used in Bangladesh and their shares in the industry is provided in the Table 4. While detailed description of the technologies are provided in the Section-5.

Table 4: Existing brick kiln technologies in Bangladesh (2012)

Kiln type	Number	Percent of total Kilns (%)	Brick production (billion bricks)	Percent of total Production (%)
FCK	≤ 5,100	80.5	13.69	80.0
Zigzag	≤ 1000	15.8	2.68	15.8
Hoffmann (gas)	≤ 20	0.3	0.10	0.6
HHK	≤ 15	0.2	0.08	0.5
Others	≤ 200	3.2	0.54	3.2
Total	**≤ 6,335**	**100**	**17**	**100**

Source: Bangladesh Brick Manufacturing Association

SECTION 5
BRICK KILNS IN BANGLADESH

5.1 Introduction

44. Bangladesh is country grappling with energy shortage which should be meticulous in using energy. By contrast it is still practicing technologies which are outdated consuming more energy than modern practices involve. BMI is not an exception; inefficient and polluting technologies are still in use here. Bangladesh uses mainly four types of technologies for brick firing namely, FCK, ZigZag Kiln, Hoffman Kiln (Natural gas) and HHK. Among these four, share of FCK is overwhelmingly high - above 90% of total kilns. FCK is the slightly modified version of the age-old BTK which was the prevalent technology in the country until 2004 when its operation was banned in the country. In this section BTK is also described along with the existing four technologies to have a comprehensive idea about brick firing technologies in Bangladesh.

5.2 Bull’s Trench Kiln (BTK)

45. The Bull’s Trench Kiln (BTK) is essentially an elliptical shaped dug out area in an open field. The kiln is about 250 ft long and 57 ft wide and has two 32 ft high moveable chimneys. The bottom and the sidewalls of the kiln are lined with bricks with the top left open. Figure 9 and shows sketch and plan view of a BTK respectively. Sun dried bricks are stacked in the kiln in an orderly fashion leaving enough room for fuel stoking and air circulation. After arranging the bricks in the kiln, the top of the kiln is covered with fired bricks and pebbles. The bricks are fired from the top and the fire moves forward towards the chimney. The air entrance opening (air hole) and the chimney are located at the two ends in such a way that combustion air is preheated by taking heat from the fired bricks, and the green bricks to be fired are preheated by the flue gas on its way out of the chimney. The bricks are fired all around the kiln, which means that the chimney and the air hole must be progressively moved forward, until all bricks in the trench are fired. The chimneys are made of iron sheets and during a typical season of five months these need to be replaced two to three times because the corrosive flue gases eat away the chimneys very fast. Rain and floodwater destroy the kiln every year because of which BTKs need to be constructed almost from scratch every year.

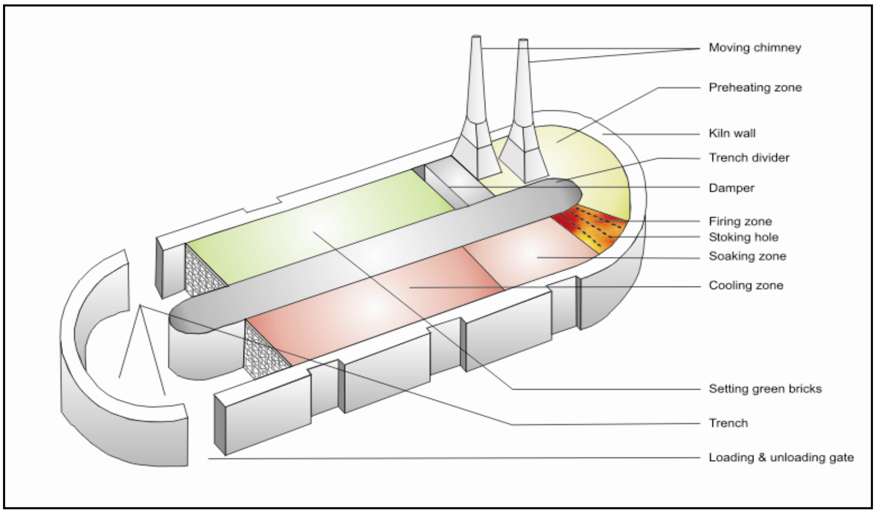

Figure 9 : Bull's Trench Kiln Isometric View

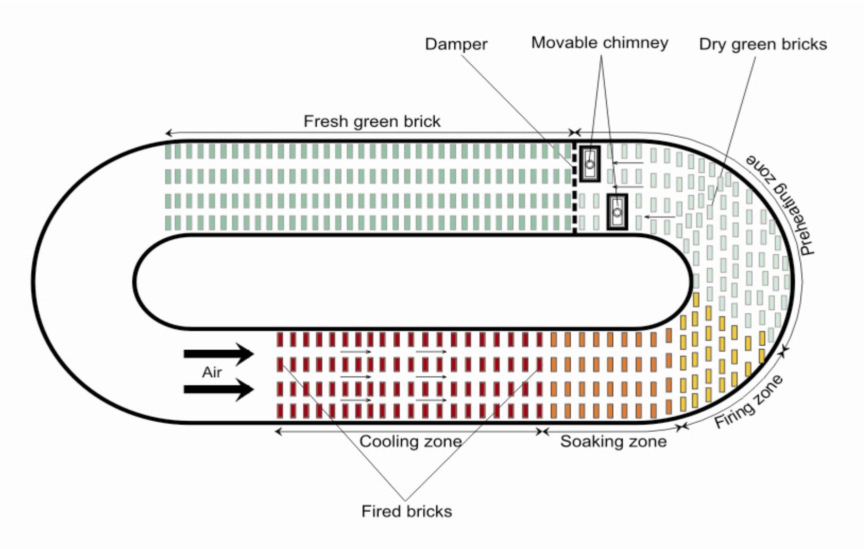

Figure 10: **Bull's Trench Kiln (Plan View)**

5.3 Fixed Chimney Kiln (FCK)

46. Isometric and plan views of Fixed Chimney Kiln (FCK) are provided in Figure 11 and 12. The chimney in a FCK as the name suggests is fixed and is approximately 130 ft high. This tall chimney creates a stronger draft thereby improving the combustion process, and releases the flue gas at a height 130 feet above the ground thus providing faster and better dispersion. In the central portion of the elliptical kiln, there is a chamber and underground piping to divert the flue gas from anywhere in the kiln to the fixed chimney. This extra bit of complication in its structure in contrast to that in the very simple BTK is the fixed nature of the chimney. In a BTK, the chimney is conveniently moved to accommodate firing in progressive sections of the kilns. In FCKs this must be managed by opening and closing dampers to guide the air in the desired path, i.e., past fired bricks for preheating the combustion air (and cooling fired bricks), and guiding the flue gas past green bricks for heat recovery (thus aiding the drying process of the green bricks) and out through the central fixed chimney. The standard kiln is about 250 ft long and 60 ft wide. The length of the kiln is about the same as that of the larger BTK but its width is greater to accommodate the central zone and underground piping. There is now a tendency to build kilns larger than the standard size. The FCK also has better insulation in the sidewalls, which reduces heat loss to the surroundings. The other details including the top of the kiln and operation of FCKs are identical to the BTK. The cost of constructing the chimney is between Taka 1,200,000 and 1,500,000 (US$ 17,100 and 21,400), which is nearly 50% of the total cost of a FCK.

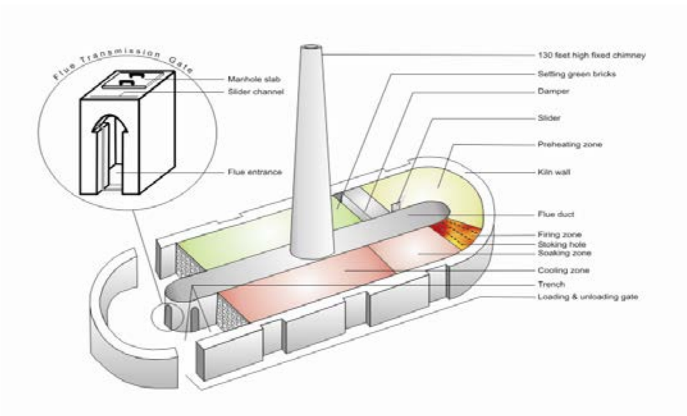

Figure 11: Fixed Chimney Kiln Isometric View

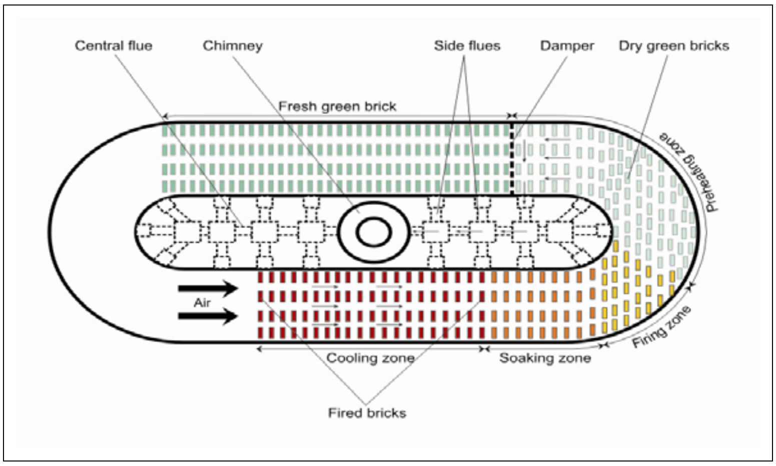

Figure 12 : Fixed Chimney Kiln (Plan View)

5.4 Habla or Zigzag Kiln

47. The Habla or Zigzag Kiln is rectangular in shape and measures 250 ft by 80 ft. It has a 55 ft high fixed chimney located on one side of the kiln (Figures 13 and 14). At the bottom of the chimney there is an induced draft (ID) fan, which draws the flue gas from the kiln and discharges it to the atmosphere. The ID fan ensures a better and more controlled air flow through the kiln thus ensuring a higher efficiency than the FCK. The Zigzag Kiln is reported to be 10-15% more fuel-efficient than the FCK. The kiln is divided into 44 to 52 chambers, which are separated from each other using green bricks in such a way that the hot gases move in a Zigzag path through the kiln. The brick stacking is done in such a way that the flue gas has to move in a Zigzag path through small openings as shown in Figure 14. The facts that the flue gas has to change directions sharply several times in addition to impinging on the walls and stacked bricks imply that significant amount of particulates are deposited. The better heat transfer of the Zigzag kiln ensures that the flue gas has much less un-burnt carbon particles. This is the reason why the emission from this type of kilns appears more brownish as opposed to the grey-black emission of the FCK *(BUET 2007).*

48. The Zigzag Kiln incorporates a very interesting feature for pollution reduction in addition to the Zigzag design. The connecting duct between the center of the kiln and the inlet of the ID fan is half to two-third filled with water. The flue gas laden with dust particles impinges on the water thus losing some of its particulate load. The water is periodically cleaned to ensure good scrubbing. Despite saving on the cost of the tall chimney, this Kiln is expensive to construct and costs approximately the same as a FCK. There are about 200 such kilns in operation with a concentration in the Comilla region. Present FCK owners are keen to convert to the Zigzag technology provided the Department of Environment is willing to grant it an environmental clearance.

