Clean Development Mechanism Project Opportunities in Bangladesh

Pre-Feasibility Report on a Brick Manufacturing Fuel Substitution CDM Project

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Preface

The Pembina Institute for Appropriate Development and the **Tata Energy Research Institute** are exploring the application of the Clean Development Mechanism (CDM) in Asia. This multi-year project is being undertaken in collaboration with:

- **The Bangladesh University of Engineering and Technology** in Dhaka, Bangladesh;
- **The Global Climate Change Institute at Tsinghua University** in Beijing, China; and
- **The Centre for Research on Material and Energy at the Technology University** in Bandung, Indonesia.

The following publications have been produced by the project partners:

- *Canada's Potential Role in the Clean Development Mechanism* (2000)
- *Negotiating the CDM: A North–South Perspective* (2000)
- Reports on CDM activities and potential CDM project opportunities in Bangladesh, China, India and Indonesia (2001)
- *A User's Guide to the CDM* (2002)
- Reports on individual CDM project opportunities in Bangladesh, China, India and Indonesia (2001)

For more information on this project visit the following Web sites:

- www.teriin.org
- www.pembina.org/international_eco3.asp

The project is being undertaken with the financial support of the Government of Canada provided through the **Canadian International Development Agency (CIDA)**, online at www.acdi-cida.gc.ca, and is being implemented in collaboration with the **International Institute for Sustainable Development (IISD)**, online at www.iisd.ca.

The following report was produced by the Bangladesh University of Engineering and Technology. The views expressed in this report are entirely those of the authors.

1. Project Description

Brick Manufacturing in Bangladesh

More than 95% of the bricks in Bangladesh are manufactured in cottage-type industries using an extremely crude technology known as the Bull's Trench Kiln (BTK). The kiln is approximately 250 ft long and 57 ft wide and has two 32-ft high moveable chimneys. 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 destroy the chimneys very quickly. An elliptical dug out area is employed to progressively fire sections of the kiln. The chimneys are shifted as the firing progresses along the kiln. As may be imagined, the combustion process is inefficient, but more importantly, the entire operation is highly polluting. Fuel for brick kilns is predominantly low-grade coal, firewood and some furnace oil. Even though natural gas is available in some places, owners do not want to take connections because BTKs are seasonal operations lasting a maximum of five months, and the gas utility insists on a year-round demand charge or a gas price much higher than the industrial rate. Moreover, because BTKs can easily shift to alternative fuels, the brickfields are the first to be disconnected whenever there are gas supply problems in the grid. All brick making activities, including the burning, are conducted in the open field. To minimize the cost of land, brickfields are usually located on low-lying land. Every year during the monsoon, the kiln gets washed away by the flood waters and must be rebuilt. Brick manufacturing season for most BTKs is from November to March or April, the end point determined by the start of the rainy season. Figure 1 shows a schematic diagram of a BTK and Figure 7 shows the layout of the brickfield.

BTK owners are converting gradually to different technologies because of government restrictions imposed on BTKs. The preferred technology is the Fixed Chimney Kiln (FCK). Figure 2 shows a schematic diagram of this kiln. It is now estimated that about 300 to 400 BTKs have been replaced by FCKs. The FCKs are more fuel-efficient (by as much as 30%) and less polluting. The fixed chimney, as the name suggests, is a permanent structure and is 120 ft high. This tall chimney creates a stronger draft and thereby improves the burning process. Additionally, it discharges the flue gas at a height of 120 ft, leading to faster and better dispersion. The kiln has an underground network of piping to convey the flue gas from any part of the kiln to the chimney. The length of the kiln is the same as in a BTK, but the width is greater to accommodate the underground piping. The FCK also has better insulation on the side walls, which reduces heat loss to the surroundings. Like the BTK, the FCK is built in the open field, and the operation period is about five months of the year. Unlike the BTK, the FCK is more expensive to construct, by at least Tk. 12,00,000 (US$ 20,700), and the technology has to be obtained from India. Although there is no law governing this, the Department of Environment (DOE) is not issuing environmental clearance certificates to BTKs, but is to FCKs.

The other kiln that is slowly gaining popularity is the Hebla or Zigzag Kiln (Figure 3). It 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. There is a blower at the bottom of the chimney, which draws the flue gas from the kiln and discharges it into the atmosphere. The kiln is divided into 44 to 52 chambers, which are separated from each other in such a way that the hot gases move in a zigzag path through the 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. The Zigzag Kiln is reported to be 20% to 25% more fuel-efficient than the BTK. This kiln is expensive to construct, costing approximately Tk. 12,00,000 (US$ 20,700) more than the BTK. There are 20 to 25 such kilns in operation, mainly in the Comilla region. The construction technology is not easily available and expertise has to be purchased from the neighboring states of India. Like the BTK and the FCK, the Zigzag Kiln is built in the open field and the operation period is limited to the five to six months of the dry winter season.

Even though the natural gas–fired Hoffmann Kiln technology has been around for some time, its penetration has been extremely slow. There are only about 25 Hoffmann Kilns in Bangladesh, located in Dhaka, Chittagong, Comilla and Bogra. A Hoffmann Kiln is rectangular in shape and measures 300 ft to 400 ft by 60 ft. Its operation is very similar to the FCK. The predominant difference between the Hoffmann Kiln and the three kilns described above is the fixed roof, which enables bricks to be fired throughout the year. The inside roof of the kiln is arched and has a firebrick lining on the inside surface of its wall. The thick wall with good insulation prevents heat loss to the surroundings. The chimney is 76 ft high with a blower at the bottom. Bricks made in Hoffmann Kilns are superior to those made in BTKs and, therefore, command a higher price. These kilns use natural gas as their fuel and are environmentally fairly benign compared to the three coal-burning kilns. The single most important factor preventing the widespread use of the Hoffmann Kiln is the extremely high initial investment required. Hoffmann Kilns also need much more land, and in a land-scarce country like Bangladesh this increases the cost of a Hoffmann Kiln significantly. Figures 5, 6 and 8 show the kiln and layout of the brickfield.

The information presented above is summarized in Table 1 for a quick comparison of the kilns in use in Bangladesh.

Apart from two to three modern brick-making factories (for specialized bricks only), all ordinary construction bricks are manufactured by the four kiln technologies described above. For the sake of completeness, it is essential to describe one other type of kiln because there exists a fair possibility that it will enter the brick-making technology mix. The kiln in question is the Vertical Shaft Brick Kiln (VSBK), first developed in China. A schematic diagram of this kiln is shown in Figure 4. A VSBK is supposed to be very fuel-efficient and saves approximately 35% to 40% in fuel compared to the BTK. In addition, the kiln is simple to construct and operate, making it ideal for rural areas. The VSBK requires one hectare of land, compared to three hectares for the BTK. The VSBK has been tested and has proven to be very successful in China, India and Nepal. There was one effort to construct a VSBK in Bangladesh, but it was unsuccessful due to the lack of adequate technical support. In a VSBK, bricks are stacked in a shaft measuring 1x1 m^2, up to a height of 6.0 m. Green bricks are loaded from the top in batches of 224 bricks, arranged in four layers. At the bottom, bricks are taken out using a special unloading device. On average, one batch of 224 bricks is unloaded every 1.5 hours. Firing occurs near the middle of the shaft. The kiln uses pulverized coal, which is loaded from the top along with the green bricks. The combustion air enters at the bottom of the shaft and moves up through the bricks that have already been fired. By taking up heat from the fired bricks, the combustion air is preheated to about 750° C. After combustion, the hot flue gases move up through the unfired bricks and in the process preheat the bricks to be fired. The VSBK is a permanent structure and can produce bricks throughout the year. It has a life of eight to ten years with minimum maintenance.

