PROJECT DESIGN DOCUMENT FORM
FOR SMALL-SCALE CDM PROJECT ACTIVITIES (F-CDM-SSC-PDD)
Version 04.1

PROJECT DESIGN DOCUMENT (PDD)

Title of the project activity	Improving Kiln Efficiency in the Brick Making Industry in Bangladesh
Version number of the PDD	Version 16
Completion date of the PDD	08/04/2014
Project participant(s)	1. Industrial and Infrastructure Development Finance Company Ltd. (IIDFC) (Private entity), Bangladesh 2. International Bank for Reconstruction and Development (IBRD) as Trustee of the Community Development Carbon Fund (CDCF)
Host Party(ies)	Bangladesh
Sectoral scope(s) and selected methodology(ies)	Sectoral Scope: 4 - Manufacturing industries; Methodology: AMS-II.D - Energy efficiency and fuel switching measures for industrial facilities, version 12, EB 51
Estimated amount of annual average GHG emission reductions	44,098t CO_2e

SECTION A. Description of project activity
A.1. Purpose and general description of project activity

Purpose of the project activity:

The purpose of the project is to construct 6 new energy efficient kilns for reducing CO_2 emissions in Bangladesh. At present, brick making is a highly energy-intensive activity and is one of the largest sources of greenhouse gas (GHG) emissions in the country, estimated to be in the order of 3 million tons per annum (ref. UNDP Project Document, titled "Bangladesh - Improving Kiln Efficiency in the Brick Making Sector", August 2006)[1]. The existing kiln technologies in the country are Fixed Chimney Kiln (FCK), Bulls Trench Kiln (BTK), Zig Zag Kiln, etc., which are highly energy inefficient, consuming more fossil fuels and thus, contributing to high GHG emissions. By employing the technology embodied in the Hybrid Hoffman Kiln (HHK), the project will pilot the introduction of modern, energy efficient and sustainable brick making technology to Bangladesh.

The HHK is a hybrid version of the Hoffman Kiln technology that was developed in Germany in the mid-nineteenth century. Since then, it has been redesigned to improve heat retention in the kilns and to capture waste heat for recirculation in the drying tunnel. In addition, coal consumption is reduced by introducing pulverized coal into the wet clay in each brick, which then bakes the bricks from inside.

The designed production capacity of a HHK may vary from a minimum of 50,000 bricks per day to several multiples of 50,000 bricks per day. Though each kiln by itself would qualify as a Clean Development Mechanism (CDM) project, the project proposes bundling of 6 HHKs, the aggregate daily production capacity of which is 500,000 bricks per day, into one Project Design Document (PDD), to reduce CDM transaction costs whilst remaining within the small scale threshold for this type of activity.

The brick kilns participating[2] in this project are listed in Table 1, below:

Table 1: Participating HHKs

Kiln name	Brick production per day
Universal Bricks Ltd.	50,000
Haair Bricks Ltd. - Dhamrai	50,000
Diamond Auto Bricks Ltd.	100,000
Kapita Auto Bricks Ltd.	100,000
Banalata Refractory Ltd.	50,000
Sunflower Bricks and Construction Materials Ltd.	50,000

Industrial & Infrastructure Development Finance Company Ltd. (IIDFC), which is a Bangladesh financial institution, will be the bundling agent for the 6 kiln owners of the 6 kilns. As the technology is new to Bangladesh, the technology services are largely imported from China by the brick kiln owners.

IIDFC has signed contractual agreements with the HHK entrepreneurs to transfer the ownership of the emission reductions from each HHK owner to IIDFC. IIDFC will retain a portion of the CER revenues to

[1] Available at http://gefonline.org/projectDetailsSQL.cfm?projID=1901

[2] SSL Ceramic Bricks Ltd. (kiln 1 and kiln 2) were initially added in the bundle during registration of PDD. However, the SSL kiln 1 discontinued its operation from 01/07/2012 due to cracking issues in baked bricks. SSL kiln 2 is also not constructed due to the above issues. Hence, these two kilns are removed from PDD through Post Registration Changes (PRC). This change has not affected the additionality or scale or technology of the PDD.

administer project activities. The remaining portions, in some cases, are escrowed as a risk mitigating instrument for HHK debt finance. The contractual agreements also spell out the environmental and social performance obligations of the entrepreneurs. The institutional arrangements are shown in Figure 1 below.

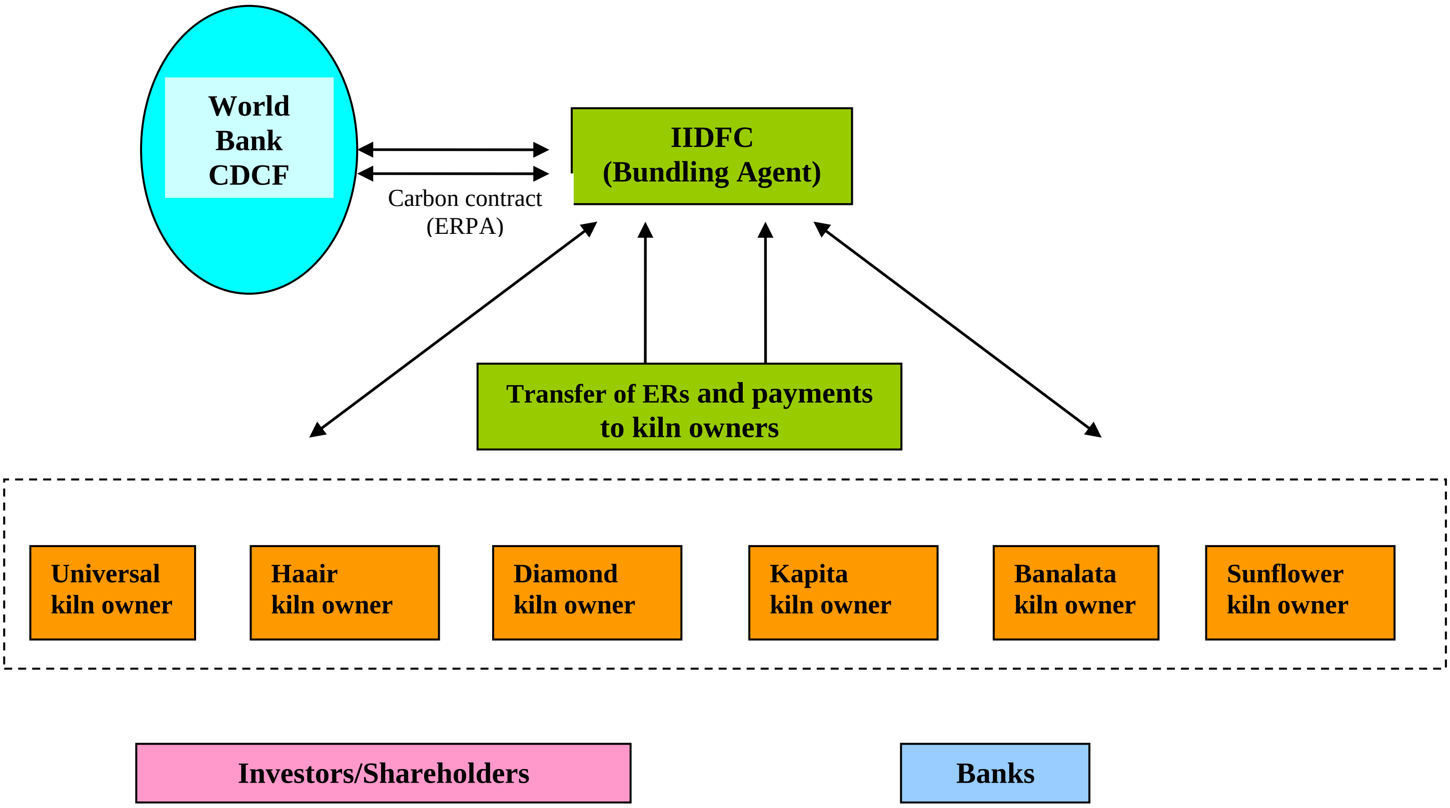

Figure 1: Project implementation arrangements

Scenario prior to the project

In absence of the project activity, brick kilns would have used the traditional tall FCKs. The same is the baseline scenario for the proposed project. When compared to the proposed HHK technology, the FCKs are highly inefficient. The proposed new kilns based on HHK technology are about 55% more energy efficient than the FCK[3].

Scenario after the project activity

By employing the HHK technology, the project will pilot the introduction of modern and sustainable brick making technology in Bangladesh. The introduction of new energy efficient HHK kilns at new facilities will reduce the thermal energy (coal) consumption for the same quantity of brick production when compared to that of the baseline kilns. Coal consumption is reduced by the energy efficient construction of HHK kilns and also by generally introducing pulverized coal into the wet clay in each brick, which then bakes the brick from inside. As a result, the particulate emissions and GHG emissions will be reduced.

[3] Refer to report titled: Clean Development Mechanism Project Opportunities in Bangladesh, Pre Feasibility Report on a Brick Manufacturing Fuel Substitution CDM Project, Bangladesh University of Engineering, December 2002, Table A, pg 3, which lists fuel use per kiln type: http://pubs.pembina.org/reports/cdm_bangladesh_brickkilns.pdf

Project Contribution to Sustainable Development[4]:

The project helps to meet a number of sustainable development objectives:

Environmental objectives: The project will reduce the use of coal, which will have a positive environmental benefit, by reducing the mining, transporting and burning of fossil fuel. As a result, particulate emissions and GHG emissions from kilns will be reduced.

Development objectives: The project will produce approximately 120 million high quality bricks (class 1) per annum which are needed for a variety of buildings and projects. In addition, the use of higher quality bricks will reduce the need for steel and cement in construction.

Economic objectives: The project will introduce new technology and help to modernize the brick industry which accounts for an estimated 1% of Bangladesh GDP. Further, coal use will be reduced which will optimize use of the resource.

Social objectives: The project will increase the production of bricks from approximately 6 months of the year to 12 months of the year. This will help in transforming the brick industry from being seasonal to permanent source of employment. Each kiln will create approximately 100 permanent as opposed to temporary jobs with a total of 1,000 permanent jobs created[5].

A.2. Location of project activity
A.2.1. Host Party(ies)

Bangladesh

A.2.2. Region/State/Province etc.

Dhaka Division (5 units), Rajshahi Division (1 unit)

A.2.3. City/Town/Community etc.

Dhamrai, Narayanganj and Natore

A.2.4. Physical / Geographical location

The plant locations of the 6 new HHK units in 6individual commercial enterprises have been finalised and are in different stages of production/construction: Dhamrai (3 kilns), Narayanganj (2 kilns) and Natore (1 kiln). Locations of the 6 HHK facilities are shown in the table below and in Figure 2, indicating the distribution of brick making enterprises in Bangladesh.

Name of Entrepreneur	Daily brick production	Location of HHK Facility		
		Area	Latitude	Longitude
Universal Bricks Ltd.	50,000	Dhamrai, Dhaka Division	+23.5852	+90.1128
Haair Bricks Ltd. (Dhamrai)	50,000	Dhamrai,	+23.5852	+90.1128

[4] UNDP Project Document, titled "Bangladesh - Improving Kiln Efficiency in the Brick Making Sector", August 2006)[4] , pg 4 Part 1 and pg 20 "National Benefits" provides an overview of the sustainable development benefits of the project.

[5] Whilst emission reduction calculations assume brick production for 9 months of the year due to the monsoon season, the currently constructed kilns are able to operate during this period.