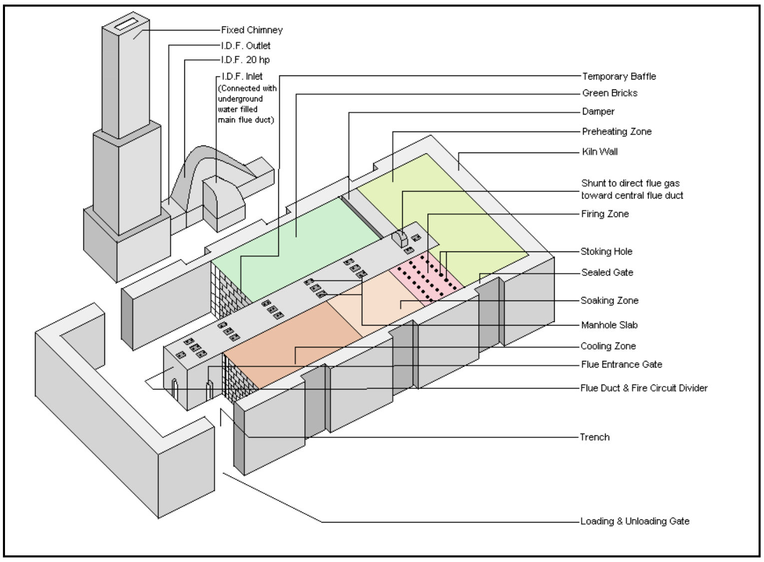

Figure 13: Zigzag Kiln (Isometric View)

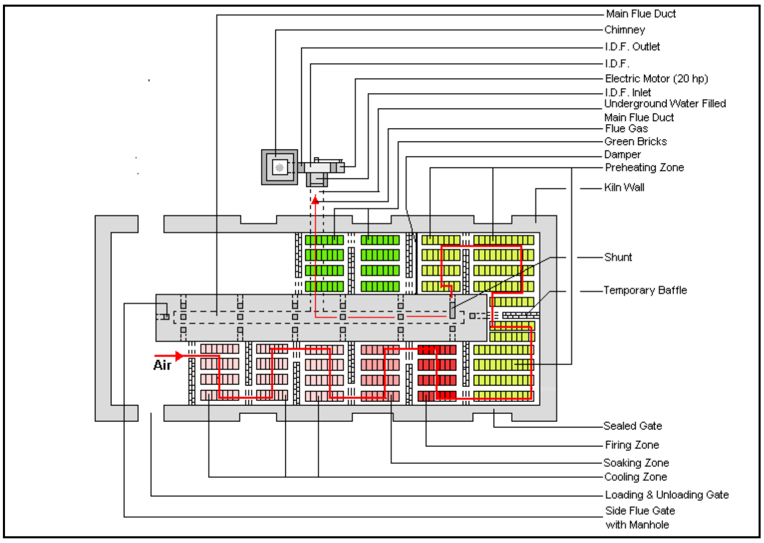

Figure 14: Zigzag Kiln (Top View)

5.5 Hoffman Kiln (Natural Gas)

49. A Hoffman Kiln is rectangular in shape and measures 300-400 ft by 60 ft. as shown in Figures 15 and 16. Building a Hoffman Kiln requires special expertise and thus involves engaging engineering consultants. The predominant difference between the Hoffman Kiln and the traditional kilns is the fixed roof, which enables bricks to be fired throughout the year, although during the rainy season,

which is called off-season, the production decreases significantly because of frequent rainfall, high humidity and greatly reduced availability of sunshine. Some manufacturers overproduce green bricks during the dry season and store them for the rainy season, but to do that adequate storage facility must be available, which is an expensive proposition. Also for off-season production clay has to be stored, as harvesting of clay becomes extremely difficult due to flooding during the rainy season.

50. The inside roof of the kiln is arched Figure 17 and has a firebrick lining on the inside surface. The thick walls of the kiln provide good insulation thus minimizing heat loss to the surrounding. Green bricks are stacked in the kiln in more or less the same fashion as that in the FCK. The bricks are fired from the top by introducing the fuel (natural gas) into the combustion zone through pipe-type burners. This firing practice is identical for all kilns in Bangladesh except for the fact that in the other three kilns coal particles are manually charged every 20-30 minutes from holes at the top of the kiln. The burners are shifted forward from section to section as the fire progresses - fired bricks are unloaded at the back while green bricks are stacked in front of the firing zone. The chimney is 76 ft high with an induced draft (ID) fan at the bottom. The flue gas is conveyed towards the chimney through a network of channels just below the kiln. Fire is controlled without the aid of any instrumentation or controllers by merely adjusting the gas flow rate and the opening and closing of dampers located at selected points in the flue gas network. Controlling the fire is the trickiest part of the whole operation. Hoffman Kilns use natural gas as fuel and the consumption rate is 15000-17000 m^3 per 100,000 bricks. On an energy basis, the Hoffman Kiln is not much more efficient than the FCK, but because it uses natural gas the carbon dioxide and particulate emissions are considerably less.

51. Needless to say, the Hoffman Kiln being natural gas fired is infinitely superior to all the coal burning kilns in terms of pollution. The FCK because of the tall chimney is able to disperse the pollutants in a much larger area thus lowering pollution in the vicinity of the kiln. In a Zigzag Kiln since the flue gas moves in a Zigzag path, most of the coarse particles are retained in the kiln and are thus prevented from being discharged into the atmosphere. In a Zigzag Kiln the combustion process is superior to the FCK because it employs an ID fan to create the draft.

52. To cope with the higher production requirement and year round production, most NG Hoffman Kilns have installed extruders for brick making. Some have also installed drying chambers, which use the flue gas from the kiln as the drying medium. With the incorporation of drying chamber, extruders and clay loaders, the back process can be fully mechanized. Depending on the type of machinery employed this can double the investment of a Hoffman kiln. A Hoffman Kiln recently built cost approximately US$ 1.2 million, while the maximum investment for an FCK or Zigzag is US$ 70,000.

53. Sourcing of clay is another logistical problem that Hoffman Kilns have to tackle. During the heavy monsoon season clay cannot be mined in most places, and availability of clay becomes a big issue. This is one of the reasons traditional kilns do not operate during monsoon months. Of course the main reason is that their kilns are built on low lying land, and most kilns are inundated.

54. Land requirement for a FCK and Zigzag Kiln is about 2.5 acres whereas that for a

Hoffman Kiln is at least 5 acres predominantly because of the latter's greater production capacity and the need to store clay for rainy season operation. It must however be made clear that the major portion of the land requirement for all four kilns is for forming and drying of green bricks. Bricks are formed manually and sun dried in a large open area four to five times the area occupied by the kiln. If only the kiln portion is compared then the land requirement for all kilns are more or less the same.

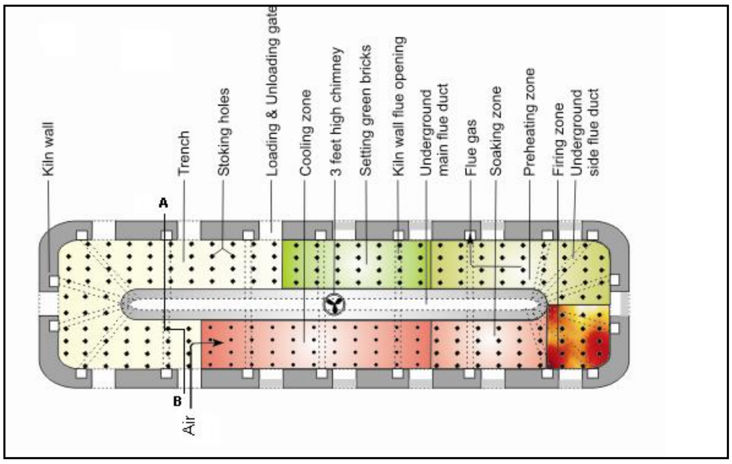

Figure 15: **Hoffman Kiln (Top View)**

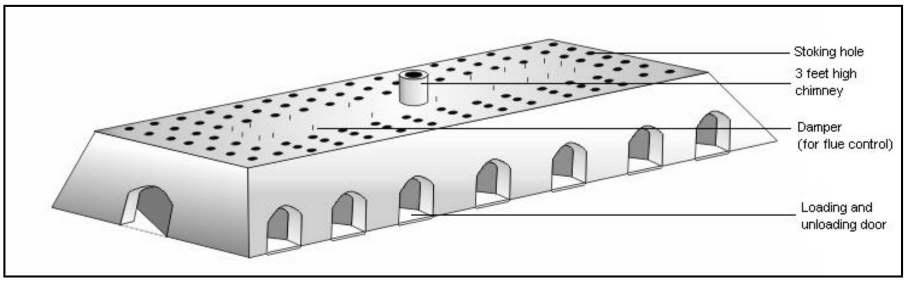

Figure 16: Hoffman Kiln (Isometric View)

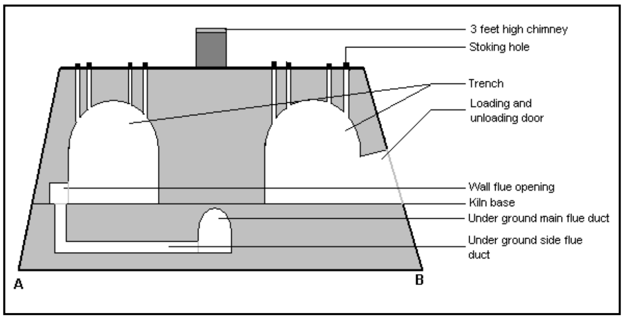

Figure 17: Hoffman Kiln Arch Showing NG Holes and Flue Gas Outlet

5.6 Summary of In-use Technologies

55. Summarized descriptions of the three in-use technologies are presented in Tables 5 & 6.

Table 5: A Comparison of the Three Kilns Being Used in Bangladesh

Parameter		Fixed Chimney Kiln	Zigzag Kiln	Hoffman Kiln (NG)
1. Land		2.5 acres, of which 1 acre used round the year	2.5 acres, of which 1 acre used round the year	Minimum 5 acres of high land round the year
2. Raw Material and Services	a) Clay	200,000 cft./yr	250,000 cft./yr	700,000 cft./yr
	b) Labour	150 (15% skilled, 15% semi-skilled)	150 (15% skilled, 15% semiskilled)	250 (25% skilled, 45% semi-skilled)
	c) Electri-city	Not essential	Needed for the ID fan	Necessary – outage hampers production
	d) Fuel	Coal	Pulverized Coal	Gas
3. Fuel consumption	100,000 Bricks	20-22 tons	16-18 tons	15000-17000 m^3
4. Pollution		Severe Pollution	10-50% less than FCK depending on management	Very little pollution
5. Production Period		November to April	November to April	Round the year
6. Wastage		3%-5%	5%-8%	8%-10%

Table 6: Comparison of Scales of Operation, Constraints in Operability, Quality of Bricks and Emissions for In-use Brick Technologies

	FCK	Zigzag Kiln	Hoffman Kiln (NG)
Scales of Operation	3-4 million	4-5 million	10-14 million
Constraints in Operability	1. Source of clay 2. Rain causes extensive loss 3. Very difficult to	1. Source of clay 2. Rain causes extensive loss 3. Pollution	1. Clay storage for rainy season 2. High thermal mass – Kiln takes long time to heat up after shutdown

	startup kiln 4. Pollution		3. Large operation
Quality of Bricks	Acceptable	Better than FCK	Good. Excellent with extruder
Emission with Poor Management	Very high	High	Low
Emission with Average Management	High	Medium	Very low
Emission with Good Management	Medium	Medium to low	Extremely low

source BUET 2007

Section 6

ALTERNATIVE TECHNOLOGIES AND PRACTICES

6.1 Introduction

56. Energy efficient and environment friendly brick kiln technologies are available in the world. Alternative technologies and practices that are in use other regions in the world can reduce particulate with other emissions and increase energy conservation potential from the thousands of brick kilns operating in Bangladesh. The alternative technologies and practices that have been considered in this report are only those that can be implemented in Bangladesh's present situation. For this reason options such as the modern Tunnel Kiln have not been dealt with. Moreover emphasis has been laid on options that achieve the desired goal with minimum changes to the existing structure of the brick kiln industry. Thus, two new technologies (VSBK and Coal Hoffman), two existing technologies having low penetration (NG Hoffman and Zigzag), one new practice (adding Gravity Settling Chamber to FCK and the use of internal fuel) and one brick substitute (cement/concrete block) have been reviewed. These alternatives are described with observations in the following sections.