Table 1 A Comparative Study of Various Types of Kiln

Parameter		**Bull's Trench Kiln**	**Fixed Chimney Kiln**	**Zigzag Kiln**	**Hoffmann Kiln**
1. Initial Investment	Taka (Tk.) US$ = Tk. 58	2,500,000	4,000,000	4,000,000	32,000,000
2. Working Capital	Tk.	1,000,000	900,000	900,000	15,000,000
3. Land		2.5 acres, of which 1 acre is used year-round; rest only during production	2.5 acres, of which 1 acre is used year-round; rest only during production	2.5 acres, of which 1 acre is used year-round; rest only during production	Minimum 10 acres, used year-round
4. Raw Material	a) Clay	100,000 cft.	95,000 cft.	95,000 cft.	425,000 cft.
	b) Labor	200 (5% skilled, 10% semi-skilled, rest unskilled)	200 (15% skilled, 15% semi-skilled, rest unskilled)	200 (15% skilled, 15% semi-skilled, rest unskilled)	400 (25% skilled, 45% semi-skilled, rest unskilled)
	c) Electricity	Necessary in small scale	Necessary in small scale	Necessary in small scale	Necessary; electricity outages hamper production
	d) Fuel	Coal/Gas. 98% use coal.	Coal/Gas. 98% use coal.	Coal/Gas. 98% use coal.	Gas.
5. Fuel Consumption	Per 100,000 bricks	26-30 tonnes	22-26 tonnes	22-26 tonnes	12,000-13,000 m^3
6. Pollution		Severe pollution	Pollution	Pollution	Very little pollution
7. Production Period		November to mid-April	November to mid-April	November to mid-April	Year-round
8. Wastage		10%-12%	5%-8%	5%-8%	15%-18%
9. Quality of Bricks		Medium	Good	Good	Very good
10. Sale Price	Tk. per 1,000 bricks	2,200-2,500	2,200-2,500	2,200-2,500	3,200-3,500