Name of Entrepreneur	Daily brick production	Location of HHK Facility		
		Area	Latitude	Longitude
		Dhaka Division		
Diamond Auto Bricks Ltd.	100,000	Narayangonj, Dhaka Division	+23.4800	+90.3437
Kapita Auto Bricks	100,000	Dhamrai, Dhaka Division	+23.5248	+90.0138
Banalata Refractory Ltd.	50,000	Natore, Rajshai Division	+23.5611	+90.1450
Sunflower Bricks & Construction Materials Ltd.	50,000	Narayanganj Dhaka Division	+23.4800	+90.3470

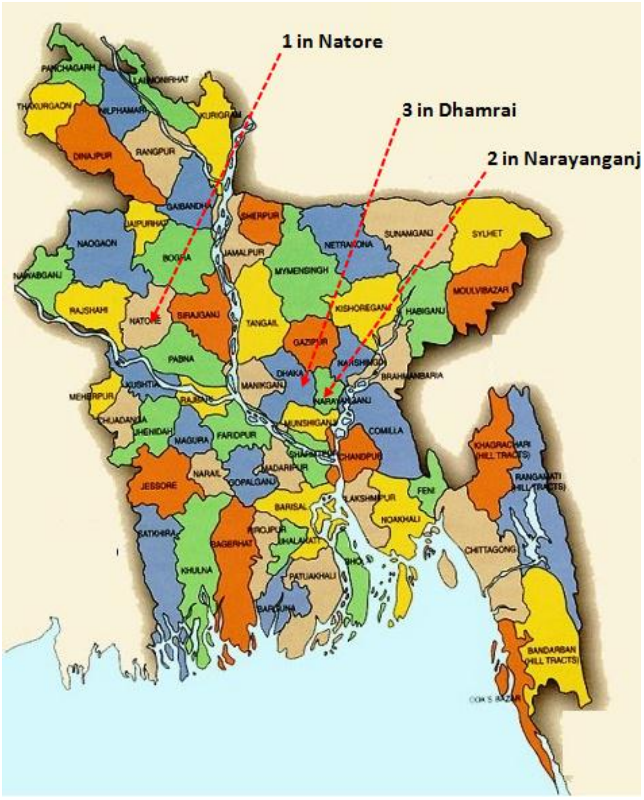

Figure 2: Map Showing Location of Project Kilns and the Distribution of Brick Making Activities throughout Bangladesh

A.3. Technologies and/or measures

According to Appendix B to the *Simplified Modalities and Procedures for Small-scale CDM Project Activities*, the proposed project activity falls under the following type and category:

Project Type : Type II – Energy Efficiency Improvement Projects
Category : D – Energy Efficiency and Fuel Switching Measures for Industrial Facilities
Version : Version 12, EB 51, December 2009
Sectoral scope : 4. Manufacturing industries

This methodology covers "efficiency measures for specific industrial processes" that "may replace existing facilities" or be installed in a new facility. This methodology is the most applicable for the project, as the project deals with energy efficiency measures, not fuel switching, for industrial facilities.

Description of Technology/Measure[6]:

Structurally, the HHK is like the Hoffman Kiln. But, unlike the few traditional Hoffman kilns in Bangladesh which uses gas, the fuel used here is coal. The kiln can be made from firebricks or from green bricks, i.e., unbaked bricks. In the latter event, the green bricks get "baked" during kiln operations. The inner kiln lining is made from standard bricks, set in arched chambers, to improve air flow and therefore, better combustion. The firing chamber can be filled manually or automatically with green bricks, usually about 7,000 to 8,000 bricks at a time, in line stack of around 1,500. Thus, there are five to six line stacks. The firing time for each line stack is about half an hour. Air-flow through the firing chamber is induced by a large vacuum pump that pumps the hot air from the firing chamber into the separate drying tunnels.

Granulated coal, is fed manually into the firing zone in the kiln through stoke holes in the roof of the kiln. Air required for the combustion process is forced from behind. As it reaches the line to be fired, it is already preheated from the previous firing zone thus reducing firing time and energy usage. The temperature in the firing zone is about 950˚ C. The process is extremely simple and is carried out mostly manually.

The mixing of pulverized coal with clay, in some instances, to form the green bricks further improves thermal bonding and reduces fuel usage and hence CO_2 and other emissions. Almost 80% of the total energy required to bake a brick is thus inside of the brick and only about 20% is fed externally into the firing chamber of the kiln. Almost all the fuel inside of the brick is burnt during firing.

One single sized HHK has a design capacity of 15 million bricks per year. The bricks are 25% larger than the sizes commonly produced in Bangladesh. The average weight of a HHK brick is 3.5 kg, whereas average weight of an FCK brick is 2.9 kg.[7] Compared to this, the traditional tall fixed chimney kiln (FCK) which constitutes about 80% of the industry, each produce only about 2 million bricks per annum over a five to six month production period (these kilns being shut down during the annual monsoons). This means that the production capacity of each HHK is about 7.5 times that of these older Energy Inefficient Kilns. Even with the larger brick size, the coal consumption per HHK is about 13 tons per 100,000 bricks. This is equivalent to 0.037 kg coal consumption per kg HHK brick production. This compares extremely favorably to the 24 tons coal consumption per 100,000 FCK bricks or 0.082 kg coal consumed per kg FCK brick production. The new kilns are, therefore, about 55% more energy efficient than the FCK's[8]. This comparatively low energy usage in the HHK will result in reduced CO_2 emissions of approximately 44,098tons per annum, for all 6 kilns.

A kiln consisting of 18-22 doors will have production capacity of 50,000 bricks per day and will be considered as single sized HHK. A kiln consisting of 36-44 doors will have a production capacity of 100,000 bricks per day and will be considered as double sized HHK.

The Production Process

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[6] See UNDP Project Document, titled "Bangladesh - Improving Kiln Efficiency in the Brick Making Sector", August 2006[6], pg 68, describes the technology.

[7] IIDFC report titled " Weight of Bricks in Bangladesh, 2009"

[8] Refer to report titled: Clean Development Mechanism Project Opportunities in Bangladesh, Pre Feasibility Report on a Brick Manufacturing Fuel Substitution CDM Project, Bangladesh University of Engineering, December 2002, Table A, pg 3, which list fuel use per kiln type: http://pubs.pembina.org/reports/cdm_bangladesh_brickkilns.pdf

Clay Extraction, Transport and Preparation - The clay is excavated by hydraulic excavator or by hand from a nearby area and transported to the kiln clay stocking yard by trucks. The clay is then crushed by means of roller mills, followed by a double-shaft mixer, where water is added to ensure 15% moisture content.

Introduction of pulverized coal and shaping the brick - Pulverized coal is mixed with the clay which is fed into a vacuum extruder. A column of clay is pushed out/extruded. This is then cut into the green bricks which are then manually loaded onto a drying car for drying.

Brick Drying - The drying car is then moved into the drying tunnel. The drying cycle lasts for about 26 hours. The hot air in the drying tunnel is sucked in from the annular kiln.

Brick Firing - The dried green bricks are then removed from the drying tunnel and loaded manually into the annular HHK kiln. The speed of the firing is 1.25 m/h at a sintering temperature of about 950° C – 1050° C. The fired bricks are unloaded and conveyed manually in carts to the stacking yard.

Main technical data includes:

Clay particle size after roll mill	: < 2mm
Brick moisture content for shaping	: 18% - 20%
Dry chamber temperature	: 120° C
Sintering temperature	: 950° C -1050° C

Facilities, systems and equipment prior to the implementation of the project activity

The project activity is a Greenfield activity. There were no other brick kilns at the site, prior to the implementation of the project. However in the absence of the project, bricks would have otherwise been produced by the inefficient FCK technology kilns. FCK technology is briefly described above under "Description of Technology/Measure" and it forms the facilities, systems and equipments in the baseline scenario.

Facilities, systems and equipment after the implementation of the project activity

The proposed project activity employs HHK technology and will pilot the introduction of modern and sustainable brick making technology to Bangladesh. Coal consumption is reduced by the energy efficient construction of HHK kilns and also by introducing pulverized coal into the wet clay in each brick which, then bakes the brick from the inside. As a result, particulate emissions and GHG emissions from the kilns will be reduced.

Technology transfer

Although, there is no technology transfer from any Annex I country, there will be technology transfer from China and involves knowhow transfer to the local people. Coal firing is an important activity in HHK brick kiln which determines the fuel consumption and also the quality of bricks. Since this is a new technology for Bangladesh, the kiln fire masters from China are being employed at the kilns to train the local skilled labors. The local staff is also trained on the operation and maintenance of the technology. This clearly shows that the project activity involves technology transfer.

The technology is replicable and will induce more installations in the country.

Environmentally safe and sound technology

The HHK is significantly less polluting than FCKs. The main reasons for this is that the green brick making process traps coal particulates inside of the brick preventing them from becoming air borne. This reduces the volume of fly ash. Secondly, the HHK uses less coal per brick which also reduces the pollution levels. Therefore, a shorter chimney is enough for HHK to disperse coal particulates when compared to that of FCK. More details are provided in Section D.

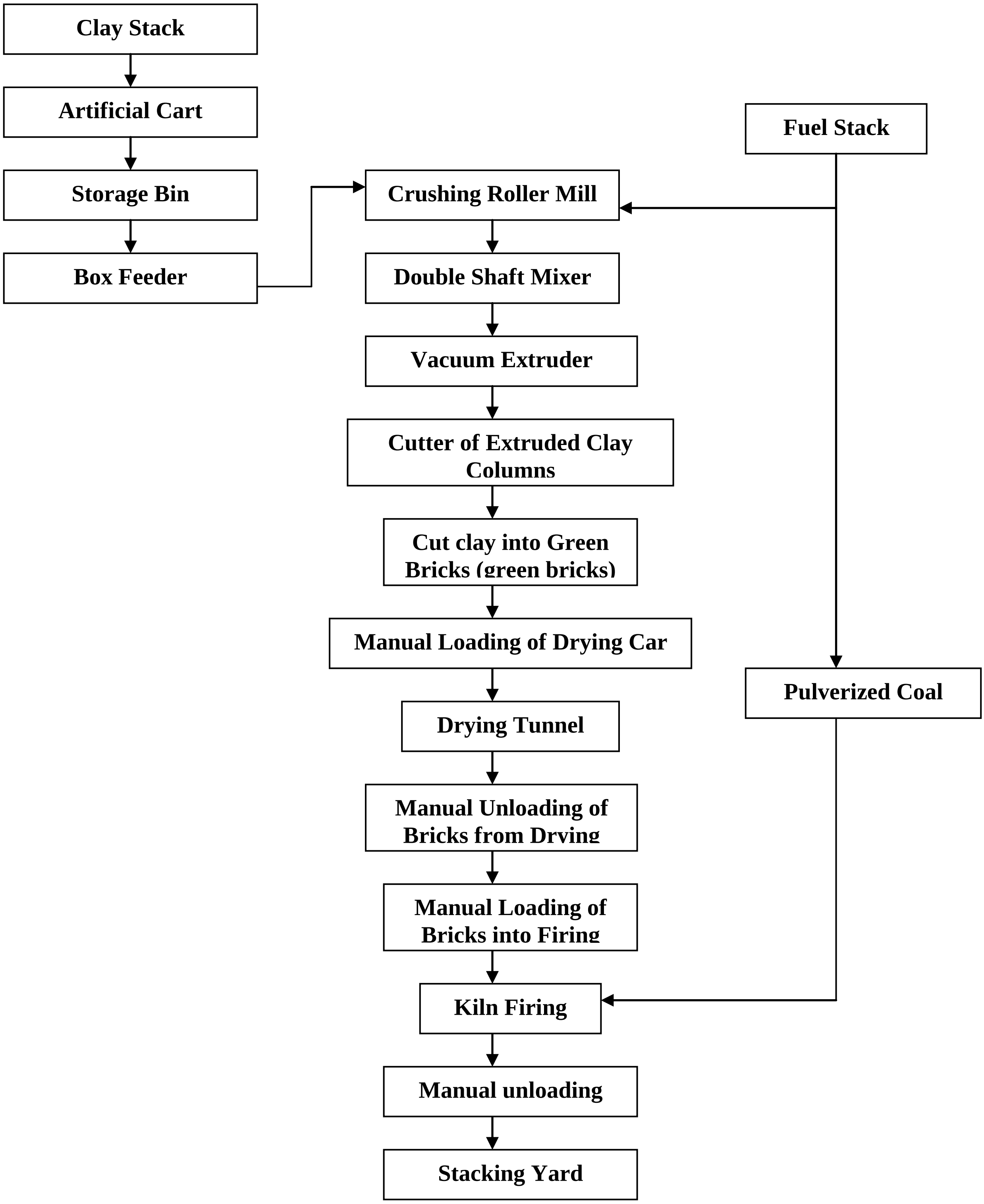

Figure 3: Schematic diagram for the HHK brick making process

A.4. Parties and project participants

Party involved (host) indicates a host Party	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Bangladesh (host)	(Private entity) Industrial and Infrastructure Development Finance Company Ltd. (IIDFC)	No
Denmark	International Bank for Reconstruction and Development (IBRD) as Trustee of the Community Development Carbon Fund (CDCF)	Yes

The contact information of project participants is provided in Annex 1.