6.2 The Vertical Shaft Brick Kiln (VSBK)

57. VSBK technology was developed in China and VSBK is a very popular kiln in rural China for small scale production of bricks. The technology was innovated in China, but now has been disseminated to many countries in South and Southeast Asia. The Vertical Shaft Brick Kiln (VSBK) unlike all other technologies has a vertical combustion chamber. As a result of the kiln being vertical, many features including operating procedures are totally different. This difference poses a significant barrier towards promoting this technology. In contrast, all other technologies including the NG fired Hoffman Kiln have more or less the same kiln design, brick stacking and firing.

58. The kiln in the VSBK is called a “Shaft”. Figure 18 shows the internal arrangement of a shaft, while Figure 19 is a real a picture of a VSBK. There are several platforms, which progressively move down. Green bricks have to be carried to the top using either a ramp or a lift, and are stacked at the top platform. The firing takes place roughly around the middle of the shaft, while fired bricks are unloaded at the bottom after 24 hours of loading. The residence time at the firing zone is around one hour. It is to be noted that in this kiln, the fire (or firing zone) is stationary, while the bricks move. This is therefore similar to the operation of a modern tunnel kiln except that the kiln is vertical rather than horizontal.

59. There are two special features incorporated in the VSBK for efficient use of fuel as well as reducing pollution. First is the practice of adding to clay a substantial portion of the coal as internal fuel. Up to 50% of the total coal in the form of a powder can be mixed in with the clay. The second unique feature of the VSBK is charging of the coal along with the green bricks. Thus, powdered coal is carefully placed in between the green bricks. This practice is a significant variation from the other kilns, where the fuel (coal and natural gas) is introduced from openings in the top of the kiln. Since the coal is stationary and slowly enters the hot combustion zone it burns out completely yielding higher efficiency and less pollution compared to the FCK. In the other kilns it

has been observed that the pollution predominantly occurs when coal is periodically charged into the kiln.

60. From the above description of the technology observations are made as under:

- VSBK is a new technology, and its construction and operation are different from the existing kiln technologies and practices. However, the technology and operation are not complicated, and adopting this technology should not pose much problem.
- Since the technology does not exist in the country, a technology supplier has to be engaged from neighboring India to provide fulltime support for 2-3 years.
- Some operational aspects such as carrying green bricks to the top of the kiln, stacking bricks, mixing internal fuel with clay, controlling the fire in the firing zone and unloading bricks require special attention and slightly more skill and effort than the traditional practice.
- Unloading of bricks is a major operational challenge because bricks tend to crack if withdrawn too quickly from the hot kiln. Apparently this problem has been solved in the new design proposed by Development Alternatives.
- The bricks in terms of compressive strength fully meet specifications, but brick makers in Bangladesh do not like the appearance of VSBK bricks (less reddish than FCK bricks). Moreover, VSBK bricks do not produce the familiar ringing tone when banged together, which is a criteria often used by buyers to test the quality of bricks.
- In terms of pollution, this is by far the best coal-fired kiln option. Its particulate emission is less than one-third of the existing FCK. VSBKs are reported to have emission levels between 200-400 mg/m3. It should easily be able to meet future emission standards.
- VSBKs are also fuel-efficient. VSBKs can easily reduce coal consumption by one-third.

Bangladeshi experience with VSBK

In 2010, Conforce Bricks, a local enterprise, implemented a two-shaft VSBK plant in Bangladesh under a project financed by the World Bank / Energy Sector Management Assistance Program (ESMAP). The investment cost was about TK3.5 million for a production capacity of 8,000 bricks per day. The operating plant emits no visible smoke, indicating low PM emissions. Conforce Bricks has long worked in the brick industry and has all the needed resources (land, human, technical, and financial) to ensure successful kiln implementation. The project consultants were Development Alternatives (DA) from India and Practical Action (PA), its local partner. DA has many years of experience building VSBKs and has worked extensively to introduce the technology in India, Pakistan, Nepal, Afghanistan, Vietnam, and South Africa. Based on the pilot implementation, DA produced three manuals on standard design, construction, and operation of the VSBK.

One shaft became operational in August 2010 and the second in November 2010. ESMAP report (No. 60155-BD) 'Introducing Energy-efficient Clean Technologies in the Brick Sector of Bangladesh' June, 2011 stated that until the time of reporting the operations had been successful, and the bricks met Bangladesh standards. The bricks were selling well—at a lower price than that of the products made by the natural-gas Hoffmann kiln located on the same site—and the entrepreneur was planning to invest in a second two-shaft kiln. The author while preparing this report came to know that the plant is now shutdown because of the two reasons, Firstly, the bricks produced in the plant are of lower compressive strength compared to those produced in FCK or Zigzag Kilns. Because of the lower strength they could not sell products although they initially produced about 700,000 bricks. Secondly, rate of production i.e. production per day is far less than that in FCK which affected overall profitability of the investor.

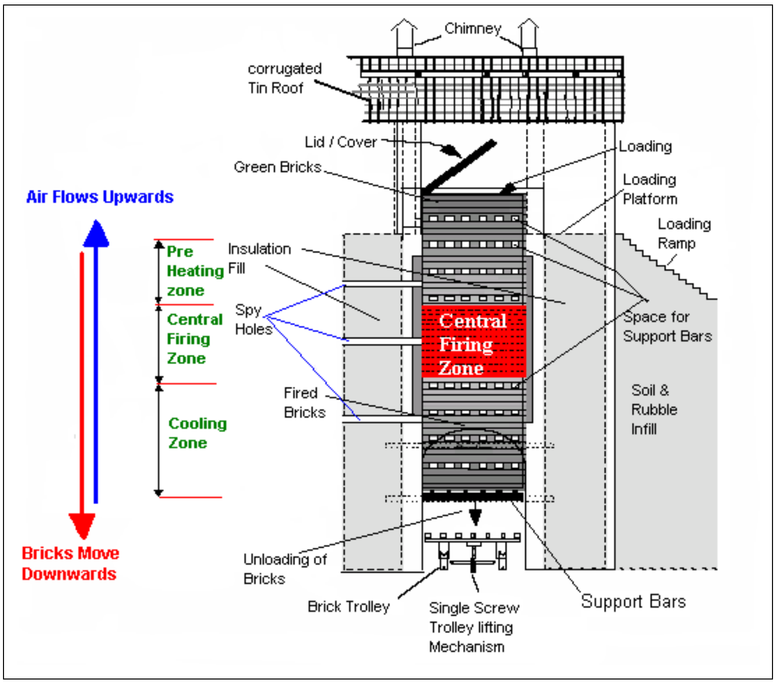

Figure 18: Internal Arrangement of a Vertical Shaft Brick Kiln

Source: IEM 2003

Figure 19 :Picture of Vertical Shaft

6.3 Zigzag Kiln

61. The Zigzag Kiln has already been described earlier under existing technology in Section 5. This technology has proved to be rather popular with brick manufacturers predominantly because of the 10-20% fuel (coal) savings compared to the FCK.

62. Experience has revealed that if initial design, construction, operational practices are not proper, a Zigzag Kiln may be as polluting as an FCK. What appear to be important are a good initial design, proper construction and good operational practices and management. If these features and measures are in place, the stack emission of Zigzag Kilns can certainly be brought down to the level of future DOE emission standards (assumed 500 mg/m^3) for brick kilns (BUET 2007).

63. From the above description following observations are made as under:

- Zigzag Kilns are similar to the FCK in construction and operation. The additional pieces of equipment are an ID Fan and a Coal Pulverizer. The existing tall chimney of the FCK can be retained, which will yield the benefit of lowering the capacity requirement of the ID fan
- It has the potential of lowering emissions, but only if the initial design is good and very careful attention is paid to several operational details. Very close monitoring is required to achieve good results from this technology.
- In addition to good management, if the concept of Internal Fuel can be successfully implemented in the Zigzag Kiln, then the pollution can be brought down to a level comparable to the VSBK and the Chinese Hoffman Kiln.
- DOE is issuing clearance to Zigzag kilns. It is learnt from BBMOA that about 1,000 Zigzag kilns have either newly been constructed or converted from FCK across the country.

6.4 Hoffman (Coal) Kiln

6.4.1 *Introduction of HHK in Bangladesh*

64. Developed in China, the Hybrid Hoffman Kiln (HHK) represents a hybrid version of the Hoffmann kiln technology developed in Germany in the mid-19th century. Unlike the gas-based Hoffmann kiln, the HHK uses coal as fuel. The HHK combines fuel injection and external firing in highly insulated kilns, leading to lower energy use, high-quality bricks, and reduced pollution. About 15 HHK are currently in operation in the country and other 12-15 kilns are under construction.

65. HHK was first introduced in Bangladesh in 2006 under a UNDP-GEF supported project. With the technical assistance of UNDP-GEF, Hybrid Hoffman Kiln (HHK) has been promoted as an alternative clean brick making technology in order to attain this win-win situation in the brick sector of Bangladesh. Most bricks work as filters inside the drying tunnel and absorb un-burnt coal particles from the exhaust during the drying process. Universal Bricks Ltd established a pilot HHK at Amtali (Dhamrai, Savar) near Dhaka, with support from the GEF project. Clean Energy Alternatives Initiatives and Xian Research and Design Institute of Wall & Roof Materials of China

provided technical assistance under UNDP-GEF funded IKEBMI for the plant design, supervision of construction, and trial operation. The plant went into trial production in 2009 and is now in commercial operation. So far 8 Kilns have been constructed under this project and another 2 kilns are construction. This project aims at completing construction of 14 HHKs by 2014.