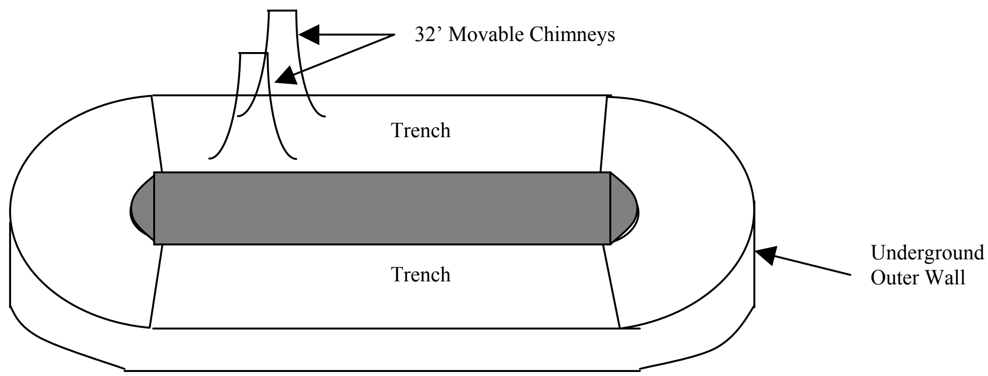


Figure 1 Schematic Diagram of a BTK

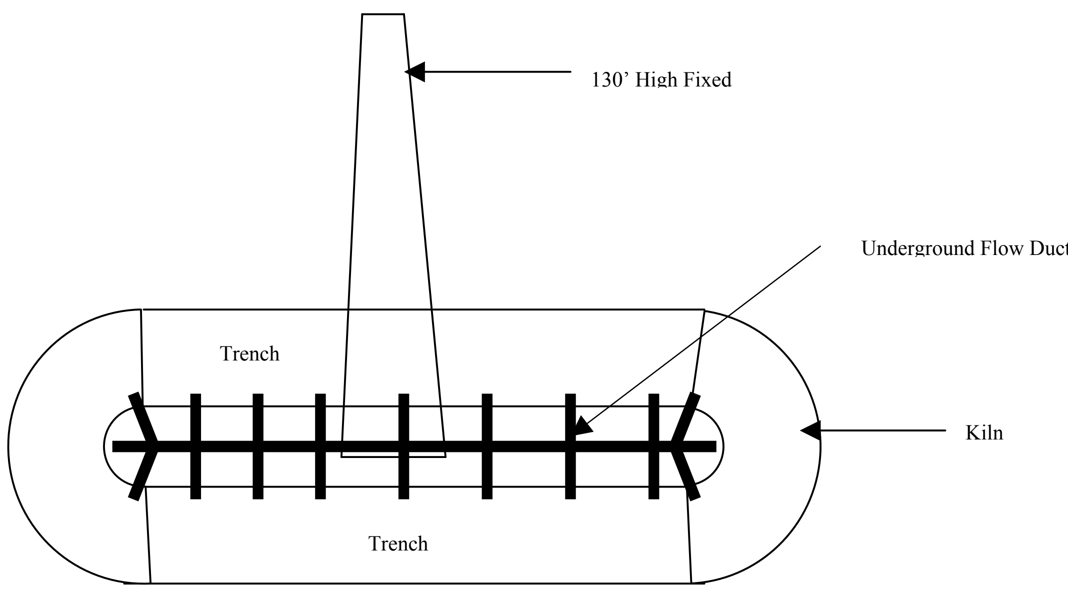


Figure 2 Schematic Diagram of a Fixed Chimney Kiln

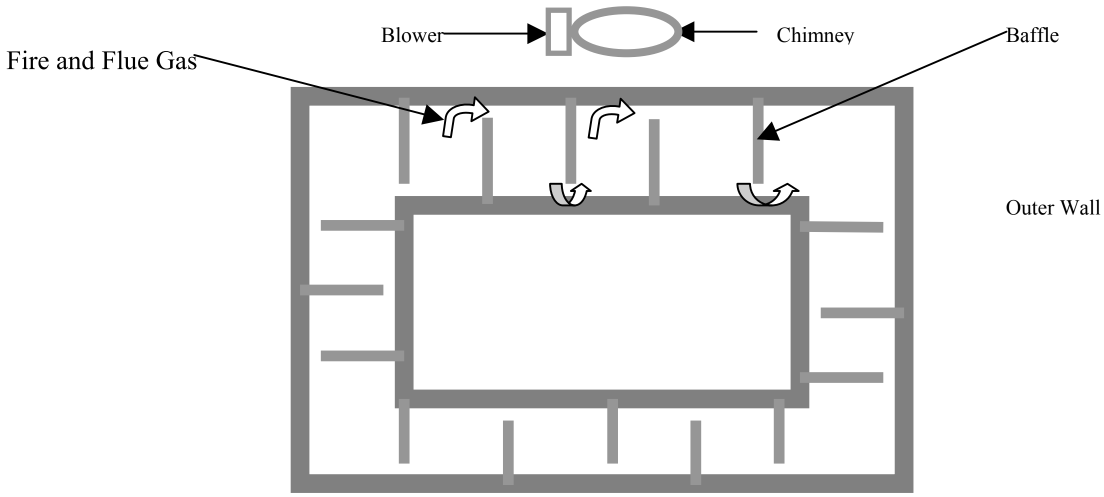
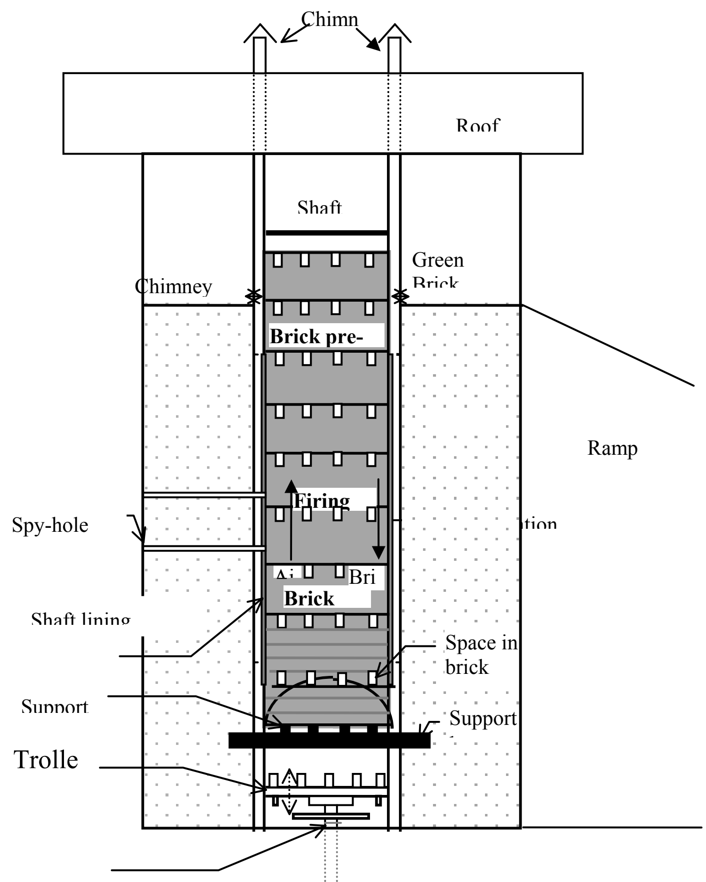


Figure 3 Schematic Diagram of a Zigzag Kiln



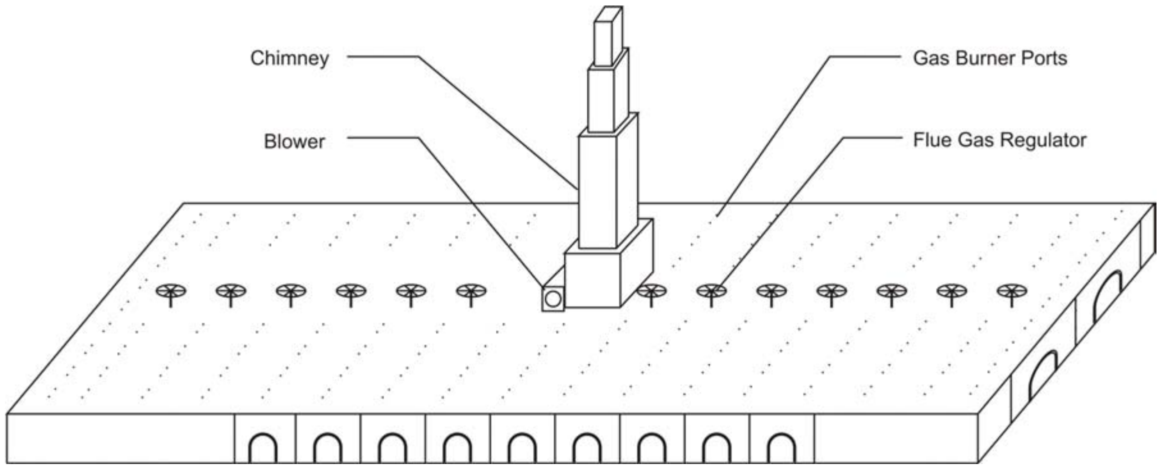


Figure 5 Schematic Diagram of a Hoffmann Kiln

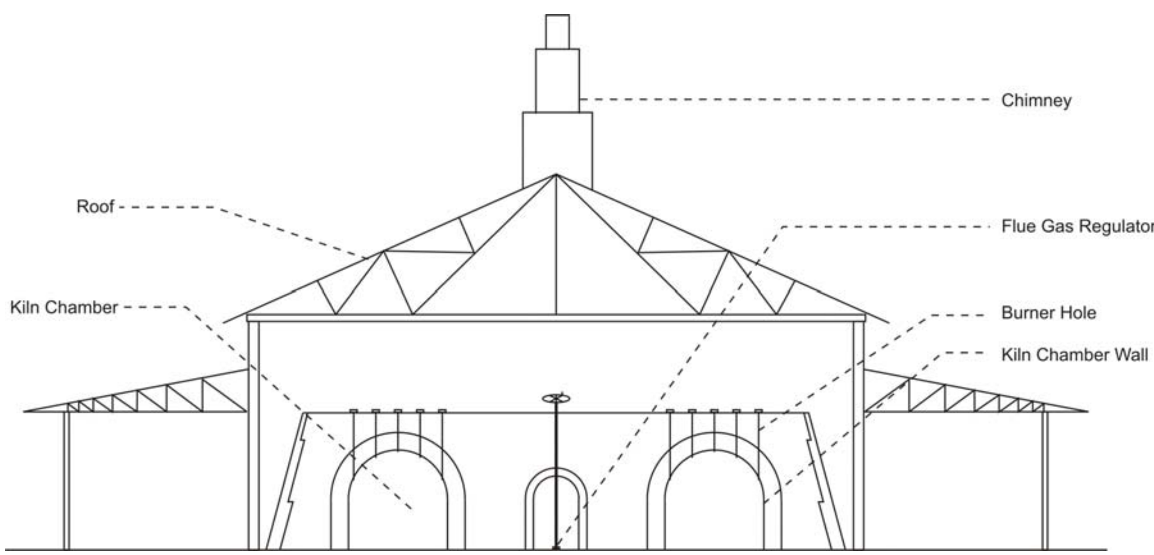


Figure 6 Cross Sectional View of a Hoffmann Kiln

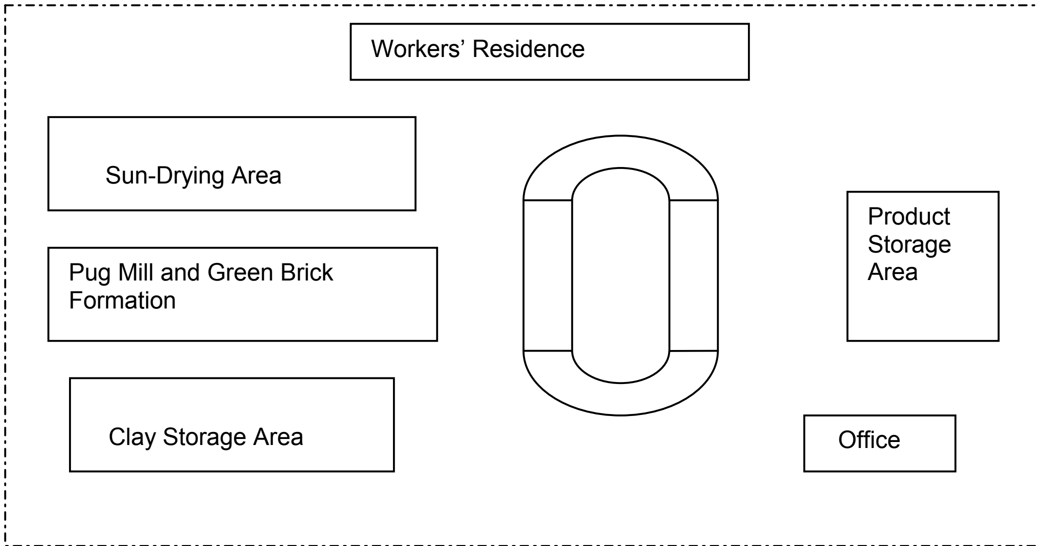


Figure 7 Plot Plan for a Bull's Trench Kiln (BTK)