A.5. Public funding of project activity

No public funding/Overseas Development Assistance.

A.6. Debundling for project activity

The project participants confirm that there is no registered small-scale CDM project activity or an application to register another small-scale CDM project activity:

- With the same project participants.
- No other project was registered by the project participants within the previous 2 years.
- The project activities are carried out in various cities and states. There is no other registered project by the project participants within 1 km distance of the project boundary of the proposed small-scale activity at the closest point.

In accordance with Appendix C[9] of the *Simplified Modalities and Procedures for Small-Scale CDM Project Activities* "Determining the Occurrence of Debundling" etc., it can be confirmed that this project activity is not a debundled component of a larger CDM project.

SECTION B. Application of selected approved baseline and monitoring methodology
B.1. Reference of methodology

Title : Type II – Energy Efficiency Improvements Projects
Reference : AMS II.D - Energy Efficiency and Fuel Switching Measures for Industrial Facilities, version 12, EB 51

B.2. Project activity eligibility

[9] http://cdm.unfccc.int/EB/Meetings/007/eb7ra07.pdf

The project activity is a Type II ("Energy efficiency improvement projects") and Category D ("Energy Efficiency and Fuel Switching Measures for Industrial Facilities") because it meets the following applicability criteria[10]:

1. Meet the eligibility criteria for small-scale CDM project activities set out in paragraph 28 of decision -/CMP.2[11] which is:

28(b) Type II project activities or those relating to improvements in energy efficiency reduce energy consumption, on the supply and/or demand-side, shall be limited to a maximum output of 60 GWh_e per year (or an appropriate equivalent which is 180 GWh_{th} in fuel input).

The project activity includes introduction of new energy efficient HHKs at new facilities which will reduce thermal energy (coal) consumption for same quantity of brick production compared to baseline kilns.

The project introduces energy efficiency measures in 6 HHK kilns. Operating at full capacity, the total energy savings are estimated to be about 131 GWh_{th} per year. This saving is under the 180 GWh_{th} per year threshold applicable to this category of activities as defined in AMS II.D., version 12, EB 51.

Since the boundary limits of the project are set, there is no possibility of exceeding the limits of 180 GWh_{th} per year for small-scale CDM project activities during the crediting period. The project activity will remain as a small scale project activity.

The calculation for aggregate energy saving per year is shown in the following table:

	Particulars	**Amount**	**Unit**	**Calculation**
A	Estimation of project activity emissions per year	39,630	t CO_2	
B	Estimation of baseline emissions per year	84,287	t CO_2	
C	Estimation of overall emission reductions per year	44,657	t CO_2	= A-B
D	Carbon emission factor for fuel used (IPCC Default value for - Bituminous coal)	25.8	t C/TJ	
E	Carbon to CO_2 conversion factor	3.66	t CO_2/ t C	
F	Aggregate Energy Saving per year	473	TJ	= C/(D*E)
G	Conversion Factor TJ to GWh (= 1000/3600)	0.2777	GWh/ TJ	
H	Aggregate Energy Saving per year	131	GWh_{th}	= (F*G)

10 Extract of paragraph 12 of Simplified Modalities and Procedures for Small-Scale CDM Project Activities.

11 28. Decides to revise the definitions for small-scale clean development mechanism project activities referred to in paragraph 6 (c) of decision 17/CP.7, as follows:

(a) Type I project activities shall remain the same so that renewable energy project activities shall have a maximum output capacity of 15 MW (or an appropriate equivalent).

(b) Type II project activities or those relating to improvements in energy efficiency which reduce energy consumption on the supply and/or demand-side, shall be limited to those with a maximum output of 60 GWh per year (or an appropriate equivalent).

(c) Type III project activities, otherwise known as other project activities, shall be limited to those that result in annual emission reductions of less than or equal to 60 kt CO_2 equivalent.

2. *Confirms to one of the project categories in Appendix B of Annex II.*

The project activity conforms to “Type II” and “Category D” project activity in Appendix B of Annex II. Justification has been provided in Section A.3.

Specifically, the applicability of the methodology AMS II.D, version 12, EB 51 is shown as follows:

The applicable conditions for AMS II.D, version 12	**The Proposed Project Activity**
This category comprises any energy efficiency and fuel switching measures implemented at a single or several industrial or mining and mineral production facility(ies). This category covers project activities aimed primarily at energy efficiency; a project activity that involves primarily fuel switching falls into category III.B.1 Examples include energy efficiency measures (such as efficient motors), fuel switching measures (such as switching from steam or compressed air to electricity) and efficiency measures for specific industrial or mining and mineral production processes (such as steel furnaces, paper drying, tobacco curing, etc.).	Manufacturing of burnt clay bricks is an industrial activity that requires thermal energy inputs for the purpose of sintering. Fossil fuel is combusted to provide the required amount of thermal energy for sintering the clay bricks, which results in CO_2 emissions. The project activity involves installation of 6 energy efficient HHKs at 6 new industrial facilities for achieving energy efficiency through reduction in fuel (coal) consumption when compared to that of the baseline kilns. The project activity perfectly fits into the category of activities defined for the methodology.
The measures may replace, modify or retrofit existing facilities or be installed in a new facility.	Since the project activity involves installation of energy efficient HHKs at several new industrial facilities, it conforms to the relevant criteria.
This category is applicable to project activities where it is possible to directly measure and record the energy use within the project boundary (e.g., electricity and/or fossil fuel consumption).	In case of the project, the use of primary fossil fuel (coal) for brick production, electricity and diesel consumption to operate plant equipment (if any) can be directly measured and recorded in the plant premises as per the standard monitoring procedure. As HHKs mainly consume thermal energy for brick making, the project will measure this energy use through monitoring the quantity and type of fuel used (coal) along with their calorific values. The annual coal, diesel and electricity consumption will be directly measured by using relevant measuring devices / instruments. Invoices from supplier and electricity bills will be used to cross check the above. The detail of metering and monitoring the energy consumption are provided in section B.7.1

This category is applicable to project activities where the impact of the measures implemented (improvements in energy efficiency) by the project activity can be clearly distinguished from changes in energy use due to other variables not influenced by the project activity (signal to noise ratio).	In the project activity case, the reduction in the coal consumption is significant (approximately 50% of the baseline) and the reduction is achieved only by following energy efficiency measures: - Mixing of pulverized coal into the wet clay in each brick which then bakes the brick from the inside. - Improved heat retention in the kilns to capture waste heat for recirculation in the drying tunnel.

3. Not be a debundled component of a larger project activity, as determined through Appendix C of Annex II.

Justification has been provided in Section A.6.

Therefore, the project activity meets the 'Small-Scale CDM Project Activities' applicability criteria.

B.3. Project boundary

AMS II.D, version 12, EB 51, defines the project boundary as the physical and geographical site of the industrial facility, processes and equipment that are affected by the project activity. In the case of the proposed project, the HHK technology will be operationalized within the kiln premises. The affected process is the brick firing activity at the kiln of a brick making plant. The HHKs will be installed within the brick kiln premises.

The project boundary is thus defined as the physical, geographical area of each of the six brick production facilities, where, HHK technology based kilns will be installed.

The sources of anthropogenic GHGs outside the project boundary include, the CO_2 emissions associated with the transport of raw material, finished product and emissions associated with the transport and usage of fuel and the usage of electricity in the automated processes of the system. Emissions occurring outside the project boundary with regard to transport are ignored in the approved methodology, as they occur both in the baseline as well as in the project. The transport of raw materials such as clay, coal and water, are unaffected by the project and possibly even reduced, as the process of making green bricks becomes more efficient. Each unit of HHK facility will produce about 7.5 times more bricks than the conventional brick facilities and at a centralized location close to good transport routes. Power used to support the brick production process and related facilities are included as project emissions[12].

[12] Based on the currently operating project HHK plant, annual electricity consumption is 270 MWh per single sized HHK per annum. Grid emission factor of the National grid of Bangladesh for most recent period of 2007- 2009, approved by DNA of Bangladesh is 0.62 t/CO_2 p/a per MWh. Emissions due to electricity consumption for all 6 kilns (4 single and 2 double sized HHK) per annum would be, grid emission factor of 0.62 t/CO2 p/a per MWh x 270 MWh x 8 = 1,339.20 t/CO_2 p/a

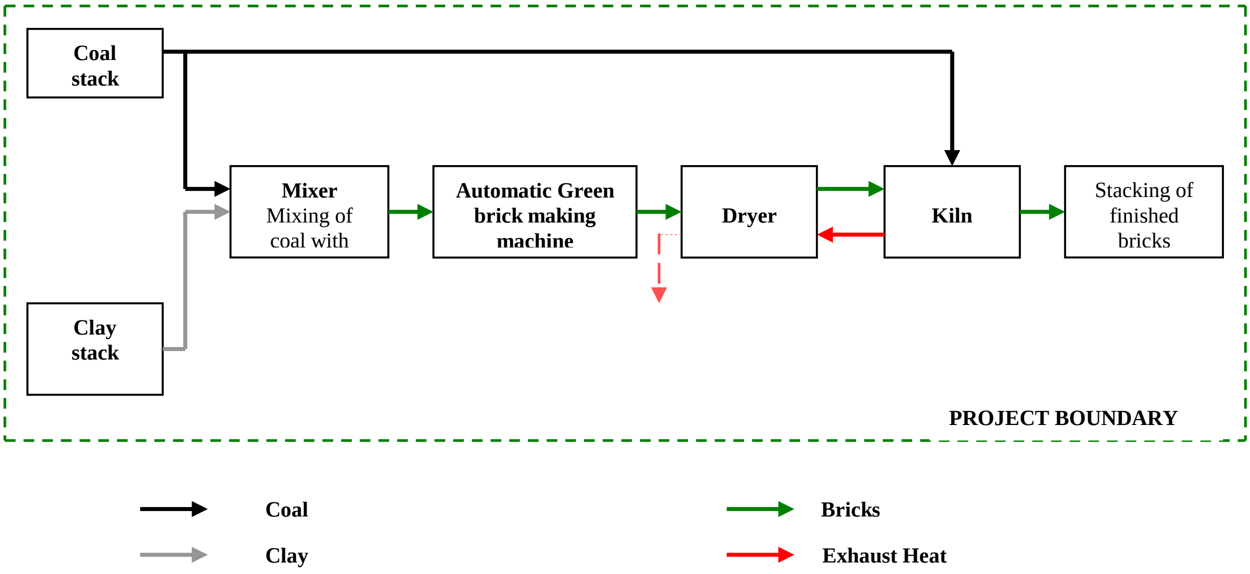

Figure 4: Project Boundary

B.4. Establishment and description of baseline scenario

As per AMS II.D., version 12, EB 51, "the energy baseline consists of energy use of the existing equipment that is replaced in the case of retrofit measures and of the facility that would otherwise be built in the case of a new facility". The proposed project establishes new and more efficient brick making kilns. Therefore, the energy use and corresponding emissions from the less energy efficient brick making kilns that would otherwise have been built and operated in the absence of the project activity, is considered to be the baseline scenario technology.