66. IIDFC, a consortium of 12 commercial banks and lending institutions in Bangladesh, signed a letter of intent (LOI) with the World Bank, the trustee of the Community Development Carbon Fund (CDCF), to act as a Nodal Agency (Bundling Agent) to develop and implement a Small Scale Clean Development Mechanism (CDM) project. The purpose of the project activity titled as "Improving Kiln Efficiency in the Brick Making Industry in Bangladesh" [Hybrid Hoffman Kiln (HHK) Project] is to construct new low energy consuming kilns to significantly reduce emission of Carbon dioxide gas (CO2) and other local pollutants that are generated by the traditional brick kilns of the country. The two bundled CDM project activity will construct 16 new energy efficient kilns, 14 with a capacity of 50,000 bricks per day (single size) and 2 kilns with a capacity of 100,000 bricks per day (double size). Under the bundle -1, eight kilns, six kilns with production capacity of 50000 bricks per day each (single size) and kilns with capacity of 100,000 bricks have been constructed and they are under operation. It is reported that CDM fund for operating 8 kilns (bundle-1) has already been released. Another 8 under the bundle 2 is under construction, they also be covered by the CDM project. One point is noteworthy here that so far none of the FCK owner has come forward to convert the existing FCK kilns to HHK, new investors are constructing HHKs in the country.

6.4.2 *Design of HHK*

67. The basic design of this kiln is identical to the Bangladeshi natural gas fired Hoffman Kiln, but using the following features, the cost of this kiln has been reduced significantly:

    (i) Much thinner kiln walls

    (ii) Ordinary bricks in place of firebricks

    (iii) No cover over the kiln

68. Only two demonstration kilns have been constructed. The inside of the kiln is pictured in Figure 20, while Figure 21 provides a full view of the kiln. In the configuration that is being employed, the technology has the following extra features compared to the existing traditional practice:

    (i) A drying chamber for drying green bricks

    (ii) Extruder for forming bricks

    (iii) Clay loader and conveyor

Coal fired Hoffman is able to lower coal consumption and reduce pollution compared to the baseline technology, i.e., the FCK because,

(i) It uses internal fuel (powdered coal) mixed with clay to make green bricks

(ii) It has better heat insulation due to the solid walls and permanent kiln roof

(iii) It achieves better combustion due to the supply of combustion air using an ID fan and no leakage of cold air from the side walls and roof

69. It is claimed that up to 80% of the total fuel required to fire bricks can be incorporated as internal fuel. This certainly needs to be tested because the proportion of internal fuel will depend strongly on the clay properties and coal quality, both of which may differ greatly from those in China. The VSBK also uses internal fuel, but a maximum of 50% is recommended.

70. The fact that the coal Hoffman has a permanent thick roof in addition to robustly constructed side-walls implies that heat loss would be greatly minimized. The FCK suffers from this design defect, and one of the suggestions to improve the performance of the FCK is to plug the numerous air leaks. In the FCK the combustion air is supplied by natural draft created by the tall 120 feet chimney. In Hoffman Kilns (also Zigzag Kiln) an ID fan is employed for that purpose. The higher and uniform draft ensures a much better environment for combustion. Additionally the fact that the entire combustion area is an enclosed space means that better temperature control and opportunity for all coal to burn out exists.

6.4.3 *HHK Manufacturing Process*

71. **Clay Extraction, Transportation and Preparation:** The clay is excavated by hydraulic excavator or by hand from nearby riverbeds or surface clay mined from open pit and transported to plant stacking yard by trucks. The clay is crushed by means of roller mills and then by double shaft mixer where water and granulated coal is added in such a manner as to ensure moisture content of 15%.

72. **Coal Crushing and Pulverizing:** Coal is crushed using steel sieve type crushing machine to pulverize the coal.

73. **Brick Shaping:** The tempered material is fed into vacuum extruder for continuous column production. The column is then cut by Clay bar cutting machine. The green bricks are set on wood planks that are manually loaded on the drying cars for drying.

74. **Brick Drying:** The green brick is then manually loaded on to the drying car, which is then transported into the drying tunnel by means of hydraulic pusher. Hot air for drying is funneled into the tunnel from the annular kiln. The drying cycle is about 24 hours.

75. **Brick Firing:** The dried green bricks are unloaded manually into the annular HHK (Hybrid Hoffman kiln). The speed of firing is 1.25 m/h at a sintering temperature of about 950-10500C. The fired brick are unloaded and conveyed manually in carts to stacking yard.

Main technical data include:

a) Clay Particle size after roll mill: < 2mm

b) Brick Moisture content for shaping: 18%–20%

c) Dry chamber temperature 120 o C

d) Sintering temperature: 950^{o} C –1050^{o}C

1. A Schematic Diagram for the brick making process using HHK is shown in Figure 20

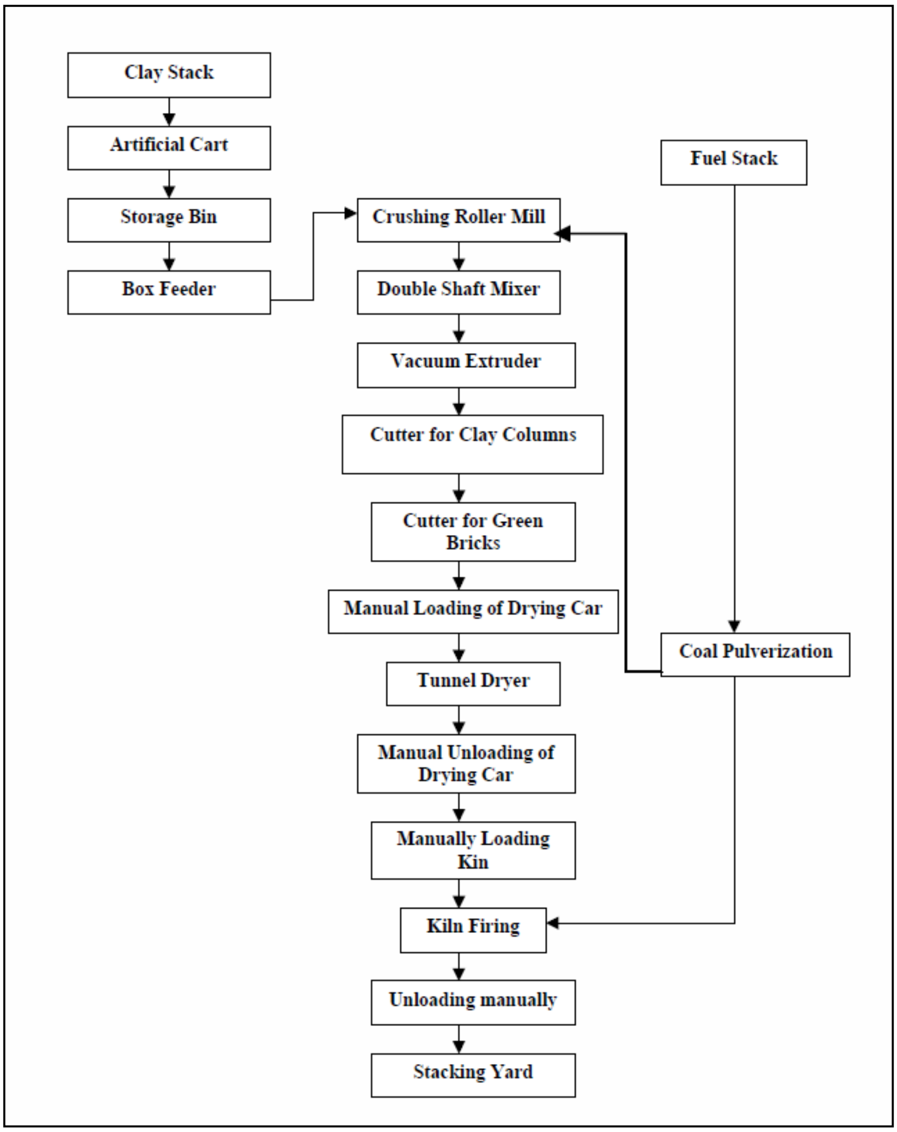

Figure 20: **: Flowchart of Brick Making Process for HHK**

Source : IIDFC 2009

76. From the above description; observations on the technology are made as under:

- There are no technical constraints to establishing this technology
- This technology improves energy efficiency in two ways: (i) internal combustion of injected fuel in green bricks and (ii) application of heat optimization techniques in a minimum heat-loss chamber in the kiln's combustion zone to capture waste heat for recirculation in the drying tunnel.
- The operation of this kiln is identical to existing NG Hoffman. Therefore, not much problems are envisaged because NG Hoffman Kilns have been operating in Bangladesh for over a decade.
- These kilns can reduce pollution substantially because of several features discussed above, and can easily meet future standards set by the DOE.

Figure 21: Inside View of Coal Hoffman Kiln (HHK)

Figure 22: Full View of Coal Hoffman Kiln (Hybrid Hoffman Kiln)

6.5 Hoffman (Natural Gas) Kiln

77. The Hoffman Natural Gas Kiln just like the Zigzag Kiln is part of the baseline technologies. The penetration level of this nearly pollution free brick making technology is so low that it forms part of the Alternative Kiln Technologies set. Despite the fact that this technology has been around for more than 15 years, its popularity among brick makers has not increased. The principal reason for this is the low profitability. Thus, even though the bricks are superior to the traditional bricks and commands a 10-15% price premium, NG Hoffman technology cannot compete against traditional technologies.

78. It is clear from the foregone discussion that without support it is impossible to expect a FCK owner to make the transition to even the semi-modern Hoffman Kiln. The predominant barrier in this transition is clearly the up-front investment requirement. The Hoffman Kiln requires more than 10 times the investment of a FCK. Transition to Hoffman Kilns must also deal with the following barriers:

    (i) For each kiln, 10 acres of high land close to a main road and the natural gas grid

    (ii) Large working capital

    (iii) Having to sell bricks at a 20-25% premium to make adequate profit

    (iv) More sophisticated management due to larger size

    (v) Reduction in the total number of kilns (1 Hoffman = 3 FCKs)

2. The land issue can sometimes be more critical than investment because it is extremely difficult to get suitable land at reasonable prices as most land holdings are fragmented. In comparison FCKs require only 2.5 acres of low-lying land. To overcome the investment/working capital barrier, loan schemes devised by the government or other organizations must take into account the following facts about FCK owners:

    (i) Many are not educated enough to manage the required paperwork, and

    (ii) They have very little creditworthiness with financial institutions.

Fortunately, the labour-intensive part of brick making, i.e., the forming of bricks from clay and the loading and unloading of raw material and bricks at various stages of production, can be retained if mechanized green brick making is not opted for. Another impediment in the spread of natural gas fueled kiln in Bangladesh is that the government is discouraging new connection to the brick kilns in view rise in demand of gas in other sectors vis-a-vis shortage in supply.

6.6 FCK Retrofit (IFCK)

79. Existing FCKs can be retrofitted with one or more of the following options for reducing stack emissions:

    - Gravity Settling Chamber (GSC)
    - Improved coal feeding
    - Plugging air leaks and better operation
    - Internal fuel (up to 50%)

Gravity Settling Chamber

80. Bangladeshi FCKs do not have gravity settling chamber. In India, the inclusion of the settling chamber is compulsory and part and parcel of the 120 feet chimney. The gravity settling chamber is a compartment at the bottom of the chimney. The chamber is a large space with many baffles so that the velocity of the exiting flue gas is reduced. An Indian study (Maithel, 1999) found that the velocity is reduced to 0.3 to 3.0 m/s. The reduction of the flue gas velocity implies that heavy particles will not be able to travel with the gas stream and will be deposited in the settling chamber. The addition of the chamber is a simple matter, and can be easily incorporated in the Bangladeshi FCKs. Some Indian data is available for gravity settling chamber modification along with improved coal feeding. The particulate emission can be reduced below 500 mg/m^3 and that would meet present and future emission standards.