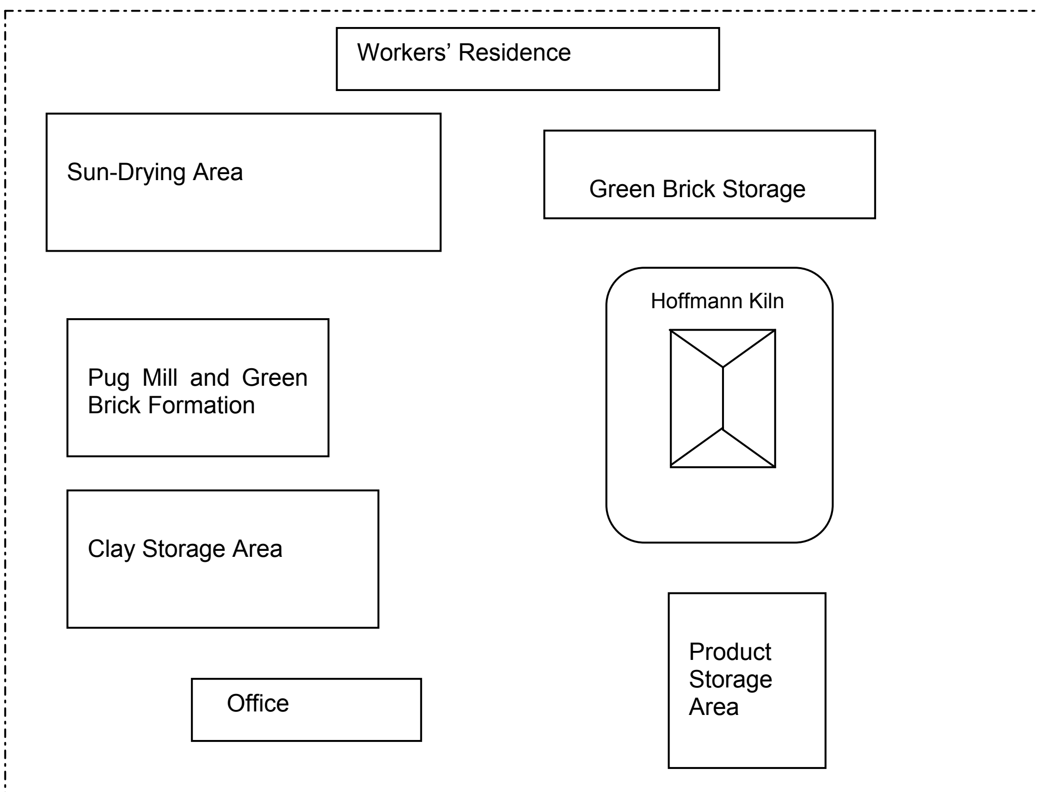


Figure 8 Plot Plan for a Hoffmann Kiln

Project Definition

Hoffmann Kilns, which are natural gas–fired and slightly more efficient, can displace coal-fired Bull's Trench Kilns (BTKs) and Fixed Chimney Kilns (FCKs). This involves not only the replacement of a crude technology, but also fuel switching from coal to natural gas. The greenhouse gas (GHG) emission reduction is achieved by using less carbon-intensive fuel and more efficient kilns. The major issue in designing a CDM project is that Hoffmann Kilns have nearly six times greater capacity than BTKs. Thus, for every six BTKs replaced, only one Hoffmann Kiln would be required. The consequences of this large reduction in the number of units have to be carefully investigated. Fortunately, the labor-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, will remain the same in the mitigation option.

This project envisages setting up 20 Hoffmann Kilns, thereby eliminating the construction of an equivalent number of BTKs to meet the same demand for bricks. It is assumed that the brick production of the project would displace the production of bricks from new BTKs and FCKs.

Because of their adverse effects on the environment, BTKs are clearly not sustainable. During the last five years, the campaign against BTKs has been so strong that the government has brought in tough laws to control their spread. The government is keen to promote more environmentally benign brick-making technologies. It is therefore expected that this project to replace BTKs and FCKs with Hoffmann Kilns will enjoy the support of both the government and the people.

Project Location

Brickfields are mostly located around major urban areas to cater to their needs. Hoffmann Kilns, in particular, need to be close to urban centers because the bricks they produce are more expensive and cannot easily be sold in semi-urban or rural areas. Other important factors in determining the location of brickfields are ease of transportation and availability of clay, fuels, etc. Major concentrations of brickfields are observed around the large urban areas of Dhaka, Chittagong, Comilla, Feni, Jaipurhat, Bogra, Khulna and Satkhira. However, brickfields are scattered all over the country. Figure 9 shows the concentration of brick kilns in Bangladesh, while Figure 10 is a map of Dhaka and its adjacent areas, which are the prospective locations for the 20 Hoffmann Kilns of the proposed project. The following two factors will determine the location of the Hoffmann Kilns:

(i) Proximity to the gas grid
(ii) Proximity to a large urban center

These two factors effectively limit the construction of Hoffmann Kilns to the belt stretching from Dhaka to Chittagong, an area with a high concentration of brick kilns (see Figure 9). It is worth noting that 50% of the total bricks produced in Bangladesh are used in and around Dhaka. The areas adjoining Dhaka are well covered by the natural gas distribution network. It is very important to locate the kilns close to the gas grid because extending the grid is very expensive. The Hoffmann Kilns can be set up at Savar, Joydevpur, Narsindhi, Narayanganj and along the Dhaka-Comilla highway, as shown in Figure 10. These locations will also be convenient for monitoring and verification purposes.

Figure 9 Major Concentrations of Brickfields in Bangladesh

Figure 10 Dhaka and Adjoining Areas, with Possible Locations for Hoffmann Kilns

Project Purpose

The purpose of this project is to reduce GHG emissions by enhancing the penetration rate of a cleaner brick-making technology. The two specific purposes are:

(i) To use natural gas for firing bricks, replacing coal-fired brick production
(ii) To abate air pollution by reducing the highly polluting baseline units

Project Type

Even though this CDM project replaces a dirty technology with a cleaner one, the overwhelming GHG reduction comes from fuel switching.

GHG Emission Reduction

Even though a new technology is being employed to reduce GHG emissions, this is essentially a fuel-switching option. The mitigation technology, i.e., the Hoffmann Kiln, is only slightly more efficient than the present baseline technology (BTK), and compared to the baseline technology in 10 years' time (FCK), it has no advantage on an energy-use basis. The GHG emission reduction results from the changeover from coal-fired BTKs or FCKs to natural gas–fired Hoffmann Kilns.

Why This Project Would Not Otherwise Go Ahead

Although there are over 5,000 brick kilns in the country, the overwhelming majority are BTKs. Over 90% of the bricks used in Bangladesh are supplied by the BTK industry. There are no more than 25 Hoffmann Kilns, located mostly around Dhaka. The principal barrier to the widespread use of the Hoffmann Kiln is the high investment required (14 times that of the BTK). BTK owners are small entrepreneurs, who are barely able to afford US$ 50,000 in annual investment and working capital. These BTK investors are mostly uneducated people looking for a quick return on their investment. The Hoffmann Kilns, due to their large investment and land requirement, are small-scale industries, whereas the BTKs are no more than cottage industries. It is difficult for existing BTK owners to make the transition from a BTK to a Hoffmann Kiln because they lack the capital to build a Hoffmann Kiln and they have absolutely no creditworthiness to secure a loan from a bank. As a result, new entrepreneurs who are able to afford the more expensive brick-making technologies are gradually replacing the small-time BTK investors.