Technology Baseline

Currently, the brick making sector in Bangladesh uses four types of technologies which are described in greater detail in Appendix 4[13]: Fixed Chimney Kilns (FCK), Bull's Trench Kilns (BTK), Zigzag Kilns, and traditional Hoffman Kilns. Prior to 2004, most of the kilns in Bangladesh used the BTK design, a relatively primitive design that is over 150 years old. It is highly polluting and exceedingly inefficient in terms of fuel use because of its poor design resulting in crevices forming in the kiln walls. These leaks allow excessive air intake, which results in poor combustion. Moreover, there is considerable heat loss through the kiln walls.

The market share for BTKs, in 1995, was 95%. After promulgation of the Brick Burning (Control) Act in 2004, almost all of the BTKs were converted to FCKs. This is due, in part, to the requirement that brick kilns must have a fixed chimney with a minimum height of 120 feet. The FCK design is slightly more energy efficient than the BTK whilst particulate emissions are similar.

Zigzag or Hebla kiln was slowly gaining popularity in the 1990's. It costs the same to construct as an FCK and initially was expected to be slightly more energy efficient than FCKs. However, due to dependency on Indian experts and informal dispersion of the technology, after a decade they make up

[13] Based on UNDP Project Document, titled "Bangladesh - Improving Kiln Efficiency in the Brick Making Sector", August 2006) Page 2

less than 5% of the kilns in Bangladesh[14]. Moreover, many Zigzag kilns operating in Bangladesh have not been constructed according to the design standard and several zigzag designs exists in the sector as the entrepreneurs had to rely on their own experts and interventions. Therefore, no specific zigzag type kiln could be considered as a model or the baseline kiln for comparative purposes.

There are only less than 30 Hoffman gas kilns, which is essentially a gas fired version of the HHK, in Bangladesh, for several reasons such as: lack of gas availability in areas where brickfields are located; high cost to finance these kilns and government policies discouraging the use of gas for the brick industry in order to use it for power generation. The 2006 market share of the different brick kiln technologies in Bangladesh is presented in
Table **2** below. The FCK market share is about 76%[15]. Therefore, the FCK has been selected as the baseline technology since it is the most common practice and meets legal requirements.

Table 2*:* 2006 Market Share of Technologies in the Brick Making Sector.

Kiln type	Number	Percentage of total	Annual brick production (billions)	Percentage of total production
FCK	3,123	75.4	9.4	75.8
BTK	794	19.2	2.0	16.1
Zigzag	197	4.8	0.7	5.7
Hoffmann (Gas)	26	0.6	0.3	2.4
Total	**4,140**	**100**	**12.4**	**100**

Energy baseline

Coal for brick making has, until most recently, been imported into Bangladesh from coalmines in the Indian state of Assam, Meghalaya and West Bengal, mainly through Hilli, Haluaghat, Srimongal and Burimari border land ports. It is sold to brick manufacturers directly from the border land ports or brought to major coal distribution centres such as Dhaka and Bhairab. Current information on Indian coal data shows that the Calorific value of coal from Meghalaya is in the range of 6,500 to 7,500 kCal/kg[16] and coal from Assam is in the range of 5,240 to 7,950 kCal/kg[17].

A UNIDO study in 1980 and an SDC-SCAT study in 1991 on the brick making sector in Bangladesh established the specific fuel consumption as 0.25 kg coal per brick and Calorific value (heat value) as 24.2 MJ/brick. It also showed the Specific Energy Consumption as 6.05 MJ/brick[18]. From these data,

[14] UNDP Project Document, titled "Bangladesh - Improving Kiln Efficiency in the Brick Making Sector", October, 2009, Page 102 http://www.thegef.org/gef/sites/thegef.org/files/repository/Bangladesh_10-20-2009-ID1901_Improving_Kiln_Efficiency.pdf

[15] Refer to report titled: Clean Development Mechanism Project Opportunities in Bangladesh, Pre Feasibility Report on a Brick Manufacturing Fuel Substitution CDM Project, Bangladesh University of Engineering, December 2002, Table A, pg 3, which discusses kiln types: http://pubs.pembina.org/reports/cdm_bangladesh_brickkilns.pdf.

[16] http://meghalaya.nic.in/industry/opens.htm

[17] http://db.nedfi.com/content/coal-deposits-assam

[18] Refer to report titled : Status and development issues of the brick industry in Asia, FAO Field Document no.35, Table 1.7, page 10, which discussed energy input in bricks: http://144.16.93.203/energy/HC270799/RWEDP/acrobat/fd35.pdf

Specific Energy Consumption per kg brick production can be derived as 2.1 MJ/kg-brick for conventional sized bricks of 2.9 kg/brick.

However, to update the present energy baseline, further review of the baseline was undertaken for the project.

Coal consumption figures for FCK are based on the following studies undertaken between 2002 and 2009:

⇒ In 2002, Bangladesh University of Engineering and Technology (BUET) prepared the "Clean Development Mechanism Project Opportunities in Bangladesh, Pre-Feasibility Report" on a Brick Manufacturing Fuel Substitution CDM Project, including a survey of coal consumption of different brick making technologies in Bangladesh. The survey showed consumption of 22-26 tons for production of 100,000 bricks.

⇒ In 2006, the UNDP-GEF project was initiated to transform the brick industry towards cleaner technologies and practices19. Under the project, a survey of coal consumption of FCK was carried out. The survey established specific fuel (coal) consumption as 24 tons of coal per 100,000 bricks, which affirmed the coal use of 22-26 ton per 100,000 bricks reported in the previous 2002 BUET Study.

Calorific value of coal and Specific Energy Consumption figures for FCK are based on the following studies undertaken between 2002 and 2009:

⇒ Both the BUET report in 2002 titled as "Clean Development Mechanism Project Opportunities in Bangladesh, Pre-Feasibility Report" and the UNDP-GEF project report in 2006 used the default IPCC data for calorific value to calculate the baseline emission. Using 24 ton coal consumption per 100,000 bricks and the default IPCC value for Indian coal at 4,000 kCal/kg [20], the UNDP-GEF project reported a lower specific energy consumption figure than the Baseline established under FAO report.

⇒ In 2008 and 2009, upon becoming aware that higher calorific values were being reported for Indian coal, the calorific values of coal, used by FCK was laboratory tested by the project[21]. The results indicated a calorific value of 6,400 kCal/kg coal, which is close to the values stated in the websites of Indian coal suppliers[22]. This result justifies the use of high calorific value rather than using the IPCC default value. The specific energy consumption of FCKs, using 6,400 kCal/kg and 24 ton coal per 100,000 bricks is thus raised to 2.21 MJ/kg-brick or 6.4 MJ/brick for a 2.9 kg conventional sized brick.

Though Indian coal has a high calorific value (5,240 kCal/kg to 7,950 kCal/kg), it has a high sulphur content. Consequently, the Bangladesh Ministry of Environment and Forest and Ministry of Commerce, promoted less import of Indian coal[23] and use of the high quality Bangladesh Barapukuria coal, which is

[19] Improving Kiln Efficiency for the Brick Making Industry - PDF B Phase (UNDP-GEF-BGD/04/014) Emission Baseline Report for the IKEMBI Project

[20] Emission Baseline Report for the IKEMBI Project (PDF-B Phase BGD/04/14) by the Louis Berger Group, Washington DC, June 2006

[21] Coal calorific tests conducted by BUET, BSCIR and Powertech Labs, Surrey Canada. Results showed that in 2008, the FCK operating primarily used Indian coal imported from Meghalaya with a calorific value measured at 6,400 kcal/kg. In 2009, a number of these FCK businesses switched coal supplies from India to Boropukuria (near Dinajpur in north-western Bangladesh). Coal measured from Boropukuria has a value of 6,135 kcal/kg.

[22] Refer to the following websites: http://meghalaya.nic.in/industry/opens.htm; http://db.nedfi.com/content/coal-deposits-assam

[23] http://www.bizbangladesh.com/business-news-2436.php

now in surplus. Consequently, domestic coal from the Barapukuria coal mine in north western Bangladesh near Dinajpur is now being used for brick making. The calorific value of this coal is laboratory tested at 6,135 kCal/kg[24].

In summary, for purposes of establishing an energy baseline, the calorific value of Barapukuria coal is taken as 6,135 kCal/kg and the specific coal consumption of 24 tons per 100,000 bricks is used. Using these values, the specific energy consumption (for conventional size FCK bricks) is as follows:

Table 3: Energy Consumption of FCK Technology

Calorific value of coal	6,135 kCal/kg
Coal consumption per 100,000 bricks (conventional size)	24 tons
Specific fuel consumption per brick	0.24 kg coal / brick
Specific energy consumption per brick (conventional size)	6.16 MJ/brick
Specific energy consumption per kg of brick (conventional size)	2.125 MJ/kg -brick

Note: Specific energy consumption per kg brick is calculated for conventional sized brick of 2.9 kg

The energy baseline established above according to the current scenario has strong resemblance to the FAO report.

Emission baseline

The emissions baseline is the historic fuel consumption times the CO_2 emission coefficient for the fuel displaced. As discussed above, for existing brick fields in Bangladesh, the coal used is sourced either from India or from the Barapukuria coal mine in northwestern Bangladesh and these coals are bituminous type coal. The Inter-governmental Panel on Climate Change (IPCC) default value for the carbon emission factor for Bituminous coal is 25.8 tons C/TJ and this value is used in the calculations.

To derive CO_2 emissions per kiln, the data shown in Table 4 have been used.

Table 4: Parameters used to derive CO_2 emissions per FCK kiln

Calorific value of coal	6,135 kCal/kg
Coal consumption per 100,000 bricks (conventional size)	24 tons
Specific energy consumption	2.125 MJ/kg-brick or 6.16 MJ/brick
Carbon emission factor for fuel	25.8 tons tC/TJ
Carbon to CO_2 conversion factor	3.66 t CO_2/ tC

Date of completing the final draft of this baseline section is 03/13/2009.

[24] www.bcmcl.org.bd

B.5. Demonstration of additionality

According to Attachment A to Appendix B of the Simplified Modalities and Procedures for CDM Small Scale Project Activities, project participants are required to provide an explanation to show that the project activity would not have occurred anyway due to at least one of the following barriers:

a) *Investment barrier: a financially more viable alternative to the project activity would have led to higher emissions;*

b) *Technological barrier: a less technologically advanced alternative to the project activity involves lower risks due to the performance uncertainty or low market share of the new technology adopted for the project activity and so would have led to higher emissions;*

c) *Barrier due to prevailing practice: prevailing practice or existing regulatory or policy requirements would have led to implementation of a technology with higher emissions;*

d) *Other barrier: without the project activity, for another specific reason identified by the project participant, such as institutional barriers or limited information, managerial resources, organizational capacity, financial resources, or capacity to absorb new technologies, emissions would have been higher.*

The project activity faces one or more barriers as defined in Attachment A to Appendix B of the *Simplified Modalities and Procedures for Small-scale CDM Project Activities*

Under "*Guidelines for Objective Demonstration and Assessment of Barriers*", version 01.0, EB 50, the guideline 7 states that "*For projects in Least Developed Countries*[25] *it is sufficient to transparently describe the relevant barriers, as less stringency is needed with regards to data availability in the actual demonstration of barrier, as compared to the projects in other countries. Projects in Least Developed Countries are not bound by the provisions in this guideline and may use other approaches that are more adapted to the local circumstances*".

The Rationale under Guideline 7 suggests that projects in least developed countries can be assumed in general to face significant barriers to their implementation. At the same time, data availability in these countries is considerably limited which complicates the demonstration of additionality and therefore further increases transaction costs. Bangladesh falls under the category of Least Developed Countries as listed by the United Nations General Assembly [26]. Accordingly the barriers to this project are transparently described below based on available information, thereby satisfying Executive Board requirements.

The barrier analysis demonstrates that a large number of barriers have so far inhibited the adoption of cleaner brick making technologies and that without the project activity; business as usual will continue to prevail. Under business as usual, CO_2 emissions will be higher than under the project. The project activity therefore meets the first additionality test.