Improved Coal Feeding

81. As explained above, the maximum pollution occurs when the coal is fed into the combustion chamber. This feeding is done every 20-30 minutes. It has been found that if this feeding is done slowly or say every 10 minutes, the pollution can be reduced substantially. Of course the best solution would be a continuous slow feeder. But that is not possible with manual coal feeding. A special device has to be used. Such a device would complicate the operation and is inappropriate for the existing technology. This is also one of the suggested pollution reduction guidelines of the Indian Standards.

Plugging Air Leakage and Better Operation

82. Several studies have revealed that many small improvements can be made to the existing operation of FCKs to reduce stack emissions. The main one is plugging air leaks. Since the FCK and the Zigzag do not have a fixed roof, unlike the Hoffman, cold air can leak into the combustion zone lowering its efficiency. Since the kilns are not repaired promptly, air leakage also takes place from numerous points in the kiln walls. Attention to how the temporary roof of the kiln is made and to the other operational details like opening and closing dampers can improve fuel efficiency and reduce emission. These practices are not easy to monitor, and are included here only for the sake of completeness in terms of good practices for brick burning in traditional kilns.

Internal Fuel[1]

83. The practice of incorporating carbonaceous material like straw into the clay to form green bricks is as old as brick making itself. It is to be noted that both the new pollution reducing alternative technologies (VSBK and Coal Hoffman) employ Internal Fuel to reduce emission. From a purely theoretical consideration, there is no reason why this should not work in the traditional

[1] Internal fuel is powdered coal mixed with clay while making green bricks for better burning. Internal fuel reduces the fuel requirement significantly.

kilns. Since the incorporation of internal fuel, in this case powdered coal, requires only the addition of a coal pulveriser and better pug mill operation, this practice can very easily be introduced into the existing FCK and Zigzag operations.

84. The Clean Air and Sustainable Environment (CASE) project piloted an IFCK for demonstration of internal fuel in green-brick making and better feeding and firing practices. The manufacturing company Rose Bricks carried out the pilot project in Rupganj, Narayangunj by integrating in the same kiln the use of internal fuel, as well as better feeding

and firing practices. It has been seen that intensity of smoke is reduced for kilns using internal fuel compared to FCKs (ESMAP 2011).

6.7 Observations on New and Retrofitted Technologies

85. The retrofit approach can reduce PM emissions by around 50 percent and improve energy efficiency by 20 percent. In contrast, newer technologies can reduce PM emissions by around 80 percent and increase energy efficiency by around 40-50 percent. A comparison of fuel consumption and emissions from retrofitted and new technologies with the baseline technologies has been shown in the Table 7.

Table 7: Fuel consumption and particulate and CO2 emissions from kiln technologies

Technology	**Coal consumption** (t/100,000 bricks)	**Particulates (SPM)** (mg/m3)	**CO2 emissions** (t/100,000 bricks)	**CO2 emission reduction** (%)
Baseline				
FCK	20-22	1,000	50	n.a.
Retrofitted				
IFCK (internal fuel, gravity settling chamber and other)	16-18	< 500	40	20
Zigzag (good management)	16-18	270-300[a]	40	20
New				
HHK	12-14 [d]	20.3 [b]	30	40
VSBK	10-12 (11-16)[e]	78 -187[c]	25	50

Sources: BUET (2007) and [a.] Maithel et al. (2002) for high draft kilns in India; [b] World Bank (2008) for measurement for an HHK in Bangladesh; [c] Pandit et al. (2004) for Nepal and Maithel et al. (2003) for India; [d] CDM (2009); [e] Heirli and Maithel (2008).

86. Technology improvement in the brick sector will reduce the environmental impacts and also help solve social issues related to this sector. However there are many challenges are there to overcome for successful introduction of modern techniques and technologies in this sector. A summary of the constraints and ability to meet current and future emission standards is given in the Table 8

Table 8: Summary of Various Constraints and Ability to Meet Current and Future Emission Standards

	VSBK	Hoffman (coal)	Zigzag (under good management)	FCK (+GSC+IF)	Natural Gas Hoffman
Constraints to establish	Brick makers resistant to new technology	-Investment barrier -Difficult to find high land	None	None, except that internal fuel (IF) is an untested option	-Investment barrier -Gas grid -Difficult to find high land
Availability of technology supplier	-None in the country -Available in India	GEF-UNDP project provided technology	Yes, but for good design, supplier from India recommended	Gravity Settling Chamber (GSC) technology has to be procured (India)	Yes, this is a Bangladeshi design
Critical skills required to establish	Initially (the first 10 kilns) would require technology support	Engineering consultant required	Consultants only required to provide good design	None	Engineering consultant required
Constraints in operation and maintenance	-New type of operation -Training required	-Reliable supply of electricity -Clay supply and storage for rainy season -Managing a 3-5 times larger operation	Careful operation and good management are critical for lowering emissions	Not known, piloting required	-Reliable supply of gas and electricity -Clay supply and storage for rainy season -Managing a 3-5 times larger operation
Technical quality of product	-Good, but bricks using IF will be new in Bangladesh -Perception problem exists	Good	Better than FCK	Good	Excellent; can be used as concrete aggregates
Emission levels **-Current Standard** **-Future Standard**	Low -Can meet very easily -Can meet easily	Low -Can meet very easily -Can meet easily	Medium -Can meet -Possibly can meet	Medium to Low -Can meet easily -Can meet	Very low -Can meet very easily -Can meet very easily

SECTION 7

ECONOMIC AND COST-BENEFIT ANALYSIS OF ALTERNATIVE TECHNOLOGIES

7.1 Introduction

87. In Bangladesh, use of the traditional FCK is profitable for the entrepreneur, but highly polluting for society. Experience in other South and East Asian countries, including India, Nepal, and Vietnam, indicates that the IFCK, VSBK, Zigzag, and HHK are substantially cleaner: they consume less energy and emit lower levels of conventional pollutants and CO2 emissions. Adopting these technologies would be made easier if they were more socially and financially profitable than the FCK. This chapter assesses the social (public) and private (financial) net benefits of the FCK, IFCK, VSBK and HHK.

88. It should be noted that the analysis is subject to some limitations. First, it covers only a set of technologies for which data could be made available. Other technologies, though successful throughout the region, could not be included, either because of lack of well-documented information or because of their unlikely viability in the Bangladesh context (e.g. technologies based on non-fired bricks). Therefore, the implications of this analysis refer only to the technologies described in this report.

89. Second, despite capturing a large portion of the impacts caused by brick kilns, the analysis does not include some effects, such as the impacts of air pollution on the value of real estate, on recreational areas, and on agricultural productivity. In addition, the negative effects of pollutants other than PM (e.g., SO2 and NOx) and of the hard physical labour on workers' health could not be estimated. Because of these limitations, present estimates should be regarded only as orders of magnitude.

90. The analysis presented in the following paragraphs has been prepared on the basis of recently (June 2011) conducted Study Report (No. 60155-BD) entitled *Introducing Energy-Efficient Clean Technologies in the Brick Sector of Bangladesh* under Energy Sector Management Assistance Program (ESMAP), the World Bank.

Comment [AM1]: This chapter has been re-produced from Report (No: 60155-BD) Ch 5, whereas it can be referred in ch 3 of the study

7.2 Assumptions for the Selected Technologies

91. The analysis focused on brick kilns located in the North Dhaka cluster, home to about 530 FCKs, which produce about 2.1 billion bricks, or nearly 15 percent of Bangladesh's total brick production. The assumptions for the selected technologies are as follows:

- The FCK is assumed to produce about 4 million bricks over a 5-month season.
- IFCK over the FCK include internal fuel, better feeding and firing practices, molders, and gravity chamber. Brick production can run from as low as 4 million (i.e., same as the FCK) to as high as 5.8 million bricks.
- A 4-shaft VSBK, with an average production of 4.8 million bricks per season based on production of 16,000 bricks per day, 360 work days /yr, and 83% capacity utilization.
- A single-sized HHK with an average production of 15 million bricks based

on production of 50,000 bricks per day, 360 work days /yr, and 83% capacity utilization.

7.3 Cost-Benefit Analysis (CBA)

92. Estimating the net returns from each technology is based on the Cost-Benefit Analysis (CBA) approach. The analysis measured the net returns from the private and social perspectives, defined as follows:

- **The private (financial) CBA—**analysis from the entrepreneur's viewpoint—includes all costs and benefits for the entrepreneur**.** Costs include investments (e.g., cost of buildings and kiln chimney, land, other inputs, and taxes), while benefits comprise the value of brick production. The costs and benefits are estimated at market prices. The analysis assumes that the entrepreneur pays all of the above costs and receives all the benefits linked to brick production.

- **The social (public) CBA**—analysis from the social viewpoint—includes costs and benefits from the private CBA, as well as the environmental and social impacts of brick kilns, including the cost of GHG emissions and the health impact of air pollution. The costs and benefits from the previous step are estimated at real (economic) prices, while taxes are eliminated.

93. Valuation of the health impacts of pollution is complex. The main estimated health impacts of pollution are:

- infant and child mortality related to respiratory disease caused by short-term exposure to PM smaller than 10 microns in diameter (PM10);

- adult mortality related to cardiopulmonary disease and lung cancer caused by long-term exposure to PM smaller than 2.5 microns in diameter (PM2.5); and

- all-age morbidity related to exposure to PM10, such as chronic bronchitis, hospital admission of patients with respiratory problems, emergency-room visits, restricted activity days, lower respiratory infection in children, and general respiratory symptoms.

94. Valuation involves the following steps:

- identify the pollutants and measure their concentration,
- estimate the population exposed,
- establish dose-response coefficients, and
- measure the health impacts (physical and monetary valuation).

95. Estimating the health impacts of air pollution in physical terms is based on the Disability Adjusted Life Years (DALYs) method, which provides a common measure of the disease burden for various illnesses and premature mortality (WHO 2009). The monetary valuation of 1 DALY is based on two approaches: (i) the human capital approach (HCA), which estimates it as a person's average contribution to production or the gross domestic product (GDP) per capita and (ii) the Value of Statistical Life (VSL), which is based on willingness to pay to avoid death by observing individual behavior when trading off health and monetary risks (Johansson 2006). In addition, society incurs direct costs of illness, such as treatment costs.

96. The analysis referred to the year 2009 and uses a discount rate of 10 percent. The kilns' lifetime is 20 years for FCK, IFCK and VSBK and 10 years for HHK. Thus, the analysis used a time horizon of 20 years and accounts for two production cycles of the HHK. Estimated costs and benefits are based on an average kiln. To compare the profitability of the selected technologies, results were reported as net returns per 1,000 bricks. The analyses used secondary data, complemented by a field survey of kiln owners conducted in September–October 2009.

7.3.1 *Private Cost-Benefit Analysis*

The private cost-benefit analysis considered the direct costs and benefits for the entrepreneur, estimated at market prices for 2009 (Table 9).

For FCK

97. The costs include upfront investments and annual costs. Investments cover the kiln structure, chimney, other machineries, and equipment; while annual costs include the land lease, operating costs, taxes and value added tax (VAT), and buildings cost. The land lease varies, depending on land quality; considering an average rental value of TK10,000 per bigha (407 m2) and an area of 15 bigha per kiln, the annual rental value of land totals TK150,000. The operating costs include the cost of fuel (mainly coal), clay, water and labour, amounting to TK11 million per year. The taxes and VAT average TK600,000 per year. Because the FCKs are located mainly in low lying areas prone to annual flooding, they usually do not have buildings. The overall present value of the costs is TK119 million per kiln.