Discussions with the Brick Manufacturers Owners' Association have revealed that BTK owners have no plans to set up Hoffmann Kilns. Hoffmann Kilns require more land compared to BTKs, and suitable land is difficult to find in many places. Building a Hoffmann Kiln may require procuring low-lying land and raising it. Lack of knowledge about the Hoffmann Kiln also acts as a barrier to its widespread use. The profitability of a Hoffmann Kiln is lower than that of a BTK. As a result of these barriers, the Hoffmann Kilns, despite being environmentally benign, are not achieving the desired penetration. It is worth noting that the technology has been available for over ten years and only about two dozen such kilns have been built. In the business-as-usual scenario, one can expect only about two to three Hoffmann Kilns to be built per year, as has been the case in the past five years.

How the Technology Will Be Transferred

As mentioned earlier, there are approximately 25 Hoffmann Kilns presently in operation in the country. The technology, therefore, already exists in Bangladesh. Consultants are readily available to assist with setting up Hoffmann Kilns, but because so many kilns would be set up in a short time span as a result of this project, people will need to be trained in the operation and maintenance of the kilns.

Project Life and Credit Period

A Hoffmann Kiln will definitely last 10 years. However, after 10 to 12 years, the kiln may require substantial overhauling. The cost of overhauling will not exceed 15% to 20% of the total investment, because 60% of the total investment is land cost. Therefore, in performing financial analysis, if the annual operation and maintenance cost is enhanced by a few percentage points, the project life can be considered to be 30 years. We made these assumptions in the analysis presented in Section 8.

For this project, it is better to use a ten-year credit period without a change in baseline rather than several seven-year crediting periods with baseline adjustment. This is because Hoffmann Kilns are not likely to yield significant emission reductions beyond 10 to 12 years.

Contribution to Sustainable Development

The government of Bangladesh hasn't as yet formulated the Sustainable Development Criteria for CDM projects. However, it is almost a certainty that cleaner brick-making technologies will be part of them. Pollution from brick kilns has become a significant environmental problem, second only to urban air pollution. Compared to the baseline option, Hoffmann Kilns would require far less land to produce the same number of bricks, thus also relieving the already heavy pressure on agricultural and other land.

BTKs are a major source of pollution in many parts of the country. Another significant environmental issue with BTKs is that they are the major cause of deforestation in Bangladesh because, despite a government ban, they use large quantities of firewood. The firewood demand from brickfields has led to the illegal felling of trees in forests, aggravating an already severe deforestation problem brought about by heavy population pressure. In addition, BTKs have been known to use tires as fuel. The use of low-grade coal mixed with firewood and all kinds of combustible matter creates unimaginable pollution in and around the brickfields. Since brickfields occur in clusters, the pollution is magnified and in certain areas of the country during the dry winter months, a truly alarming situation can sometimes develop. As may be imagined, environmental concerns have led to a huge public outcry against these polluting BTKs. The government has stepped in with regulations, but is unable to enforce them because no alternative brick-making technology that is affordable by BTK owners is available. From a national sustainable development perspective, this project will enjoy the full support of the government.

The Recipient of These Benefits

From an environmental point of view, the mitigation technology is infinitely superior to the baseline technology. It also uses less land, thus easing the pressure on much-needed agricultural land. Clearly society at large stands to benefit from this project because it will abate a worsening air pollution problem and lessen deforestation. More specifically, inhabitants of areas where shut-down BTKs were located will enjoy the most significant environmental benefits. The project addresses a big issue confronting the government: how to achieve the transition from polluting BTKs to cleaner brick-making technologies in a cost-effective manner. The Hoffmann Kiln owners, especially those who were previously BTK owners, stand to benefit directly from the project because many of them would not have been able to set up these kilns without CDM support. It is important for BTK owners to realize that their old industry is under severe threat from government regulations.

Adverse Environmental or Social Impacts

Despite its numerous direct and indirect benefits, the project does have to deal with the following two significant social issues:

(i) BTK owners put out of business (i.e., those who fail to join the project)
(ii) Reduction in the number of people employed

Even though every effort will be made to prevent BTK owners from being put out of business, it may not be feasible to develop the project so all the project developers are BTK owners. If the project is badly planned, its benefits may reach only newly created affluent Hoffmann Kiln owners, at the expense of poorer BTK owners.

The second social issue arises from the fact that the Hoffmann Kiln, a year-round operation on a much larger scale than a BTK, benefits somewhat from economies of scale in terms of the labor requirement per brick produced. Therefore, the project will probably result in a 20% reduction in labor force, which is undesirable in a populous developing country. These adverse social impacts must, however, be put into the correct context. It must be remembered that due to continually tightening government regulations, the existing polluting brick industry must transform itself, and, in fact, a far worse fate is in store for the BTK owners with modern tunnel kiln mechanized brick-making replacing both the primitive production processes of the BTKs and the semi-modern Hoffmann Kilns. Strong environmental lobbies and vested interest business groups are already forcing the government in that direction.

2. Partner Industry/NGO in Host Country

This project envisages the construction of 20 Hoffmann Kilns. The true partners of this project should be the owners of these Hoffmann Kilns. Since it is not possible for the CDM investor to deal with such a large number of people, the execution of this project requires an operator who will be responsible for the CDM project development. Ultimately, this CDM operator will remain responsible for delivering the CERs to the CDM investor and the financing to the project developers/owners. The CDM operator could be one of these four entities: (i) Brick Manufacturers Owners' Association; (ii) Hoffmann Kiln Owners' Association; (iii) an existing environmental/development NGO; or (iv) a private business group interested in promoting

CDM projects in Bangladesh. It would be the responsibility of the operator to locate the prospective project developers/owners.

As mentioned earlier, to minimize putting too many BTK owners out of business, a concerted effort would be made to form consortiums or partnerships among BTK owners so that the owners of the Hoffmann Kilns are ex-BTK owners. There are many cases where the same person or group owns several BTKs. Efforts would be made to convince them to become Hoffmann Kiln owners. However, realistically, it may not be possible to ensure that an equivalent number of BTKs are shut down. Thus, the project owners may be: (i) the present owners of BTKs, either singly or in groups of two to five; (ii) the present Hoffmann Kiln owners who want to expand their businesses; (iii) new entrepreneurs who are interested in getting into this industry; or (iv) any combination of these three groups of people. There are indications that the Hoffmann Kiln Owners' Association members are very keen to participate in the project. Discussions with the Brick Manufacturers Owners' Association have revealed that they are also interested in participating.

3. Project Scope/Boundary

This project has been evaluated as a new "greenfield" project, meeting new demand for bricks that would otherwise have been met using new BTKs. The 20 Hoffmann Kilns constructed by the project would be the project boundary. Since in this project very little electricity is involved, the project boundaries are well defined and there are no sources of leakage. It is assumed that the outputs of the project displace the baseline products that would have been produced by the BTKs. The brick production from the Hoffmann Kilns is identical to the baseline products in every respect except that the Hoffmann bricks are slightly superior and fetch a higher price. The important thing is that the Hoffmann bricks provide the same service as the BTK bricks. That this assumption is reasonable can be appreciated by pondering the fact that without the CDM project, the baseline BTKs would have to be built. This, however, imposes on the project the burden of carefully monitoring and verifying the number of bricks sold from the CDM project.