Barriers faced by the project are described below:

Investment Barrier:

[25] As defined by the United Nations General Assembly in its resolutions (59/209, 59/210 and 60/33) and its updates.
[26] http://unfccc.int/files/cooperation_and_support/ldc/application/pdf/ldc-list-31jan08.pdf

The investment barrier is used to demonstrate that the project activity has at least one alternative which is financially more attractive than the project activity and hence leads to higher emission.

The possible alternatives to the project activity are as follows:

1. Invest in HHK without CDM
2. Invest in FCK
3. Invest in other technologies

Since FCK technology is established as the baseline, the financial attractiveness of the project activity is compared with only alternative 1 and alternative 2.

It is demonstrated below that the Internal Rate of Return for the project activity (project IRR) and also the equity IRR is lower than that of an average FCK technology brick field (baseline) and the Pay Back period of the project activity is higher than an average FCK technology brick field. Project activity if implemented without CDM has lower project IRR and higher pay back period than a project activity implemented with CDM.

Description of the Investment Analysis:

"Tool for demonstration and assessment of additionality" (Version 05.2) Step -2 option A was chosen for investment analysis.

Sub-step 2a: Determine appropriate analysis method

(1) Determine whether to apply

Option 1: simple cost analysis
Option 2: investment comparison analysis
Option 3: benchmark analysis

Since the project activity generates financial or economic benefits (revenue from brick sale) other than CDM related income, Option 1 cannot be taken. Option 2: Investment comparison analysis is chosen to demonstrate the investment barrier.

Sub-step 2b: Option II. Apply investment comparison analysis

The financial indicators to compare financial attractiveness of the project activity with its alternatives are:

1. Project IRR
2. Payback period

The reason for choosing payback period as one of the financial indicator is that the risk averseness of majority of the entrepreneurs of the country made it a very popular and commonly used tool in the investment decision making.

Sub-step 2c: Calculation and comparison of financial indicators

The PDD financial analysis is as follows:

- The CDM project was initiated by IIDFC in October 2005 with the submission of first PIN to the World Bank. However, IIDFC made the first financial analysis on HHK during its first HHK project finance to Diamond Auto Bricks in 2007. Since IIDFC had no realistic data on HHK during the first project finance investment decision making to Diamond Auto Bricks, the assumptions of the analysis were based on available data. In this connection, it is mentionable that IIDFC decided to finance HHK technology brick fields after approval of the PIN and signing the first LOI with the World Bank which substantiates strong CDM consideration prior to the investment decision.

- Investment analysis of FCK brick field technology using the data obtained in 2005 from a survey on 17 Fixed Chimney Kiln brick fields under the UNDP project showed that an average capacity FCK technology brick field has an Internal Rate of Return as 57%.

- However, financial analysis of Diamond Auto Bricks was done in 2007 during the investment proposal appraisal. The analysis was based on 5 years lending period. From the analysis, considering 10 years equivalent project cash flow, the project IRR could be derived as approximately 30%.

- Due to lack of data availability for both baseline technology (FCK) and as well as HHK technology (reliable and actual HHK data), investment comparison at the same point of reference was not possible. However, since at present a few HHK kilns have been stabilized, after facing substantial teething problems for almost two years and adopted the technology locally, actual HHK and FCK data is available. The actual cost of the project and other assumptions on HHK substantially varied from the initial assumptions. Meanwhile, the raw material prices along with other costs have substantially increased. Hence the financial analysis is revised based on the actual data.

- The financial comparison analysis was made between one single sized HHK of 50,000 daily bricks production capacity and an average capacity FCK of 25,377 bricks per day. With the cost of one HHK, 15 FCK can be built. If financial comparison is made between one HHK and 15 FCKs combined (equal size investment approach) results will show even less investment attractiveness for HHK.

- On the other hand, if we consider obtaining equal production capacity; to install 15 million annual brick capacity in HHK technology, the amount required is BDT 146 million whereas the cost required for installing similar brick production capacity in FCK technology is approximately BDT 38.6 million only. With the investment to construct a single HHK, one can install 4 times more capacity in FCKs than a single HHK. By any means comparing a single HHK to a single FCK is the most conservative approach.

The current assumptions based on actual and present data are as follows (<u>the rest of the assumptions are same for baseline and project activity and provided in the workbooks):</u>

Table 5: Parameters of the investment analysis

			FCK (1 kiln)	**HHK (1 kiln)**
		Unit	Value	Value
A	**Project Cost**	BDT	9,617,955	146,480,446
	Land and land development	BDT	Rented Land	26,000,000
	Kiln and other civil construction	BDT	1,943,500	37,200,000
	Machineries	BDT	199,083	61,311,711

			FCK (1 kiln)	HHK (1 kiln)
	Working capital	BDT	5,659,705	9,262,000
B	**Means of Finance**			
	Debt	Percentage		60%
	Equity	Percentage	100%	40%
C	**Production**			
	No of working days in a year	days	177	330
	Daily production capacity	bricks	25,377	50,000
	Annual production capacity average	bricks	4,483,333	16,500,000
	Capacity utilization	%	85-95%	60%-80%[27]
	Average brick price	BDT	5.26	5.96
D	**Raw material and Fuel**			
	Clay price	Tk/cft	10	10
	Sand price	Tk/cft	6	6
	Coal price	Tk/ton	7,500	7,500
	Diesel price	Tk/litre	45	45
	Clay consumption per brick	cft	0.10	0.125
	Coal consumption per brick	gm	240	130
	Sand consumption per brick	cft	1.00E-04	-
E	**Manpower**			
	Total employment	No.	150	96
	Permanent employee	No.	7	96
	Administrative employee	No.	7	14
	Factory workers	No.	143	82
F	**Inventory**			
	Clay stock required	Days	90	120
	Coal Stock required	Days	30	60

[27] Last two years actual capacity utilization in the operating kilns has been considered.

			FCK (1 kiln)	HHK (1 kiln)
G	**CER Revenue**			
	CER per brick 1st and 2nd year	CER/brick		3.67E-04
	CER per brick -3rd year onwards			3.87E-04
	CER price	Tk/CER		532

The outcome of the final investment analysis

The result of the investment analysis is provided in the following table 6, where it is clear that at least one alternative to the project activity is more financially attractive than the project activity.

Table 6: Outcome of the investment analysis

	FCK	HHK	
		Without CER	With CER
Project IRR	40%	14%	16%
Equity IRR	40%	32%	35%
Pay Back Period	2.26	7.21	6.56

Sensitivity analysis

A sensitivity analysis has also been carried out to check the sensitivity of the project IRR to the assumptions, considering a 10% variation. The results are presented in Table 7.

Table 7: Sensitivity analysis

Variables	IRR at -10% variation			IRR at + 10% variation		
	FCK	HHK without CER	HHK with CER	FCK	HHK without CER	HHK with CER
Kiln, dryer & other civil works	41%	14%	16%	39%	13%	15%
Main machinery & equipment		15%	17%		13%	15%
Total investment	44%	16%	12%	36%	12%	14%
Clay price		15%	17%		12%	15%
Coal rice		15%	17%		13%	15%

Variables	IRR at -10% variation			IRR at + 10% variation		
	FCK	HHK without CER	HHK with CER	FCK	HHK without CER	HHK with CER
Sales price				61%	19%	21%

In all cases, the project IRR of the project with or without CER revenues would be below the IRR of the baseline FCK technology by an substantial margin even in the case of significant (±10%) variations of the input parameters.

Based on this analysis, it can be considered that the project activity is not the least cost option and there is at least one financially more attractive alternative (the baseline FCK technology) which would lead to higher emissions. Therefore, the project is additional.

Technology Barriers

According to the "*Guidelines for Objective Demonstration and Assessment of Barriers", version 01.0, EB 50,* guideline 3, the existence of the technology barrier for HHK technology is confirmed from the evidence that the use of the HHK technology in the sector is marginal e.g. below 10%. The market share of the HHK technology was zero when the CDM project Activity was undertaken and after more than 3 years, despite serious effort of IIDFC to promote this technology through CDM, the market share of the HHK technology is still very marginal (0.2%). Most importantly, no other HHK in Bangladesh has been implemented outside the CDM projects undertaken by IIDFC[28]. The current market share is as follows:

Table 8: Slow market penetration of HHK confirms the existence of Technology Barriers

Kiln Type	Number (Range)	Use of Technology as Percentage of Total
FCK	≤ 4500	92.21%
BTK	N/A	0.00%
Zigzag	≤ 150	3.07%
Hoffman – gas	≤ 20	0.41%
HHK	≤ 10	0.20%
Others	≤ 200	4.10%
Total	**≤ 4880**	**100%**

Source: Department of Environment, Bangladesh Government-Memo no: DOE/Enforcement/37

Barriers due to prevailing practise[29]

[28] Department of Environment, Bangladesh Government, Memo no: DOE/Enforcement/37.

[29] First of its kind barrier would be used if the CDM EB definition was not defined to only be applicable to the first project kiln rather than the first PDD. Ie the assumption that once one project has been successfully

One of the main barriers in the implementation of HHK technology is that the prevailing baseline technology is well known, easily implemented and financed and hence it remains as the common practice.

Whilst it may at first appear that the import and implementation of brick kiln technology would be simple, in a country with over 4,000 brick kilns, there are a number of significant barriers which need to be overcome. The baseline technology is clearly easily implemented whereas the project technology is not easily implementable. Some of these barriers were recognized upfront whilst others have emerged during the preparation and constructions of the kilns in this PDD, questioning the viability of the project.

Currently, HHK plans/technical drawings are provided from China. Chinese specialists, supported by local engineers are required to supervise the kiln site preparation, construction and firing up of the first brick kilns. Local engineers and workers do not have and have not acquired the knowledge or experience to perform these tasks. This creates a significant constraint in diffusing the technology as baseline brick kiln owners are not able to implement the technology without external support. Even the import of the few engineers and fire masters from China has faced practical problems. These have included visa entry difficulties, language difficulties and ensuring sufficient technical staff as and when needed. Under the baseline, the technology is readily applied and readily trained staff and labor exists.

Much of the electrical equipment and mechanical equipment required for operating the HHK needs to be imported. This adds to transaction costs as does the procurement and import process, possible delays and need to pay import duties. The reliance on imported equipment has resulted in the construction of 1 kiln (Diamond Kiln) being delayed as some of the equipment was missing from the shipped container[30]. Under the baseline technology, no imports are required as indigenous technology is used.

Also, the plant design could not be directly transferred from China without modification to local operating conditions. It has been learnt that the difference in soil conditions between Bangladesh and China needs to be considered. For instance, plants at SSL[31] and Diamond kiln developed cracks as the foundations were built assuming similar hard soil conditions in China, which is not the real case. Whilst it is believed that these have now been fixed, it remains to be seen whether the problem will re-emerge or impact plant operations. In another kiln the drying tunnel flooded as it was not foreseen that the high water table in Bangladesh would cause flooding. Experience now demonstrates that drying tunnels need to be built above and not below ground level to avoid flooding. The first kiln which was constructed, Universal, was completely flooded in the first monsoon season, bringing operations to a halt as it was built on low lying ground due to incorrect site location by the Chinese experts, unfamiliar with local conditions. It is believed that this has been remedied through appropriate earth works. It has also been found that additional doors need to be constructed in the firing chambers in Bangladesh HHKs as the outside temperature is hotter than in China. These are needed for ventilation purposes for workers to be able to enter the firing chamber when the bricks need to be stacked for firing and then removed. Time will tell whether Bangladesh workers are able to load and unload as many bricks each day from the kilns as in China.

The timeline below also demonstrates that the first HHK (Universal) took 14 months to construct whereas the expected norm is meant to be 3 - 4 months. At present, there is no historical record to demonstrate that the HHK can be designed and operated to the China standards. The only reasonably reliable brick production data is from the Universal kiln and Diamond Auto Bricks which is believed to have now been stabilized.

[30] Personal comment, Diamond Kiln owner.