98. The benefits include the value of brick production. Bricks can be broken (5–8 percent of the total number), over burned (5–10 percent), third class (5–10 percent), second class (10–20 percent) and first class (the remainder). The market price is TK6 for first-class, over burned, and broken bricks; TK5.8 for second-class bricks; and TK5.3 for third-class bricks. Accordingly, the annual value of bricks is TK24 million, with a present value of TK198 million. Overall, the 20-year use of a FCK leads to a net benefit of TK103 per thousand bricks.

For IFCK

99. The costs include the same items as for the FCK. The investment cost is higher than for the FCK due to the additional capital investment in internal fuel, better feeding and firing processes, molders, and gravity chamber. Both the IFCK and the FCK occupy the same land area; thus the land cost, taxes, and VAT are similar. Overall, the present value of costs is estimated at TK109 million.

100. The benefits include the value of bricks, which can be broken (5–8 percent of the total number), over burnt (5–10 percent), second class (10–20 percent), and first class (80–62 percent). Based on their market price, the present value of benefits is TK200 million. Overall, the 20-year use of an IFCK leads to a net benefit of TK107 per thousand bricks.

For VSBK

101. The costs include construction, equipment, green-brick transport system, office space, and green-brick storage shed (DA 2009). Operating costs are lower than for the FCK, primarily because of the lower cost of coal and labour. The cost of land is slightly lower than for the other kilns, mainly because the VSBK occupies a smaller area (4 bigha versus 15 bigha). Overall, the present value of the VSBK costs is TK106 million.

102. The benefits include the value of bricks, of which 95 percent are first class and the remainder broken. Based on their market price, the present value of benefits is TK214 million. Overall, the 20-year use of a 4 shaft VSBK has a net benefit of TK108 per thousand bricks.

For HHK

103. The costs are substantially higher than for the other kilns, mainly because of its advanced technology and considerably larger brick production. The investment cost in the first year is about TK60 million (UNDP 2010). The price of the three categories is similar, because over-burnt and broken bricks are usually mixed and sold to the cement industry. ; while the cost of coal, clay, and electricity account for the bulk of operating costs. The taxes and VAT are high since they are proportional to brick production. Overall, the present value of costs is TK386 million. The benefits include the value of bricks, estimated at TK746 million in present-value terms. Overall, the net returns from a 20-year use of an HHK kiln are TK116 per thousand bricks.

104. Summing up, the HHK is the most profitable technology for the entrepreneur, while the returns from the FCK, IFCK, and VSBK are lower. Despite the higher net returns, adopting the HHK is difficult for two major reasons (i) HHKs operate on high land, which is scarce and expensive and (ii) the adoption requires a substantial investment (TK60 million), which is unaffordable for most FCK owners, who operate on rented land that cannot be used as collateral.

Table 9: Cost -Benefit Analysis

Cost/benefit	**FCK**	**IFCK**	**VSBK**	**HHK**
Annual production (million bricks)	4.0	4.0	4.8	15
Area occupied by the kiln (bigha)[1]	15	15	4	12
Costs (million TK/kiln)	**119**	**109**	**106**	**386**
Investment	4.4	7.4	6.4	55.7
Land	1.3	1.3	0.6	2.7
Buildings	0.0	0.0	0.7	9.1
Operations	108.7	95.3	91.5	300.0
Taxes and VAT	5.1	5.1	6.4	18.7
Benefits (million TK/kiln)[2]	198	200	214	746
Net benefit (benefits minus costs)	79	91	109	360
Net benefit (TK/thousand bricks)	103	107	108	116

Payback period (no. years)[3]	1.8	1.9	1.8	2.2

Sources: 2009 field survey, UNDP (2010), World Bank (2011a)

1. *1 bigha = 407 m^2,*
2. *2 Includes the value of bricks. 3. The first year is the year investment occurs.*

7.3.2 *Social Cost-Benefit Analysis*

105. The social cost-benefit analysis considered the direct costs and benefits; the health impacts from PM-related pollution (PM2.5, PM10) and the cost of CO_2 emissions from the brick sector.

106. **Direct Costs and Benefits:** The market prices used for estimating the direct costs and benefits are not subsidized, thus they can be considered economic or real prices. Therefore, the social CBA includes all of the direct costs and benefits, as estimated for the private cost-benefit analysis, excluding taxes and the VAT.

107. **Health impacts from air pollution:** Estimating the health impacts from pollution is a complex task. The brick sector is one contributor to air pollution, along with transport and other industries. Separating out the brick kilns' contribution to pollution requires data on pollutant emissions and dispersion patterns, which are not always available. Moreover, since the North Dhaka brick cluster consists mainly of FCKs, such an exercise would estimate only the FCK's impact on health. Valuing the health impacts of the IFCK, VSBK, and HHK requires even more precise data. In the absence such information, the most realistic assumptions have been made for the purpose of this analysis.

108. The kilns' contribution to the average PM ambient concentration depends primarily on their particulate emissions and the brick production for each kiln type. Table 10 summarizes the estimated impacts in annual and present value terms. The FCK is the most polluting technology, causing annual health damages estimated at about TK0.9 per brick. By contrast, the VSBK is the cleanest technology, with TK0.3 per brick.

Table 10: Estimated health-damage cost from air pollution caused by brick kilns

Kiln type (million bricks)	Present value of health damages				Present value of health damages			
	Min	Max	Average	Damage cost	Min	Max	Average	Damage cost
	(million TK/kiln)			(TK/brick)	(million TK/kiln)			(TK/brick)
FCK (4)	2.5	14.0	8.2	2.1	20.6	117.1	69	0.9
IFCK (4)	1.3	7.1	4.2	1.1	10.5	59.8	35	0.5
VSBK (4.8)	0.9	5.7	3.3	0.7	8.3	47.4	28	0.3
HHK (15)	4.7	26.7	15.7	1.0	39.3	223.6	131	0.5

Note: Because of data uncertainty, these values should be interpreted with caution.

1 Based on GDP per capita.

2 Based on VSL.

3 Present value over 20 years with a 10-percent discount rate.

109. The Bangladesh Country Environmental Analysis reported that poor air quality in Dhaka city (due to all polluting sources, including brick kilns, transport, road dust, metal smelters, and other causes) contributes to an estimated 3,500 premature deaths per year (World Bank 2006). While the 1,200 brick kilns north of Dhaka are an important contributor to air pollution, their overall health impact has not been quantified. This analysis was limited to estimating the health impacts of the North Dhaka cluster (530 kilns) in terms of PM10 and PM2.5 pollution only. Despite these limitations, the analysis shows that PM10 and PM2.5 pollution from these 530 kilns currently leads to 750 premature deaths per year, accounting for 20 percent of total premature deaths due to poor air quality.

110. It is interesting to estimate the avoided mortality and morbidity that could be achieved by adopting alternative kiln types. Use of the VSBK would reduce current mortality by 63 percent, followed by 45 percent for the HHK and the IFCK (Table 10).

Table 11: Avoided mortality and morbidity by adopting alternative kiln types

Factor	**IFCK (4 mill.)**	**VSBK (4.8 mill.)**	**HHK (15 mill.)**
Mortality no. cases (percent)	336 cases (45%)	469 cases (63%)	336 cases (45%)
Morbidity Chronic bronchitis (PM10) (no. cases)	0	0	0
Hospital admissions (PM10) (thousands of cases)	2	2	2
Emergency room visits (PM10) (thousands of cases)	32	44	32
Restricted activity days (PM10) (millions of cases)	3	4	3
Lower respiratory illness in children (PM10) (thousands of cases)	145	200	145
Respiratory symptoms (PM10) (millions of cases)	9	12	9

111. The FCK has the highest unit cost per brick (TK4.2), primarily because it has the greatest specific coal consumption among the selected technologies. By contrast, low coal consumption (TK2.5 per brick) makes the VSBK and the HHK the cleanest technologies in terms of CO2 emissions (Table 12).

Table 12: Estimated annual cost of CO_2 emissions by kiln type and brick (2009)

Factor	FCK (4 mill.)	IFCK (4 mill.)	VSBK (4.8 mill.)	HHK (15 mill.)
Total brick production (thousand kg-bricks)[1]	11,600	11,600	13,860	104,580
Coal per 100,000 bricks (t)[2]	22	15	13	13
Specific energy consumption (TJ/kg-brick)[3]	0.0019	0.0013	0.0012	0.0009
Carbon emission factor (tC/TJ)[4]	25.8	25.8	25.8	25.8
Carbon to CO2 conversion factor	3.66	3.66	3.66	3.66
CO2 per kiln per season (t)[5]	**2,134**	**1,455**	**1,507**	**4,710**
CO2 per100,000 bricks per season (t/100,000 bricks)	**53**	**36**	**35**	**31**
Price CO2 (US$/t)[6]	13.5	13.5	13.5	13.5
Cost of CO2 emissions (thousand TK/kiln/year)	2,017	1,375	1424	4,451
Cost of CO2 emissions (TK/brick/year)	**0.50**	**0.34**	**0.30**	**0.30**
Cost of CO2 emissions (TK/brick, present value)	**4.2**	**2.9**	**2.5**	**2.5**

*(1) Based on total number of bricks for each kiln and brick weight (3.5 kg/brick for HHK and 2.9 kg/brick for the other technologies) (World Bank 2011a). (2) FCK (BUET 2007), VSBK (Heirli and Maithel 2008), HHK (World Bank 2011a), and IFCK (2009 field survey in North Dhaka cluster). (3)Estimated as specific coal consumption (kg/100,000 bricks) * calorific value (TJ/kg) * brick weight (kg/brick). (4) IPCC (2006). (5) Equals = total brick production * specific energy consumption * carbon emission factor * carbon to CO2 conversion factor. 6 Market price for carbon credits for the project Improving Kiln Efficiency in the Brick Making Industry in Bangladesh (World Bank 2011a).*

Results of the social CBA

112. The social CBA and the results in terms of net benefits per thousand bricks are presented below (Table 13). The analysis shows that VSBK and HHK are the most socially profitable technologies, with net benefits of TK68-75 per thousand bricks. In contrast, the high costs of air pollution and CO_2 emissions make the FCK socially unprofitable.

Table 13: Social cost-benefit analysis (present value 2009)

Costs/benefits	FCK	IFCK	VSBK	HHK
Annual production (million bricks)	4.0	4.0	4.8	15
Area occupied by the kiln (bigha)*	15	15	4	12
Costs (million TK/kiln)	**200**	**151**	**139**	**536**
Investment cost	4.4	7.4	6.4	55.7
Cost of land	1.3	1.3	0.6	2.7
Cost of buildings	0.0	0.0	0.7	9.1
Operating costs	108.7	95.3	91.5	300.0

Costs/benefits	**FCK**	**IFCK**	**VSBK**	**HHK**
Health impacts of pollution	68.8	35.1	27.8	131.5
CO2 emissions	16.9	11.5	11.9	37.2
Benefits (million TK/kiln)	**198**	**200**	**214**	**746**
Net benefits (million TK/kiln)	**-2**	**49**	**76**	**210**
Net benefits (TK/thousand bricks)	**-3**	**43**	**75**	**68**
Economic IRR (%)	**30**	**84**	**123**	**59**

Sources: 2009 field survey, UNDP (2010) and World Bank (2011a)

*Note: All costs and benefits reflect present (2009) values estimated based on a time horizon equal to a 20-year kiln life span and a 10-percent discount rate. *1 bigha =0 407 m^2.*

7.4 Sensitivity Analysis

113. A sensitivity analysis of net returns at different discount rates (2 and 5 percent) is presented below (Table 14). The results indicate that for any chosen discount rate, the HHK is the most profitable technology. FCK is the least attractive, and becomes unprofitable from the social viewpoint.