4. Emissions Baseline

Defining the baseline for this CDM project is complicated by the fact that the way in which the brick industry has operated in the past is undergoing rapid changes due to tightening environmental regulations. Even though the overwhelming number of bricks produced in the country are the products of the coal- and firewood-burning BTKs, and will remain so in the next 10 years, present government regulations do not permit these operations. In areas where government regulations are being enforced, the Fixed Chimney Kiln (FCK) is replacing BTKs. The changeover from BTKs to FCKs is mostly taking place in the areas adjoining Dhaka and Comilla, and these are precisely the areas where the CDM project is being envisaged. It may thus be expected that in the next 10 years, the baseline technology will be the FCK. However, the rate at which this changeover will be achieved is not clear. An FCK (a 20% more efficient technology) baseline will underestimate the emission reduction, while a BTK baseline will overestimate the emission reduction. A safe baseline is, of course, the FCK one. However, such a strict baseline will render this otherwise excellent CDM project less attractive. It is therefore recommended that a certain proportion of BTKs be retained in the baseline determination.

In addition BTKs and FCKs, several other technologies are vying to join the brick-making technology mix. The Zigzag Kiln, the VSBK and the mitigation technology itself (the Hoffmann Kiln) will all have some place in the future technology mix. Justification for the choice of the Hoffmann Kiln as the mitigation technology has already been provided in Section 1, but a slow but certain penetration of such kilns, even without CDM, cannot be denied. The Vertical Shaft Brick Kiln (VSBK) poses a significant challenge. These kilns are 50% more efficient, more compact, less polluting and favored by the Department of Environment in Bangladesh. Again, the possibility of such kilns penetrating the Bangladesh market is undeniable because stricter and stricter environmental regulations and enforcement may force the present BTK owners to look for cleaner technology. But the important thing is that not a single such kiln exists in Bangladesh, and the probable owners of such kilns, i.e., the present BTK owners, are uneasy about the technology mainly because they are totally unfamiliar with it. However, if the government actively encourages this technology, there may be a slow but certain penetration.

The biggest challenge to the whole baseline determination is the option of fuel-switching from coal to natural gas for the existing BTKs. Bangladesh has plentiful natural gas, but due to various operation and management issues, the gas utility does not supply natural gas to BTKs. There are no technical reasons hindering the use of natural gas in BTKs. In fact, about 10 years back, many BTKs were operating on natural gas. Then the gas utility stopped supplying gas to most BTKs, causing them to shift back to coal. BTKs prefer to use coal because they do not have to deal with a government-controlled utility. Furthermore, it is marginally cheaper to use coal because the utility demands a fixed charge throughout the year, and BTKs are seasonal operations (four to six months, depending on the year). If the government decides that the best way to tackle pollution is to force BTKs to use natural gas, and if they change the gas policy to encourage the changeover, the rationale for the CDM project will disappear because the efficiency difference between the Hoffmann Kiln and BTK is not sufficient to justify a CDM project. The emission reduction considered in this project is derived from fuel-switching – from coal using a BTK or FCK to natural gas using a Hoffmann Kiln.

Government regulations and policies, gas utility policies and plans, and the penetration of clean brick-making technologies will all shape the baseline in the next 10 years. As this discussion demonstrates, it is impossible to incorporate the very diverse, and sometimes contradictory, factors that may affect the brick industry. The way forward is to judge these factors from the perspective of how things actually happen in the real world, especially in developing countries, and to put them in the correct context in defining a baseline, incorporating only those things that are known with certainty. A combination of BTKs and FCKs is the most realistic baseline for brick-making in Bangladesh in the next 10 years. Table 2 shows the baseline determination for 10 years, starting from either 2004 or 2005. In year 1, the FCK penetration is assumed to be 20%, while by year 9, the penetration is assumed to have reached 100%. The CO_2 emission per brick improves from 0.539 in year 1 to 0.475 kg in year 10.

In this project, there are no leakage issues because the Hoffmann Kiln technology is a fairly straightforward substitution for the baseline technology. The project uses natural gas from the grid, while the baseline technology uses coal transported by trucks. In this case, the project can take credit for the CO_2 emission difference between the delivery-to-kiln emissions of the two fuels. The auxiliary consumption of electricity by the Hoffmann Kiln has been taken into account in calculating the emission reduction.

Table 2 Baseline Emissions per Brick

YEAR	BTK (%)	FCK (%)	Coal Consumption per Brick[1] (kg coal)	CO_2 Emissions per Brick[2] (kg)
1	80	20	0.8 x 0.28 + 0.2 x 0.24 = 0.272	0.539
2	70	30	0.268	0.531
3	60	40	0.264	0.523
4	50	50	0.26	0.515
5	40	60	0.256	0.507
6	30	70	0.252	0.499
7	20	80	0.248	0.491
8	10	90	0.244	0.483
9	0	100	0.24	0.475
10	0	100	0.24	0.475

1. Coal consumption per brick: BTK = 0.28 kg; FCK = 0.24 kg.
2. Coal calorific value and emission coefficient taken from the IPCC 1995 Revised Guidelines.

5. Emissions Estimation and Monitoring and Verification Approach

Estimating Emissions Reduction

The mitigation technology, which is the Hoffmann Kiln for making bricks, will consume natural gas and grid electricity. The natural gas will be used to fire bricks in the kilns and is the major source of energy for the process. Electricity will be used for lighting, cooling (fans), air conditioning (in office), blowers in the kiln and mixing clay for the pug mills. The BTKs (baseline technology) in many cases do not have electricity connections and meet their lighting needs with kerosene lamps and their pug mill needs with animal power. The auxiliary energy consumption is certainly greater for Hoffmann Kilns, but cannot be estimated correctly, especially in relation to BTKs. However, the increased consumption is not likely to be more than 1% to 2%. In this predominantly fuel-based project, the extra effort of estimating the emissions from the use of grid electricity is certainly not worth the effort. Therefore, an extra 2% emission due to the increased auxiliary consumption has been added to the emissions computed for the CDM project (mitigation technology).

Table 3 Emission Reduction by the Project

Year	Bricks Produced (millions)	Baseline CO_2 Emission (tonnes)	Annual Natural Gas Consumption[1] (million m^3)	Project CO_2 Emission[2] (tonnes)	Emission Reduction (tonnes)
1	170	91,554	27.2	54,500	37,079
2	170	90,208	27.2	54,500	35,732
3	170	88,861	27.2	54,500	34,386
4	170	87,515	27.2	54,500	33,040
5	170	86,169	27.2	54,500	31,693
6	170	84,822	27.2	54,500	30,347
7	170	83,476	27.2	54,500	29,001
8	170	82,129	27.2	54,500	27,654
9	170	80,783	27.2	54,500	26,308
10	170	80,783	27.2	54,500	26,308

1. Natural gas emission coefficients taken from IPCC 1995 Revised Guidelines.
2. Emission increased by 2% to account for the auxiliary electricity consumption.

Monitoring and Verification Approach

The emission characteristics of the project can be summarized as follows:

	Description	**Emissions**
Baseline Technology	Coal used for firing bricks. Negligible auxiliary consumption of electricity (where available). Kerosene for lighting and cooking.	<u>ON-SITE</u> Emissions from burning coal in the brick kilns.
Mitigation Technology	Natural gas used for firing bricks. Auxiliary consumption of electricity to operate blowers and pug mills. Mix of electricity and kerosene for lighting and cooking (more or less the same as baseline).	<u>ON-SITE</u> Emissions from burning natural gas in the brick kilns. <u>OFF-SITE</u> Emissions due to grid electricity generation.