[31] SSL kilns later removed from bundle through PRC

On the investment side, there is only an emerging track record to demonstrate the actual costs of designing, constructing and operating the HHK. HHK kilns are considerable more costly than baseline kilns to construct. The cost of a baseline FCK is approximately US$ 100,000 – 150,000 excluding land where as the forecasted cost of a single unit HHK was US $1,000,000. The actual costs are now estimated by IIDFC to be closer to US $ 2,000,000. Kiln owners have said that the actual costs of the kilns are twice as high as forecast[32]. The increased cost has made the Sunflower kiln to limit its investment plan to a single sized kiln spending the same amount of money with which was originally planned to construct a double sized kiln.[33] The only reason that they report that they are able to continue with the projects are because they either have no choice, having made significant personal investments which now need to be recovered, or they have other solid business interests or they like the idea of introducing cleaner brick production and are encouraged by the concept of the CDM and the carbon revenues which may be generated if the project is registered.

Due to the above risks and barriers, the first wave of HHK owners are not from the brick making sector as the regular FCK owners lack the financial resources and appetite to take the risks inherent in investing in new and unproven technology[34]. In fact, a study on the Bangladesh brick making industry notes that old technology kiln owners are locked into a vicious cycle of low incomes and are unable to afford to introduce new brick kiln technology[35]. Therefore, it is hoped that the revenues earned from the CDM will help to offset these barriers. This lack of experience amongst HHK owners has created its own set of issues as it is possible that some of the construction problems discussed previously may have been avoided if FCK owners were involved in this pilot phase. The technology and project difficulties associated with the first kilns, coupled to higher than planned investment costs, do not help to encourage the technology. Despite these difficulties, the few entrepreneurs comprising this PDD are willing to take the risk of piloting the new technology, partly based on an expectation of being able to earn carbon revenues.

Other Barriers at the Project Participant level:

On the project participant/bundling agent (IIDFC) side, there are also significant institutional and financial barriers to be overcome.

Only 2 CDM projects were registered in Bangladesh at the time of request for registration of this project. IIDFC does not have prior experience in the brick kiln sector or in the CDM. As a result, it had to employ 2 staff members specifically for this project and the relevant experience has to be acquired in the brick sector and in CDM. The revenues which may be generated by the CDM are expected to partly offset these costs.

On the investment side, IIDFC is not able to finance the investment requirements of all brick kiln owners due to its size and need and risks associated with investment in a new sector. It is only able to finance 3 brick kilns with financing provided by other institutions. The income which IIDFC will derive from the CDM will be shared with the brick kiln owners in the ratio of 50% for IIDFC and 50% for brick kiln owners in the first 2 years and in the ratio of 40% (IIDFC) and 60% (brick kiln owners) in the remaining 8 years of the crediting period i.e., CDM revenues are not able to directly assist IIDFC to overcome the investment barrier itself – it only assists IIDFC to make the technology known to other financing

[32] Personal comment from more than 3 HHK owners.
[33] IIDFC Board Memo: Sunflower Bricks and Construction material Ltd.-Revival of the suspended loan facility for completion of the project, Page 1&2.
[34] Refer to "Improving Kiln Efficiency for the Brick Making Industry. October, 2009 http://www.thegef.org/gef/sites/thegef.org/files/repository/Bangladesh_10-20-2009-ID1901_Improving_Kiln_Efficiency.pdf
The report describes the throughout barriers which the brick industry faces on converting to cleaner technology.
[35] BUET, 2002, "Fuel Substitution in Brick Manufacturing", Report prepared for the TERI-Canada Energy Efficiency Project, www.pembina.org.

institutions thereby helping them to decide whether or not to invest in this sector. The results of these efforts have over the last 12 months resulted in very modest investment as can be demonstrated by IIDFC through the high attrition rate of brick kiln owners expressing interest in the project and finally constructing an HHK[36].

Finally, the difficulty which IIDFC has had in retaining kiln owners in this version of the PDD is demonstrated through a review of the first version of this PDD advertised for global stakeholder consultations on 27/10/2007. Since the first version of the said PDD, 5 kiln owners have dropped out of the project[37] due to various barriers which could not be overcome - including financial barriers. Whilst the kiln owners have been replaced, the project commissioning schedule and validation process has slipped by over 12 months. IIDFC has also had to invest significant management and staff time recruiting the new kiln owners into the project. This translates into additional costs and loss of CDM revenues.

Project activity timeline:

Below is an outline of the CDM project processing timetable that demonstrates the prior consideration of CDM for this project:

- Draft Carbon Finance Assessment Memorandum completed for project: 31/5/2006[38]
- Financial analysis prepared by Bank: 5/6/2006[39]
- PIN reviewed by World Bank: 20/07/2006
- PIN approved by World Bank: 01/11/2006
- Project start date of first HHK (Universal) as evidenced by Sub Contract issued: 20/11/2006
- Construction begins for the first HHK with Universal Bricks: 15/12/2006
- Letter of Intent signed with World Bank: 18/02/2007
- PDD preparation begins: 15/06/2007
- DOE appointed: 23/6/2007
- Global stakeholder consultations (first time): 27/10/2007
- Test firing of first HHK (Universal): February 2008
- ERPA Negotiation: 15/06/2009
- ERPA signed with the World Bank and Danish Ministry of Climate and Energy: 25/08/2009
- Web hosting of the PDD version 12 for Global Stakeholder Consultation (second time): 30/10/2009
- Site Validation request: 3/3/2010

The project start date of various kilns is tabled as below:

Name of Entrepreneur	Project start date
Universal Bricks	20/11/2006
Haair Bricks	28/12/2006

[36] Documents provided at validation to demonstrate the point.
[37] The kiln owners who have exited from the project include: BK Ceramic Bricks, Sun and Rahman, Modern Rotor, Uttara and Comfort Bricks.
[38] Completion of the Carbon Finance Assessment Memorandum indicates that significant prior work including consideration of the CDM was undertaken by the Client and the Bank, Due to elapsed time this paper trail is unavailable. This is the first project record available with the Bank
[39] File name says 02-05 which implies February 2006 – to be conservative actual file save date of 5/6/2006 is used.

Name of Entrepreneur	Project start date
Diamond Auto Bricks	03/06/2007
Kapita Auto Bricks	05/05/2009
Banalata Refractory	14/09/2009
Sunflower Bricks & Construction Materials	11/09/2009

B.6. Emission reductions
B.6.1. Explanation of methodological choices

Type II – Energy Efficiency Improvement Projects. Type AMS II.D: Energy efficiency and fuel switching measures for industrial facilities, version 12, EB 51.

For new facilities, the approved methodology requires the following:

1. Documenting the specifications of the equipment replaced;
2. Metering the energy use of the industrial or mining and mineral production facility, processes or the equipment affected by the project activity; and
3. Calculating the energy savings using the metered energy due to the equipment installed or alternate technology adopted.

The project involves the implementation of energy efficient measures in the form of HHKs at brick manufacturing facilities to reduce the thermal inputs to brick making. As per the approved methodology AMS-II.D (Version 12: EB 51): Energy efficiency and fuel switching measures for industrial facilities, the critical parameter that needs to be monitored is the energy use in the equipment installed. In the case of the proposed project, the critical parameter is the thermal energy use in the HHK. The monitoring method proposed in the project is in line with those described in the type II.D of the small-scale CDM project categories. Therefore, the methodology for monitoring proposed in project type II.D is applicable to this project.

Monitoring and metering the energy use of the equipment installed

The approved methodology AMS-II.D (Version 12: EB 51): Energy efficiency and fuel switching measures for industrial facilities, requires metering of the energy use of the equipment installed. In the case of the project, the use of electricity, coal and diesel consumed to operate plant equipment will easily be metered.

As HHKs mainly consume thermal energy for brick making, the project proposes measuring this energy use through monitoring the quantity and type of fuel used (coal) along with their calorific values. The coal consumed is monitored by measuring the daily coal consumption at the kiln using a digital weighing scale and cross checked using the purchase invoices provided by the supplier. The calorific values will be monitored with each new consignment of coal which will be centrally purchased.

The diesel consumption is monitored by measuring the daily diesel consumption at the kiln using 1/2/5 litre standard measuring cans. The overall diesel consumption can be cross checked against invoices. The electricity is measured by the energy meters installed by the electricity distribution utilities and the monthly electricity bills paid will serve as the records for the same.

The additional parameter that needs to be monitored to enable the estimation of energy savings is the output of the plants in terms of the number of bricks produced. The number of baked bricks produced daily is manually counted after unloading from the kiln after firing and stacking.

It should also be noted that the amount of coal used in the HHK process is dependent on the calorific value of the coal. The amount of heat in the kiln and that injected into the green bricks is a pre-determined number and must be maintained within a reasonable band variation. Too much heat will result in over burnt bricks and too little in un-burnt second grade bricks. It is, therefore, necessary to monitor the calorific value of coal at regular intervals to ensure coal feed amounts.

Calculating the emission reductions of the installed equipment

The emission reductions will be calculated by subtracting the amount of energy used in HHK (project emissions) from the amount of energy that would have been used if the same amount of bricks were produced using FCK technology (baseline emissions).

As per AMS II.D, version 12, EB 51 and "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" version 2, EB 41, Annex 11; 02/08/2008 and "Guidelines for completing the simplified Project Design document (CDM-SSC-PDD) and the form for proposed new Small Scale Methodologies", version 01, EB 66, the following equations will be applied for the estimation of emission reductions for the project activity:

A. Description of formulae used to estimate project emissions

Total Project Emissions in y^{th} year, $PE_{y,}$ by operations of N units of HHK plant is given by:

$$\mathbf{PE_y = \sum_{i=1}^{N} PE_{HHK\ i,y}} \quad \text{..........(1)}$$

Where,

$PE_{HHK\ i,y}$ = Project emissions from operation of i^{th} plant in year y
N = No of HHKs included in the bundle = 6

$$\mathbf{PE_{HHK\ i,y} = (SEC_{i,y} \times TP_{Bricks,i,y} \times CEF_{,coal} \times CF) + (EC_{i,y} \times EF_{CO2,ELEC}) + PE_{FC,j,y}} \quad \text{..........(2)}$$

Where,

$SEC_{i,y}$ = Specific Energy Consumption in plant i (TJ/kg-brick)
$TP_{Bricks,i,y}$ = Total Production of bricks per year in plant i (kg-bricks/year)
$CEF_{,coal}$ = IPCC default Carbon Emission Factor for fuel used (t C/TJ)
CF = Carbon to CO_2 Conversion Factor (t CO_2/t C)
$EC_{i,y}$ = Electricity Consumption in plant i per year (MWh)
$EF_{CO2,ELEC}$ = Grid emission factor of Bangladesh for year 2009 based on figures provided by Bangladesh DNA (t CO_2/MWh)
$PE_{FC,j,y}$ = CO_2 emissions from fossil fuel combustion in process j during the year y (t CO_2/yr) in HHK plant i. This parameter shall be calculated as per the latest version of the "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" where j stands for the processes required for the operation of the HHK plant.