Table 14: Estimated net benefits at changes in discount rates (TK/1000 bricks)

Private net benefits	Discount rates		
	10% (base analysis)	**5%**	**2%**
FCK	103	109	147
IFCK	107	127	172
VSBK	108	187	269
HHK	116	205	282
Social net benefits			
FCK	**-3**	-1	-1
IFCK	**43**	53	73
VSBK	**75**	106	144
HHK	**68**	185	256

7.4 Result of Cost-Benefit Analysis

114. The net returns per thousand bricks for each technology for the private entrepreneur and for the society are presented below (Figure 23). Despite the higher profitability of VSBK and HHK, most entrepreneurs around Dhaka continue to use FCK, the most polluted technology. As previously mentioned, adopting cleaner technologies is difficult primarily because they operate on flood-free highlands, whereas most FCK owners are located in lowlands. In addition, adopting HHK would involve a substantial added investment (TK60 million); this is unaffordable for most FCK owners, who operate on rented land that cannot be used as loan collateral.

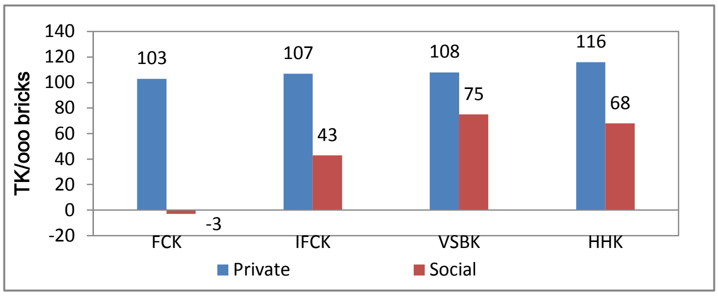

Figure 23: CBA results for different brick technologies

7.5 Energy Saving Potentials of different Technologies

115. Coals consumption per 100,000 bricks in different kilns are shown Table 15. The table shows FCK consumes highest amount of coal while VSBK requires the least per 100, 000 bricks. It is clear that a huge energy saving potential, as high as nearly 50%, is available through adoption of energy efficient technologies in the brick manufacturing. Country could save about 200 million US dollars from import of coal.

Table 15: Energy Saving Potentials of Different Technologies

Technologies	Coal per 100,000 bricks (Tonnes)	Total Coal Requirement (Million Tonnes)	Investment on fuel (Million USD)	Percent Savings
Baseline				
FCK	20-22	3.612	433	0
Zigzag	18-20	3.268	392	9.4
Alternatives				
FCK (+ GSC + IF)	16-18		351	18.9
Coal Hoffman	12-14	2.236	268	38.1
VSBK	10-12	1.892	227	47.6

Assumptions: Total coal production 17.2 billion per year, Cost of imported coal : USD120 per tonne (Indian coal).

SECTION 8

BRICK SECTOR LEGISLATION

8.1 Environmental Legislations

116. The Bangladesh Environment Conservation Act (ECA) of 1995 provides for the protection of the environment, improvement of environmental standards, and the control and abatement of environmental pollution. This Act authorizes the DOE to undertake any activity needed to conserve and enhance quality of environment and to control, prevent and mitigate pollution. The Environment Conservation Rules (ECR) of 1997 (adopted under the provision of ECA 1995 and amended in 2002 and 2003) provides rules related to the declaration of ecologically-critical areas, obtaining environmental clearance certificate, environmental quality standards, acceptable limits for discharges of waste, and environmental guidelines on pollution prevention. ECA 1995 and ECR 1997 outline the regulatory mechanism to protect the environment in Bangladesh.

8.2 Environmental Clearance

117. Following the ECR 1997, DOE has classified development interventions into four main categories based on potential adverse environmental impacts for the purpose of issuing the environmental clearance certificate as follows:

(i) Green - NO environmental assessment required

(ii) Orange A – “no objection certification” from local authority required

(iii) Orange B – initial environmental examination required

(iv) Red – environmental impact assessment required

118. According to DOE, the conversion of FCKs to improved zigzag kiln and the construction of new VSBKs, HHKs, and tunnel kilns fall under the Orange B category based on potential environmental impacts.

8.3 Brick Sector Rules, Regulations, Acts etc.

119. There is a lack of government brick sector strategy (policy), or other relevant energy efficiency guidelines to promote sustainable brick sector development. As a result, the legal and regulatory framework is poorly guided to address the underlying deficiencies in the brick sector development. The existing legislations are based on the Brick Burning Act (1989) and various amendments and circulars thereafter. Prior to 1989, brick making was an unregulated industry in Bangladesh.

120. A summary of the legislations on brick burning and air pollution in Bangladesh is presented in the Table below.

Table 16: Summary of the legislations on brick burning and air pollution in Bangladesh

(A) Regulations for Brick Burning

Year	Regulations	Responsible Agency	Details	Remarks
1989	The Brick Burning Act (Regulation)	DOE, MOEF	First brick-making law which banned the use of firewood for brick manufacturing and introduced licensing for brick kilns.	Use of firewood has been discontinued but it still continues in a limited scale in the remote areas.
2001	Revision of the Brick Burning Act of 1989	DOE, MOEF	Amendment to regulate the location of brick kilns which provides that they should not be set up within 3 kilometer (km) of the upazilla or district center, municipal areas, residential areas, gardens, and the government‗s reserve forests.	The Bangladesh Brick Manufacturing owners Association considers this provision as a major weakness. The location requirement in this amendment has not been enforced.
2002	Brick Burning rules	DOE, MOEF	Requires that chimney for brick kilns should be compulsory 120 feet.	Enforced successfully particularly in the vicinity of urban areas. Most Bull‗s trench kilns were upgraded to fixed chimney kiln technology but some Bull‗s trench kilns continue to operate illegally.
2007	Government of Bangladesh Notification	DOE, MOEF	Notification that environmental clearance certificates will no longer be renewed if the owner did not shift to alter-native fuel and other improved technologies by 2010.	Not implemented as there are no guidelines to assist brick kiln owners and facilitate the transition.
2010	Government of Bangladesh Notification	DOE, MOEF	Notification that bans FCK operation in 2013 (three years from notification date).	Clean Air and Sustainable Environment project funded by the World Bank assists the Gov-ernment in the imple-mentation of this regula-

Year	Regulations	Responsible Agency	Details	Remarks
				tion.
2011	Revision of Brick Burning Act	DOE, MOEF	Changes in the Act aim to facilitate the transition to more energy efficient technology and reduce level of air pollution from the brick industry.	Ongoing and may take more than one year.
	(B) Regulations on Air- Pollution			
1977	Environment Pollution Control Ordinance, 1977.	DOE, MOEF	Provides limited conditions for environment conservation.	Replaced by Environment Conservation Act of 1995
1992	Environmental Policy and Action Plan	MOEF	Provides the priority areas for conservation of environment.	A document to guide actions for environment conservation but has no legal mandate.
1995	ECA, 1995 or ECA95	DOE, MOEF	Provides for environment conservation, improvement of environmental standards and control, and mitigation of environmental pollution.	ECA 1995 replaced the Environment Pollution Control Ordinance 1977. The Government can issue notification in the official Gazette and make rules for carrying out the purposes of this Act, including emission standards.
1997	ECR, 1997, or ECR97	DOE, MOEF	Sets air emission standards for industries including brick kilns.	The suspended particulate matter standard for brick kiln emission is set at 1,000 mg/m3, which is rather lenient. Even this standard could not be enforced due to limited capacity in the DOE.
2005	Revision of ECR97	DOE, MOEF	Sets ambient air quality for criteria pollutants and vehicular emission standards Fine particulate (PM2.5) standard is defined under this rule.	Violation of ambient air quality standards can be enforced under this rule.

Source: Bangladesh Bank 2012, Note: Upazilla means sub-district which comprises of several unions.

121. The Brick Burning Act 1989 was revised in 2001 to regulate the location of brick kilns not to be within 3 km of the district center (or upazilla), municipal areas, residential areas, and the government's reserve forests. In October 2002, another revision was introduced to the Brick Burning Act requiring the mandatory use of a 120-foot chimney for brick kilns. To address the contribution of brick kilns to widespread air pollution, DOE issued a notification in March 2007 which provides that environmental clearance certificates would not be renewed if the brick kiln owner will not shift to alternative fuel and improved technologies by 2010. Another DOE Notification was issued in July 2010 which bans FCK operations by July 2013. In 2011, the Brick Burning Act of 1989 is being revised to facilitate the transition of the brick sector into a more energy-efficient and less polluting process.

122. Government of Bangladesh created a fund of 50 million US Dollars in September 2012 for promotion of construction of environment friendly brick kilns in the country. This fund has been created with the support of Asian Development Bank and will be used to improve the energy efficiency of brick kilns. Other objectives of the project include reduction of carbon emission and ensuring appropriate use of fuels. Out of the total allocation by ADB, 30 million US Dollars will be utilized in conversion of Fixed Chimney Kilns (FCK) into Zigzag Kilns. While, rest 20 million US Dollars will be spent in construction of Vertical Shaft Brick Kiln (VSBK), Hybrid Hoffman Kilns (HHK) and Tunnel Kilns.

SECTION 9

BARRIERS TO PRIVATE INVESTMENT

9.1 Introduction

123. Barriers that have contributed to the current state of the BMI and its inability to adopt new efficient technologies, particularly in the way energy is utilized in brick making operations includes: technical barriers, investment barriers, institutional and regulatory barriers, and other barriers.

9.2 Technical Barriers

124. The major technical barriers to the adoption of energy efficient kiln technologies and in the way energy is utilized in making bricks are:

(i) Lack of ability to design and construct brick making facilities that utilize energy including process heat in the most efficient way to lower the energy intensity of brick making;

(ii) Lack of R&D and training facilities;

(iii) Lack of capacity in terms of technical skills at the enterprise level to bring about even small changes that could have made production more efficient and less polluting

(iv) Lack of worker and management capacity to enhance productive efficiency.

125. While the conventional brick industry relies on relatively unskilled labour, an efficient kiln like HHK brick industry will require more skill-oriented personnel involving an organized production process. This, as has been pointed out earlier, is perceived as a significant barrier.

126. In response to this need, UNDP-GEF project arranged the long-term presence of the Xian Institute of Wall Building Materials (XIAN), a Chinese institute mandated to assisting in capacity building of new brick industries in emerging economies. Under GEF funded project (Improving Kiln Efficiency for the Brick Industry in Bangladesh) XIAN staff gave technical support for constructing first HHK in 2006-07 and is committed to be in Bangladesh even beyond 2012 to provide the necessary technical assistance including planning, design, construction, operations, maintenance, brick molding, accounting and management. As a consequence of this long-term presence of XIAN, it is expected that the brick industry's capacity to absorb the HHK technology will increase as will their willingness to adopt the cleaner and more profitable brick making technologies. Another objective of the long-term presence of XIAN is to develop and sustain a local service industry to provide backstop engineering and technical services to the emerging industry.