If for any reason the CDM project fails to produce and sell its design capacity of bricks, the project will fail in its obligation to deliver the stipulated amount of CERs, based on which the project was developed. If the project has been financed by up-front contribution, then this non-performance has serious implications for the CDM investor. For annual CER purchase, this is not such a serious matter. Both the fuel consumption and production of the project have to be carefully monitored. The comparison with the baseline can then be made on a specific energy consumption per brick basis. The following two critical items need to be monitored by the project to establish the emission reduction:

Gas consumed per year in m^3 or ft^3 Number of bricks sold per year

It is extremely important for this project to have very good record-keeping facilities. While the gas consumed can be easily monitored using tamper-proof meters, the number of bricks produced and sold cannot. However, if annual gas consumption is known with some certainty, a good estimate of the number of bricks produced can be established, enabling cross-checking of uncertain data. It is proposed that the following also be also monitored to ensure further cross-checking:

The quantity of raw material purchased and consumed
The number of people employed throughout the year
The number of times the kiln was charged during the year
The VAT paid by the factory
The number of trucks loaded

In this project all 20 kilns must be monitored every year. This level of monitoring stipulates that a local monitor should be engaged. The local monitor will need to visit each of the 20 projects once a year to perform detailed auditing. In addition, sometime during the year an unannounced random quick check may be performed to ensure that production targets are being met. The annual data collection per kiln, including travel time, will require one full day. The monitor should, however, be able to manage at least one spot check at another kiln during the day's work. Compiling all the data for the year and producing a monitoring report will require about 10 days. Thus, 30 days, or one man-month, must be allocated for this work. At a rate of US$ 100 per day, the local monitoring professional cost would be US$ 3,000 annually, or US$ 30,000 for the entire 10-year duration of the CDM project. Assuming travel costs for the local monitor to be US$ 1,000 per year, the total local monitoring costs amount to US$ 40,000. A regional or international monitor/verifier would probably need to visit every two years initially, and later every three years, to audit the local monitor's reports, visit all the project sites and collect general information about the CDM project and its baseline from independent sources. The effort required to achieve this will be approximately one man-month, of which approximately two weeks will be in the field (host country) and two weeks will be in the regional or international monitor's/verifier's own station. Including travel, this cost could vary between US$ 10,000 and US$ 20,000. Four such expenditures during the crediting period of 10 years, at an average cost of US$ 15,000, would amount to US$ 60,000. Thus, a total of US$ 100,000 must be allocated for monitoring and verification of the CDM project.

6. Project Components and Costs

The initial investment required to set up a Hoffmann Kiln is estimated to be Tk. 36,500,000 (US$ 0.63 million). This cost estimate is based on acquiring land around Dhaka, where land prices are very high. Approximately 60% of the initial investment will be for land. Other significant cost components are construction fees and construction materials. These are estimated to amount to 10% each of the total initial investment.

The most significant item in the transaction costs is the CDM project development cost. As explained in Section 1, the operator will not only need to formulate the total project, but will also have to facilitate the Operational Entity's tasks, and in particular aid in the monitoring and verification process. The project owners will remain fully responsible for setting up the kilns, getting government approval for running the brick industries. The operator's role with respect to the brick industry will only be to initiate the project by linking the CDM funding to each kiln. The following cost-bearing activities may be envisaged for the operator:

(i) Formulate of a participation plan for owners of 20 Hoffmann Kilns
(ii) Locate the project developers/owners
(iii) Complete formalities with the government's Climate Change Focal Point
(iv) Assist in securing loans, if required
(v) Formalize the financial transaction with the CDM investor
(vi) Formulate a monitoring plan during the crediting period
(vii) Manage the monitoring and verification during the crediting period
(viii) Assist the Operational Entity in managing the CERs

The CDM Project Development cost items, as detailed above, are expected to be approximately 3.7% of the total cost of the project. The other significant cost component is the expense of engaging the Operational Entity. The Operational Entity, as stipulated in the guidelines for CDM, will first validate the baseline and later, during the crediting period, monitor and validate the CERs produced. In addition to these two expenses for the project, there are other CDM transaction costs, as shown in Table 4. As Table 4 demonstrates, the CDM-related expenses for the project amount to 8% of the total costs. All the cost items for this CDM project and the total capital requirement are shown in Table 4. In performing the financial analysis, the total investment shown in Table 4 has been used.

Table 4 Itemized Costs for the CDM Project

Item	Description	Cost[1]
1.	Project operator's costs Initial project formulation – US$ 0.05 million All project documentation – US$ 0.15 million Contracts and legal costs – US$ 0.05 million CDM project approval – US$ 0.15 million Office running cost for 10 years – US$ 0.10 million	US$ 0.5 million
2.	Construction cost of 20 Hoffmann Kilns Land (60%) Design and engineering (5%) Construction fees (10%) Construction materials (10%) Gas connection (10%) Approval and contingency (5%)	US$ 12.6 million
3.	Operational Entity costs Baseline validation – US$ 0.15 million Monitoring and verification – US$ 0.25 million	US$ 0.4 million
4.	Other transaction costs Government (4% of CER) – US$ 0.1 million	US$ 0.2 million

	Executive board (2% of CER) – US$ 0.05 million Adaptation fund (2% of CER) – US$ 0.05 million	
	Total	US$ 13.7 million

1. All future annual costs have been discounted to the present at a 12% interest rate.

7. Investment Plan

There are several ways that this project can be implemented. At one end of the spectrum, the investor can put up the entire cost for setting up all the Hoffmann Kilns. On the other, the investor only puts in enough to remove the barrier to setting up Hoffmann Kilns. It is important to point out that Hoffmann Kilns are viable projects in their own right, but yield a lower return than the baseline option. In the event that the investor provides the entire cost, some mechanism of profit-sharing has to be worked out. Given the complexity of this proposition, it is better to consider a scheme where the investor provides the minimum required to make the project happen and collects only the CO_2 benefits.

In the alternative plan it is assumed that the CDM investor puts up only a small portion of the total investment required for the construction of the kilns. The following is a suggested breakdown of the sources of capital for the initial investment of the CDM project.

20%	Project developer
20%	CDM investor (actual % will depend on the price of the CERs)
60%	Bank loan

Thus, it is envisaged that a Debt-Equity ratio of 60-40 will be maintained. It is hoped that the CDM investor's 20% contribution towards equity would enable the project to go forward. The CDM investor's role here is threefold, namely: (i) to formulate and initiate the energy efficiency project; (ii) to provide creditworthiness to investors that banks would never consider; and (iii) by treating the investor's portion of the investment as a grant, to lower the per-unit cost of bricks, thus making them fully competitive with the ordinary BTK product. The last point is important because without this, the outputs of the Hoffmann Kilns may find it difficult to compete, especially if the kilns are set up in rural areas where the market cannot support their superior but expensive outputs.

8. Financial and Credit Analysis

This CDM project is conceived as a "greenfield" project. Thus, conducting a financial analysis for this project on an incremental investment (i.e., Hoffmann – BTK) is not appropriate. Moreover, the Hoffmann bricks, being slightly superior, fetch a higher price. In fact, without this price premium, the FIRR of the Hoffmann Kilns becomes extremely low. The financial analysis to calculate the FIRR for the CDM project requires the following data for a typical year.