From the monitored data, the specific energy consumption for the individual kilns is calculated using the following formulae:

$$\mathbf{SEC_{i,y} = (TC_{Coal\ i,y} \times NCV_{Coal\ i,y} \ / \ TP_{Bricks,i,y})} \quad \ldots\ldots (3)$$

Where,

$TC_{Coal\ i,y}$ = Total consumption of coal per year for plant i (kg)
$NCV_{Coal\ i,y}$ = Net Calorific value of coal used in y^{th} year in plant i (kJ/kg)

$$\mathbf{TP_{Bricks,i,y} = \sum_{d=1}^{n} (DP_{bricks\ d\ i} \times DMW_{HHK\ brick,d\ I})} \quad \ldots\ldots (4)$$

Where,

$DP_{bricks\ d\ i}$ = Daily production of bricks in kiln i (bricks/day)
$DMW_{HHK\ brick,\ di,}$ = Daily Mean Weight of HHK bricks in Kiln i (kg/brick)
n = Total no. of production days for kiln i in a year

$$\mathbf{PE_{FC,j,y} = FC_{Diesel,j,y} \times COEF_{Diesel,y}} \quad \ldots\ldots (5)$$

Where,
$FC_{Diesel,j,y}$ = Quantity of diesel (fuel type) combusted in process *j* during the year *y* (kilolitre /yr);
$COEF_{Diesel,y}$ = CO_2 emission coefficient of diesel (fuel type) in year *y* (t CO_2/ kilolitre)

The CO_2 emission coefficient $COEF_{diesel,y}$ will be calculated using Option-B of the baseline methodology procedure of the latest version of the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion", depending on the availability of data on the diesel (fossil fuel type), as follows:

$$\mathbf{COEF_{Diesel,y} = NCV_{Diesel,y} \times EF_{CO2,Diesel,y}} \quad \ldots\ldots (6)$$

Where,

$NCV_{Diesel,y}$ = Weighted average net calorific value of Diesel (fuel type) in year *y*(TJ/kilolitre)
$EF_{CO2,Diesel,y}$ = Weighted average CO_2 emission factor of Diesel (fuel type) in year *y* (t CO_2/TJ)

Emission Coefficient:

$EF_{CO2,ELEC,y}$ = Emission factor in year y calculated in accordance with the provisions in AMS I.D, version 15 (t CO_2e/MWh). The value is provided by the Bangladesh Designated National Authority in letter dated 09/02/2011.

Simple OM = 0.626 tCO_2e/MWh

Built Margin = 0.615 tCO_2e/MWh

Combined margin (CM) emission factor is 0.62 tCO_2e/MWh. (50% of each)

B. Description of formulae used to estimate baseline emissions

The emissions from the baseline activity are calculated ex-post using the specific fuel consumption of FCK bricks from BUET report and using specific energy consumption as established in Section B4: Emission and Energy Baseline against the total actual brick production figure (kg-bricks) for the HHKs. The formulas are as follows:

$$BE_y = \sum_{i=1}^{N} BE_{FCK\ i,y} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 7)$$

$BE_{FCK\ i,y}$ = Baseline emissions per year for the i^{th} plant
N = No of HHK units included in the bundle = 6

$$BE_{FCK\ i,y} = TP_{Bricks,\ i,y} \times SEC_{FCK,\ Bricks,} \times CEF_{,coal} \times CF \quad \ldots\ldots\ldots\ldots\ldots (8)$$

Where,
$TP_{Bricks,\ i,y}$ = Total Production of bricks per year in HHK plant i (kg-bricks/year)
$SEC_{FCK,\ Bricks,}$ = Specific Energy Consumption in FCK technology (TJ/kg-brick)
$CEF_{,coal}$ = IPCC default Carbon Emission Factor for fuel used (t C/TJ)
CF = Carbon to CO_2 Conversion Factor

$$SEC_{FCK,\ Bricks} = SFC_{FCK,\ Bricks} \times CV_{Coal,\ FCK} \ / \ M_{FCK\ brick} \quad \ldots\ldots\ldots\ldots\ldots (9)$$
$$= [0.24 \text{ kg coal / bricks} \times (6{,}135 \times 4.186 \times 10^{-9} \text{ TJ/kg})] / 2.9 \text{ Kg /brick})$$
$$= 2.125 \times 10^{-6} \text{ TJ/kg-bricks}$$

Where,
$SFC_{FCK,\ Bricks}$ = Specific Fuel (Coal) Consumption per unit brick production in the FCK technology (kg of coal/100,000 bricks)
= 24 tons coal per 100,000 bricks
= 0.24 kg of coal/brick

$CV_{Coal,\ FCK}$ = Calorific value in the Baseline FCK technology (TJ/kg)
= 6,135 kCal/kg
= $6{,}135 \times 4.186 \times 10^{-9}$ TJ/kg

$M_{FCK\ brick}$ = Weight of FCK brick (kg /brick)
= 2.9 kg/brick

C. Description of formulae used to estimate emission reductions for the project activity

Emission reduction achieved by each HHK plant is calculated by using the formula

$$ER_i = BE_{FCK\ i,y} - PE_{HHK\ i,y}$$

Total emission reduction achieved by all the plants is thus calculated as

$$ER_{Total} = BE_y - PE_y$$

B.6.2. Data and parameters fixed ex ante

(Copy this table for each piece of data and parameter.)

Data / Parameter	**CEF_{coal}**
Unit	t C/TJ
Description	Carbon emission factor per energy unit of coal
Source of data	2006 IPCC Guidelines for National Greenhouse Gas Inventories: Chapter 1: Introduction, Table 1-3; Default values of carbon content, pg.21.
Value(s) applied	25.80
Choice of data or Measurement methods and procedures	Default data from IPCC has been used as Country specific data is not available
Purpose of data	To calculate baseline emissions
Additional comment	Default data from IPCC has been used, as the country specific data is not available.

Data / Parameter	**CF**
Unit	t CO_2e/t C
Description	Carbon to CO_2 conversion factor
Source of data	Not applicable
Value(s) applied	3.66
Choice of data or Measurement methods and procedures	Not Applicable
Purpose of data	To calculate baseline emissions
Additional comment	Not applicable

Data / Parameter	**$EF_{CO2, Elec}$**
Unit	t CO_2e/MWh
Description	Grid emissions factor per MWh of power produced
Source of data	Bangladesh Designated National Authority, letter dated 09/02/2011
Value(s) applied	0.62
Choice of data or Measurement methods and procedures	The Bangladesh designated National Authority which is competent on such matters provided the most recent value to be used in letter dated 09/02/2011.
Purpose of data	To calculate baseline emissions
Additional comment	The value has been fixed ex-ante.

Data / Parameter	**$SEC_{FCK, Bricks}$**
Unit	TJ/kg-brick
Description	Key value in determining the current energy consumption of the existing FCK in Bangladesh
Source of data	Calculation result using equation
Value(s) applied	2.125×10^{-6}
Choice of data or Measurement methods and procedures	In the absence of published data, calorific value of Barapukuria Coal 6,135 kCal/kg (as measured for this project) and coal use of 24 tons per 100,000 bricks were utilized to calculate the Specific Fuel Consumption per kg-bricks in the baseline (FCK) technology.
Purpose of data	To calculate baseline emissions
Additional comment	The value has been fixed ex-ante.

Data / Parameter	**$SFC_{FCK, Bricks}$**
Unit	kg of coal/brick
Description	Specific fuel (coal) consumption (SFC) per unit FCK brick
Source of data	1. Clean Development Mechanism Project Opportunities in Bangladesh, Pre-Feasibility Report on a Brick Manufacturing Fuel Substitution CDM Project, Bangladesh University of Engineering, December 2002, Table A, pg 3: http://pubs.pembina.org/reports/cdm_bangladesh_brickkilns.pdf 2. Emissions Baseline Report for the IKEBMI Project (PDF-B Phase BGD/04/014) by The Louis Berger Group, Washington DC, June 2006, Table 2, pg 3
Value(s) applied	0.24
Choice of data or Measurement methods and procedures	Country specific SFC data for FCK is available and therefore used
Purpose of data	To calculate baseline emissions
Additional comment	Data provided in Appendix 4

Data / Parameter	**$CV_{Coal, FCK}$**
Unit	TJ/kg fuel (TJ/kg coal)
Description	Net calorific value (energy content) per mass unit of a fuel (*Calorific value of the coal used in the Baseline)*
Source of data	www.bcmcl.org.bd
Value(s) applied	6,135 kCal/kg or $6135 \times 4.186 \times 10^{-9}$ TJ/kg
Choice of data or Measurement methods and procedures	Country specific CV data of coal is available and therefore used
Purpose of data	To calculate baseline emissions
Additional comment	Data provided in Appendix 4.

Data / Parameter	$M_{FCK,brick}$
Unit	kg /brick
Description	Weight of a single FCK brick
Source of data	As per IIDFC study titled " Weight of Bricks in Bangladesh, 2009"
Value(s) applied	2.9
Choice of data or Measurement methods and procedures	Average specific weight per unit brick was determined through direct measurement of a substantial number of FCK bricks, by the project.
Purpose of data	To calculate total mass of brick produced per year used for estimating baseline and project emissions
Additional comment	Data provided in Appendix 4. Data available at validation from IIDFC

Data / Parameter	$NCV_{Diesel,y}$
Unit	TJ/kl
Description	Weighted average net calorific value of diesel (fuel type) in year y
Source of data	IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Value(s) applied	0.036509
Choice of data or Measurement methods and procedures	Default data from IPCC is used in the absence of values provided by the fuel supplier in invoices, Measurements by the project participants and regional or national default values.
Purpose of data	To calculate project emissions
Additional comment	In mass unit, the value is 43.3 TJ/Gg or 43.3 MJ/kg . The density used for the conversion is 0.8432 litre/kg .

Data / Parameter	$Density_{Diesel,y}$
Unit	kg /litre
Description	Density value of diesel (fuel type) in year y
Source of data	IPCC default values as provided in Table 11 (pg. 81) of Chapter Energy of the 2002 IPCC Background Papers on Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories
Value(s) applied	0.8432
Choice of data or Measurement methods and procedures	Default data from IPCC is used in the absence of values provided by the fuel supplier in invoices, Measurements by the project participants and Regional or national default values.
Purpose of data	To calculate project emissions
Additional comment	Density = 1/Specific volume. The specific volume published by IPCC is 1,186 kilolitre/Gg or 1.186 litre/kg .

Data / Parameter	$EF_{CO2, Diesel,y}$
Unit	t CO_2/TJ
Description	Weighted average CO_2 emission factor of fuel type i in year y
Source of data	IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories

Value(s) applied	74.8
Choice of data or Measurement methods and procedures	Default data from IPCC is used, in the absence of values provided by the fuel supplier in invoices, measurements by the project participants and regional or national default values.
Purpose of data	To calculate project emissions
Additional comment	Not applicable

B.6.3. Ex-ante calculation of emission reductions

The ex-ante emission reductions are calculated using the method detailed in the following steps. To accommodate the likelihood of entrepreneurs selling bricks of differing sizes to meet market demands, the emission reductions will be measured against energy used per weight or kilogram of a brick.

Calculation of the Project Emissions

Total Project Emissions in y^{th} year, $PE_{y,}$ by operations of N units of HHK plants (N=6) are given by:

$$\mathbf{PE_y = \sum_{i=1}^{6} PE_{HHK\ i,y}}$$

Out of 6 kilns in this PDD, 4 kilns are single sized and 2 kilns are double sized. Considering this the expected project emission, for all 6 kilns in a particular y^{th} year, can be calculated as follows:

= [4,954 t CO_2/year × 4] + [(4,954× 2) t CO_2/year] + [(4,954× 2) t CO_2/year]

= 39,632 t CO_2/year $_{(y)}$

Where, $PE_{HHK\ i,\ y}$ = Project emissions from operation of i^{th} plant in year y

For a double size kiln the annual project emissions is estimated as = (4,954 × 2) t CO_2/year $_{(y)}$

For a single size kiln of daily capacity 50,000 bricks, the annual project emissions are as follows:

Project emissions from operation of i_{th} plant in year y,

$\mathbf{PE_{HHK\ i,y}}$ [t CO_2/year]	=	$\mathbf{SEC_{i,y}}$	**x**	$\mathbf{TP_{Bricks,\ i,y}}$	**x**	$\mathbf{CEF_{coal}}$	**x**	**CF**	+
		[TJ/kg-brick(y)]		[kg-bricks(y)]		[t C/TJ]		[t CO_2/tC]	
		9.54×10^{-7}	**x**	52,500,000	**x**	25.8	**x**	3.66	+
		$\mathbf{EC_{i,y}}$ [MWh]	**x**	$\mathbf{EF_{CO2,Elec}}$ [t CO_2/MWh]	+	$\mathbf{PE_{FC,j,y}}$ [t CO_2/year]			
		270	**x**	0.62	+	57			
	=	4,954		t CO_2/year $_{(y)}$					

Where,

$SEC_{i, y}$ = Specific Energy Consumption in plant i (TJ/kg-brick)
$TP_{Bricks, i, y}$ = Total Production of bricks per year in plant i (kg-bricks/year)
CEF_{coal} = IPCC default Carbon Emission Factor for fuel used (t C/TJ)
CF = Carbon to CO_2 Conversion Factor (t CO_2/t C)
$EC_{i, y}$ = Electricity Consumption in plant i per year (MWh)
$EF_{CO2, ELEC}$ = Estimated CO_2 emissions factor for grid electricity in Bangladesh (t CO_2/MWh)
$PE_{FC,j,y}$ = CO_2 emissions from fossil fuel combustion in process *j* during the year *y* (t CO_2/yr). in HHK plant i.