127. With regard to technology transfer, the strategy is to implement the transfer in two clearly identified and distinct ways:

- Through capacity building of local manufacturers and consulting firms to design, engineer, construct and commission HHKs; and
- By "training of trainers" who will train enterprise level staff and workers in the use of the HHK production process.

9.3 Investment Barriers

128. It is a challenge in Bangladesh to mobilize finance for implementing new technology projects, especially in the brick making sector because the financial sector has rarely engaged in lending to this sector. This is due to the 'footloose' nature of the brick manufacturing industry, which is highly unorganized in terms of management and financial matters.

129. There is no access to liquidity to finance modernization of brick making operations. The brick making industries are considered high-risk due to the seasonal, itinerant nature of their operations and their lack of collateral. The commercial lending agencies in Bangladesh have very limited experience with Small and Medium Enterprises (SMEs) and in particular brick making enterprises. The investment requirement for the conventional brick making industry is very less when compared to new technologies like HHKs.

130. The existing conventional brick kilns like BTK, FCK and the Zigzag Kiln, all have approximately the same production capacity of 2 to 2.5 million bricks per season, but in terms of initial investment, a BTK is the cheapest requiring Taka 2.5 million compared to Taka 4 million for a FCK or a Zigzag Kiln However, because of the yearly rebuilding requirement of the BTK and the fuel savings of the FCK and Zigzag Kiln, on a life-cycle costing basis, the cost of bricks is nearly the same for the three types of kilns.

131. The HHK, which has a capacity of up to 15 million bricks, is clearly the most expensive, requiring an initial investment of at least Taka 30 million. Building a HHK requires special expertise and thus involves engaging engineering consultants. Working capital requirement for a BTK, FCK and Zigzag Kiln is approximately Taka 1 million, but for a HHK it can go up to Taka 7.5 million because of higher inventory, maintenance and overhead costs (UNFCC 2006).

132. Profitability in the current brick business largely depends on the sales volume as the profit margin per brick is low. Given limited capital resources, the manufacturers generally prefer to increase production capacity by setting up a new plant in a new location over investing in cleaner and efficient technologies. The appreciation of energy saving and related savings in the operational cost continues to be low among the brick manufacturers. Given this reality and the current lack of specific regulatory pressure, current brick manufacturers are likely to be reluctant to invest in the more costly HHK technology unless investment returns are improved.

9.4 Institutional and Regulatory Barriers

133. In Bangladesh, there is a lack of supporting regulations, fiscal incentives and standards to encourage more energy efficient practices and technologies. Except for some sporadic efforts to regulate the industry, government has made little effort to establish effective boundary-limit emission standards. There is very little or no governmental activity to assist the brick industry to undertake comprehensive programs to transform the industry and make it less polluting and more profitable. Brick makers have been left to bring in changes on their own, which they have failed to do since they are locked into a vicious cycle of a low efficiency/low income trap. A few initiatives that have taken place in the past have come from new entrants and not from traditional brick makers.

9.5 Other Barriers

Business Skills

134. The majority of the brick kiln entrepreneurs use traditional methods of green brick production, brick firing and marketing. They lack capacities in regard to modern practices in marketing, business opportunities and kiln management.

Trained Manpower

135. There is also lack of trained manpower to cope with new technology changes

Lack of Experience of lenders with SMES

136. Limited experience of commercial lending institutions with SMEs and in particular, brick SMEs. They lack interaction with and understanding of the brick industry.

SECTION 10

NATIONAL COAL POLICY AND PRESENT SITUATION OF COAL INDUSTRY IN BANGLADESH

137. Natural gas so far being the principal commercial primary energy can no more keep pace with rising demand of energy. Indigenous coals might play an important role in meeting the future energy demand of the country. Five coal fields have so far been discovered in Bangladesh having total proven plus probable reserve of 3,300 million tonnes of high quality coals. Field-wise reserves of coal are shown below (Table 17).

Table 17: Coal Reserve in Bangladesh

Name of Field	District	Area (Sq. Km)	Depth Meter	Reserve (Million Tonnes)
Barapukuria	Dinajpur	6.68	118 -506	390
Phulbari	Dinajpur	30.00	150 -240	572
Dighipara	Dinajpur	Yet to be Known	328 -407	600
Khalashpir	Rangpur	12.00	257 -483	685
Jamalganj	Joypurhat	16.00	640 -1,158	1,053
			Total	**3,300**

138. Fields are located in the north western region of the country as shown in the Figure 24. Depth of the coal reserves, the overlain aquifers and thick population living in mine areas have made mining challenging in the country. Out of this five only one filed, Barapukuria, is being mined through underground mining process. From this field 4000-5000 MT coal is being extracted per day and is being used as fuel for 2X150 MW capacity Mine-Mouth Power Plant.

Figure 24: Location of coal fields in Bangladesh

139. In order to facilitate mining and utilizing the coal resources of the country, the government of Bangladesh has been trying to formulate a Coal Policy for pretty long time. After long deliberation Energy and Mineral Resources Division of the Ministry of Power Energy and Mineral Resources first published a draft

coal policy (version 1) for comments from the public. After that it was revised several times. Energy and Mineral resources division again published another version in 2010. This new Coal Policy is expected to cover coal development strategies, import coal, method of extraction, investments and environmental measures in the country. The Government has been putting efforts to finalize the Coal Policy where the strategies and rules of coal extraction will be spelled out. It is expected the approved Coal Policy will help achieving targets and appropriate steps could be taken developing the prospective coal sector of the country.

140. Although Bangladesh has substantial deposit of quality coal, there is concern about the method of extraction as well as technological security. A recent Study on Coal Power Development in Bangladesh recommends that the quick resolution of energy problems lies in coal import from abroad. There is an initiative to establish imported coal-based power generation plants in the country.

141. Bangladesh imports a significant amount of coal from India, but these are all in private sector and mostly used for brick burning and arc furnace.

SECTION 11

EXPERIENCES, EXPERTISE AND BEST AVAILABLE PRACTICES FOR SHARING WITH OTHER MEMBER COUNTRIES

142. Success in introducing modern technologies particularly efficient and less polluting brick firing technologies in Bangladesh so far is very limited. Nevertheless, some of the decisions taken by the government of Bangladesh are considered as steps towards right direction, which may be shared with other countries. Other countries in the SAARC region may follow these steps if they have not done those already. Steps taken by Bangladesh for adoption of new technology, and reduction of environmental pollution and degradation caused by brick industries that can be followed by other countries are as follows.

Ban on use of fuel wood for brick burning

143. Brick Burning Act 1989 imposed a ban the use of firewood for brick manufacturing and introduced licensing for brick kilns which prevented tree felling for brick burning and contributed in projected of forest resources.

Ban on FCK

144. As part of efforts to reduce pollution and coal use in 2010 Government of Bangladesh has issued a notification that all FCK will be banned from September 2013 exactly three years after the notification. Renewal of licenses fixed chimney kilns has been stopped since September 2012.

US$ 50 million Fund for energy-efficient brick kilns

145. The Asian Development Bank (ADB) has provided US$ 50 million to Bangladesh to improve the environment by financing more energy-efficient brick kilns in the country. The Bank and Financial Institutions Division under the Ministry of Finance will be the executing agency and Bangladesh Bank being the implementing agency will implement the project during 2012-2015 period. Under the project, ADB will provide US$50 million in local currency to the Bangladesh Bank which will be re-lend later on to the funds to participating Financial Institutions (FI).

146. The FIs will then provide loans to brick makers seeking to upgrade their existing kilns to cleaner kinds of kilns or to those looking to build the cleaner kilns for the first time.

SECTION 12
CONCLUSION AND RECOMMENDATIONS

12.1Conclusion

147. Bangladesh brick making industry is growing fast due to rising demand of bricks. Natural Gas being the least polluting fuel, use of natural gas has to be restricted due to shortage of supply in the face of rising demand in other sectors. Thus coal, mainly imported, has become the predominant fuel in brick burning. Age old technologies are prevalent in the industry, which is resulting in low energy efficiency and high emissions. Due to its seasonal nature the brick industry is dominated by small investors who lack in ability to invest in modern and cleaner but expensive technologies.

148. The current status of brick industry is by no means sustainable. It is therefore imperative for Bangladesh to modernize/upgrade its brick sector in order to save valuable natural resources, reduce air pollution, and increase energy efficiency. The government has already established regulations that ban the use of fuel-wood and FCKs, and has reconsidered the location and height of brick kiln chimneys. Donor agencies are also patronizing in introduction of energy efficient and less polluting technologies like VSBK and HHK through pilot projects and technical supports. VSBK seems to have failed to attract investors due to failure of the pilot project to produce bricks of desired quality. On the other hand, HHK did not show any technical constraint; however, relatively large investment requirement appears to be main impediment in fast propagation of this technology. Zigzag relatively cleaner than FCK, although not as good as VSBK or HHK, appear to be the choice of the industry in general. However, this transformation is not taking place at a pace that the government has targeted. The Brick Field owners lead by BBMOA are in favour extending time for conversion of existing FCK to Zigzag beyond 2013.

12.2 Recommendations

149. In order to prevent environmental degradation and air pollution, brick industry has to make a paradigm shift from old age polluting and less efficient to environment friendly cleaner and fuel efficient in the long-term. This report suggests that the development of the brick industry in Bangladesh over the next 10-15 years should aim at: (i) moving from traditional brick-making technologies (e.g. FCK) to cleaner ones (e.g. HHK, VSBK).

150. To achieve these goals, following actions need to be taken:

(i) The government should recognize brick kilns as a formal industry to enable easier access to financial resources which in turn will enable investment in cleaner technologies and improved working conditions by introducing higher levels of mechanization, social programs to reduce child labour, occupational safety and health measures in kilns.

(ii) The government and BBMOA should jointly create a Brick Technology Center to raise awareness about the benefits of cleaner technologies. The center should:

a) disseminate information on the social benefits provided by cleaner technologies, new wall materials (e.g. perforated and hollow bricks) and alternative raw materials;

b) promote pilot projects of new technologies with improved provisions (e.g., mechanized, higher labour productivity and larger product lines);

c) improve use of existing dissemination channels (e.g., field visits to pilot plants, video demonstrations of the technologies etc.) and

d) introduce new channels (e.g., newsletters, industry journals, conferences, and Internet blogs).

(iii) Government and donor agencies may assist the entrepreneurs in getting access to carbon markets for carbon emission reductions provided by cleaner technologies.

(iv) Government should revise emission standards aiming at reduction of environmental pollution by the brick kilns and should take effective measures to enforce the regulations and policies such as the ban of traditional high polluting kilns (e.g. FCK, BTK).

(v) To establish a federation of associations for relation of mutual cooperation in brick manufacturing industries in the SAARC region. The association may be named as SAARC Regional Brick Manufactures Federation (SRBMF).

(vi) Government should resolve all issues in relation to the finalization of coal policy to pave the way for exploitation indigenous coal to a greater extent for ensuring energy security of the country. At the same time, it should put in place an appropriate EE policy for utilization of coal.

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