(i) The gross profit
(ii) The fuel cost
(iii) The raw material cost
(iv) The labor cost

(v) The operation and maintenance cost

The gross profit has been calculated by multiplying the sale price of one brick by the expected number of bricks to be produced. The fuel cost has been calculated based on the prevailing gas price and a per-brick gas consumption, which has been established from actual factory data.

The firing section of the kilns is subjected to very high temperatures (600° C to 800° C), and is therefore continually undergoing wear and tear. Regular maintenance is required to keep the kilns in a good operational state. Before stacking green bricks for firing, visual inspections are conducted and any detected damaged zone is repaired. In addition, general maintenance is performed once a year to clean all flue gas ducts, the chimney, the blower, etc. The operation and maintenance costs are therefore high for Hoffmann Kilns. Without regular repairs, the kilns would not last more than five years. The lives of these kilns have been taken as 30 years because land is a significant cost component. Therefore, every 10 to 12 years, approximately 20% of the total initial investment must be spent to enhance the life of the project.

The other costs are raw material and labor. To simplify the financial analysis spreadsheet, all non-fuel costs, i.e., raw material, labor, operations and maintenance, have been lumped together and a per-brick cost of Tk. 1.7 has been used. This cost data has also been collected from an operating Hoffmann Kiln brick industry.

The financial analysis has been worked out based on the assumption that the CERs would be sold at US$ 10/tonne of CO_2 abated. From a CDM perspective, the following two mechanisms of financing have been considered:

(i)	Annual purchase of CERs – transaction costs paid by project host
(ii)	Up-front contribution – transaction costs paid by carbon financier

The summarized version of the results is presented in Tables 5 and 6. As can be seen, the up-front contribution per kiln amounts to US$ 0.1 million (2.06/20), which is 15% of the total cost of one kiln. The question that immediately arises is, will this CDM investment remove the barriers to the project? The critical point here is not so much the direct contribution to the project, which is not substantial, but the assistance provided to developers in gaining adequate creditworthiness with banks and other financial institutions so that the loan component of the project (60%, in this case) can be secured. Another way of constructing this project is to treat the entire CDM amount as a loan guarantee provision. This can provide banks with a fairly secure guarantee because the fund covers the risks of up to three projects failing. Moreover, the equity portion provided would be mortgaged land, so the banks would be able to recover the equivalent of one kiln's investment from the failed project.

As can be seen from the summary in Table 5, the FIRR of the project without carbon financing is not that attractive, at 18.9% on equity and 17.3% on total costs. It is worth pointing out here that interest rates on industrial loans in Bangladesh can be as high as 18%. In the last year, the government has taken measures to bring interest rates down. For the present analysis, an interest rate of 15% has been used. After the deduction of taxes and duties, the project is not at all attractive. This, therefore, is the most significant barrier. The few Hoffmann Kilns in existence have mostly been built with 100% equity on the land.

The role of carbon financing is clearly visible in Table 5. The FIRR on equity is increased by 6% and 8%, due to the sale of CERs and the up-front contribution, respectively. Thus, CDM's role in promoting an environmentally friendly technology (compared to the baseline) is abundantly clear.

Table 5 Summary of Financial Analysis of the Project

	Type of Financing	Financing	FIRR on	
			Equity	Total Costs
1	Without carbon financing	Total costs – $8.2 million Equity – $5.5 million	18.9%	17.3%
2	With up-front carbon financing – transaction costs paid by carbon financier	CDM contribution towards equity – $2.1 million	27.4%	20.6%
3	With sale of CERs – transaction costs paid by project host	CERs purchased per year – $0.45 million	24.8%	20.2%

Table 6 Snapshot of the Financing Mechanisms Considered for the Project

Items	Units	Value
Claim period	years	10
Annual emissions reduction	tonnes/year	45,059
Annual purchase of CERs – transaction costs paid by project host		
Price paid per CER	US$/tonne	10.0
Annual Carbon Financing	million US$/year	0.45
Proceeds to CDM Adaptation Fund (**2.0%** of CERs)	million US$/year	0.009
Proceeds to CDM Executive Board Administration (**2.0%** of CERs)	million US$/year	0.009
Operational Entity costs (**0.5%** of project cost)	million US$/year	0.068
Net Contribution	million US$/year	0.36
NPV of contribution at discount rate of **12.0%**	million US$	2.06
Percent of equity	%	38%
Percent of total costs	%	15%
Up-front contribution - transaction costs paid by carbon financier		
Percent of Equity	%	37.7%
Percent of Total Costs	%	15%
Financial Contribution	million US$	2.06
Annual Carbon Financing at discount rate of **12.0%**	million US$/year	0.37
Proceeds to CDM Adaptation Fund (**2.0%** of CERs)	million US$/year	0.009
Proceeds to CDM Executive Board Administration (**2.0%** of	million US$/year	0.009

CERs)		
Operational Entity Costs (**0.5%** of project cost)	million US$/year	0.068
Net carbon financing	million US$/year	0.45
Net cost of CERs	US$/tonne	10.0

9. Risk Assessment/Sensitivity Analysis

The risk in this project is predominantly associated with the baseline. In the strictest sense, this project fails under the CDM Regulatory Criteria. However, as has been argued, developing countries have numerous stated environmental policies, but very few are being either followed or enforced. Moreover, it is an obvious fact that despite regulation, there exist many barriers to the transition to cleaner technologies in developing countries. The uncertainties associated with the baseline have been discussed in Section 4, Emissions Baseline.

The other risk is the failure of the project operator to manage the CDM project properly. For example, in the case of up-front CDM contribution, the project operator may not deliver the required services to the CDM investor, as contracted.

Sensitivity Analysis

The most uncertain parameter in the FIRR calculations is the land cost. Land price can vary a lot, depending on location and type (high or low). Despite many efforts, the value of this parameter could not be ascertained with any confidence.

10. Summary of Results

The results of the CDM project, which aims to construct 20 Hoffmann Kilns to replace an equivalent number of Bull's Trench Kilns, is presented in Table 7. The FIRR calculations have been performed assuming a CER price of US$ 10 per tonne of CO_2 abated.

Table 7 Project Description, Specifications and Emissions Reduction

		Baseline	**Project**
Technologies			
Description		Bull's Trench Kilns	Hoffmann Kilns
Fuel (units)		Coal (kg)	Natural gas (m^3)
Plant capacity (units)	Annual brick production	170,000,000	170,000,000
Fuel consumption	kg or m^3/unit	0.2544	0.125
	million kg or m^3/year	43.248	21.25
Project specifications			
Capital investment	US$/unit	0.02874	0.0805
	million US$	4.89	13.69
Fuel costs	US$/kg or m^3	0.052	0.09
	million US$/year	2.25	1.91
Annual O&M costs	% project cost per year	20.0%	36.4%

	million US$/year	0.98	4.98
Project life	years		30
Equity financing	%		40%
Debt financing	%		60%
Financing interest rate	%		15%
Loan term	years		10
Emissions reduction			
Carbon dioxide emissions – on-site	kg/kg or m^3 fuel	2.00	1.95
Total emissions (CO_2 equivalent)	tonnes/year	86,496	41,438
	kg/unit	0.51	0.24
Emission reduction per year	tonnes/year		45,059
Financial analysis (CER price of US$ 10/tonne of CO_2)			
Without carbon financing	FIRR on equity FIRR on total costs	– –	18.9% 17.3%
With up-front carbon financing	FIRR on equity FIRR on total costs	– –	27.4% 20.6%
With sale of CERs	FIRR on equity FIRR on total costs	– –	24.8% 20.2%