From the monitored data, the specific energy consumption for the individual kilns is calculated using the following formulae:

$\mathbf{SEC_{i, y}}$	**=**	$\mathbf{TC_{Coal\ i,y}}$	**x**	$\mathbf{NCV_{Coal\ i, y}}$	**/**	$\mathbf{TP_{Bricks, i, y}}$
[TJ/kg-brick]		[tonnes(y)]		[TJ/kg(y)]		[kg-bricks (y)]
		1,950,000	x	2.57×10^{-5}	/	52,500,000
	=	9.54×10^{-7}	TJ/kg-brick $_{(y)}$			

Where,
$TC_{Coal\ i,y}$ = Total consumption of coal per year for plant i (kg) = 1,950,000 kg
$NCV_{Coal\ i, y}$ = Weighted average net Calorific value of coal used in y^{th} year in plant i (TJ/kg)
$TP_{Bricks,i,y}$ = Total production of bricks per year in kiln i (kg-bricks/year)

Total Production of bricks per year in plant i (single size kiln),

$$\mathbf{TP_{Bricks,i,y}} = \sum_{d=1}^{n} \left(\mathbf{DP_{Bricks,di}} \times \mathbf{DMW_{HHK\ brick,di}} \right)$$

[kg-bricks/year] [nos] [kg/brick]

$$= \sum_{1}^{300} (50,000 \times 3.5)$$

$$= 52,500,000 \text{ kg-bricks}_{(y)}$$

Where,
$DP_{bricks\ di}$ = Daily production of bricks in kiln i (bricks/day)
$DMW_{HHK\ bricks\ di}$ = Daily Mean Weight of HHK Bricks unloaded from kiln i (kg/brick)
n = Total no. of production days for kiln i in a year

Electricity Consumption in plant i per year (MWh):
EC $_{i,y}$ = 270 MWh

Estimated CO_2 emissions factor for grid electricity in Bangladesh (t CO_2/MWh):
EF$_{CO2,ELEC}$ = 0.62 t CO_2/MWh

CO_2 emissions from fossil fuel combustion in process *j* during the year *y* (tCO2/yr) in HHK plant i.

PE$_{FC,j,y}$	**=**	**FC**$_{Diesel,j,y}$	**x**	**COEF**$_{Diesel,y}$
[t CO_2/yr]		[kl/year]		[t CO_2/ kl]
	=	21	x	2.7
	=	57	t CO_2/year	

Where,
FC $_{Diesel,j,y}$ = Quantity of diesel (fuel type) combusted in process *j* during the year *y* (kilolitre/yr)
COEF $_{Diesel,y}$ = CO_2 emission coefficient of diesel (fuel type) in year *y* (t CO_2/ kilolitre)

CO_2 emission coefficient of diesel (fuel type) in year *y*,

COEF $_{Diesel,y}$	**=**	**NCV** $_{Diesel,,y}$	**x**	**EF** $_{CO2,Diesel,y}$
t CO_2/ kl		TJ/kl		t CO_2/TJ
	=	0.036509	x	74.80
	=	2.7	t CO_2/kl	

Where,
NCV $_{Diesel,,y}$ = Weighted average net calorific value of Diesel (fuel type) in year *y* (TJ/kilolitre)
EF $_{CO2,Diesel,y}$ = Weighted average CO_2 emission factor of fuel type *i* in year *y* (t CO_2/TJ)

The CO_2 emissions resulting from electricity consumption and diesel consumption generated from the operation of each HHK plant is estimated using the electricity and diesel consumption data based on the experience of the Universal Bricks Ltd and Diamond Auto Brick field Ltd which are operational HHK brick fields.

In actual case, the consumption of diesel and electricity may vary from kiln to kiln due to different machinery and diesel generators. The actual data will be monitored for each kiln and will be used to calculate the project emission.

Calculation of Baseline Emissions

The baseline emissions BE_y from the baseline activity, if the equivalent amount of bricks that were produced in the i^{th} plant were to be produced by using FCK technology, are calculated as follows:

6

$$BE_y \; [t\ CO_2/year] = \sum_{i=1} BE_{FCK\ i,\ y}$$

$$= [10{,}536\ t\ CO_2/year_{(y)} \times 4] + [(10{,}536\ tCO_2/year_{\ (y)} \times 2) \times 2]$$

$$= 84{,}288t\ CO_2/year_{\ (y)}$$

Baseline emissions per year for the i^{th} kiln,

$BE_{FCK\ i,\ y}$	=	$TP_{Bricks,\ i\ ,y}$	x	$SEC_{FCK,\ Bricks,\ y}$	x	CEF_{coal}	x	CF
[t CO_2/year]		[kg-bricks(y)]		[TJ/kg-brick]		[t C/TJ]		[t CO_2/t C]
	=	52,500,000	x	2.125×10^{-6}	x	25.8	x	3.66
	=	10,536		t CO_2/year $_{(y)}$				

Where,

$TP_{\ Bricks,\ i\ ,y}$ = Total Production of bricks per year in HHK plant i (kg-bricks/year)
$SEC_{\ FCK,\ Bricks,\ y}$ = Specific Energy Consumption in FCK technology (TJ/kg-brick)
$CEF_{\ coal}$ = IPCC default Carbon Emission Factor for fuel used (t C/TJ)
CF = Carbon to CO_2 Conversion Factor

Calculation of Emission Reductions

Emission reduction achieved by each HHK plant is calculated by using the formula

$ER_{\ i}$	**=**	**$BE_{\ FCK\ \ i,\ y}$**	**-**	**$PE_{\ HHK\ \ i,\ y}$**
t CO_2/year		t CO_2/year		t CO_2/year
	=	10,536	-	4,954
	=	5,582	t CO_2/year	

Total emission reduction achieved by all the plants is thus calculated as:

$ER_{\ Total}$	**=**	**$BE_{\ y}$**	**-**	**$PE_{\ y}$**
t CO_2/year		t CO_2/year		t CO_2/year
	=	84,288	-	39,632

= 44,656 t CO_2/year

B.6.4. Summary of ex-ante estimates of emission reductions

Year	Baseline emissions (t CO_2e)	Project emissions (t CO_2e)	Leakage (t CO_2e)	Emission reductions (t CO_2e)
Year 1 (1 September 2011 - 31 August 2012)	34,678	73,752	0	39,074
Year 2 (1 September 2011 - 31 August 2013)	39,632	84,288	0	44,656
Year 3 (1 September 2011 - 31 August 2013)	39,632	84,288	0	44,656
Year 4 (1 September 2011 - 31 August 2015)	39,632	84,288	0	44,656
Year 5 (1 September 2011 - 31 August 2016)	39,632	84,288	0	44,656
Year 6 (1 September 2011 - 31 August 2017)	39,632	84,288	0	44,656
Year 7 (1 September 2011 - 31 August 2018)	39,632	84,288	0	44,656
Year 8 (1 September 2011 - 31 August 2019)	39,632	84,288	0	44,656
Year 9 (1 September 2011 - 31 August 2020)	39,632	84,288	0	44,656
Year 10 (1 September 2011 - 31 August 2021)	39,632	84,288	0	44,656
Total	**391,366**	**832,344**	**0**	**440,978**
Total number of crediting years	**10 years**			
Annual average over the crediting period	**39,137**	**83,234**	**0**	**44,098**

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

(Copy this table for each data and parameter.)

Data / Parameter	$TC_{Coal\ i,y}$
Unit	Tonnes/year
Description	Total consumption of coal for brick making in brick plant i in year y
Source of data	Measured using digital weighing scale
Value(s) applied	1,950 (estimated value for ex-ante calculation. Actual value will be monitored)
Measurement methods and procedures	The coal consumption at the kiln is measured through counting the number of buckets/sacks of coal consumed per day. A bucket/sack of coal is weighed to determine the weight of a bucket of coal using a digital weighing scale. The coal purchased is also cross verified by the supplier invoice provided with each coal consignment. The records are maintained at the kiln office for the amount of coal consumed, which can be cross checked against the invoices taking into account the balance of coal not consumed for the monitoring period concerned.
Monitoring frequency	Every brick production day
QA/QC procedures	Coal stock at the end of each verification period is estimated and noted down. The coal stock register is used to cross check the brick production. The kilns may purchase a new weighing scale every year or calibrate the existing weighing scale in case the calibration services/facilities become more affordable, during that monitoring period. In case of any delay in procuring new weighing scales or calibration of existing equipment after one year, then the maximum permissible error as per the respective manufacturer specifications shall be applied on the measured readings for the period until next calibration or procurement of new equipment.
Purpose of data	To calculate the project emissions
Additional comment	The data will be archived for up to two years after the end of the crediting period.

Data / Parameter	$NCV_{Coal\ i,y}$
Unit	TJ/kg
Description	Net Calorific value of coal used in y^{th} year in brick plant i
Source of data	As per the data provided by the supplier and independently verified by a credible Bangladesh laboratory. (Ex-ante value is from: www.bcmcl.org.bd)
Value(s) applied	2.57 ×10-5 (or 6,135 kCal/kg. Value used for ex-ante calculation)
Measurement methods and procedures	A composite sample of 1 kg coal will be taken from each new consignment of coal. At the end of each quarter all the samples taken in that quarter will be crashed and mingled to produce a representative sample for that quarter and will be laboratory tested to determine the net calorific value of coal used for that particular quarter and the value will be reported in the quarterly report. The entire data will be monitored and will be archived on paper and electronically. Average of the net calorific values of different

	quarters will be calculated at the end of each verification/crediting period and will be considered as the net calorific value of coal used by related brick company in that crediting period
Monitoring frequency	Quarterly
QA/QC procedures	IIDFC will cross check the coal consumption data by inspecting the coal stock register and reports of calorific value tests at the end of each verification/crediting period.
Purpose of data	To calculate the project emissions
Additional comment	The data will be archived for up to two years after the end of the crediting period.

Data / Parameter	**DP** $_{Bricks, i}$
Unit	Bricks/day
Description	Daily production of bricks in Kiln i
Source of data	On-site measurements by the kiln owner
Value(s) applied	50,000 - estimated value for single sized kiln 100,000 – estimated value for double sized kiln)
Measurement methods and procedures	The daily production (units of bricks manufactured) will be noted in a log sheet which will be maintained in the kiln. Measurements will be noted by technicians in the plant in the log sheets every day. Supervisor will sign the log sheet at the end of each day and data will be provided to the CDM Monitoring and Compliance officer, who will maintain data gathered in the kiln/kiln head office. Monthly Reports will be prepared periodically by the CDM Monitoring and Compliance officer and will be gathered in electronic and paper mode.
Monitoring frequency	Every brick production day
QA/QC procedures	The amount of bricks manufactured at the end of each crediting period is cross checked with the invoices for the sale of bricks and the stock in the plant.
Purpose of data	To calculate the baseline and project emissions
Additional comment	The daily brick production value will be used along with daily average mean weight of bricks for calculation of daily mass of brick production. The data will be archived for up to two years after the end of the crediting period. In the event that different size or types of bricks, such as holed brick are produced, the number of each type of brick produced will be recorded in the daily register.

Data / Parameter	**DMW** $_{HHK\ Bricks, di}$
Unit	kg
Description	Daily Mean Weight of baked HHK bricks in kiln i
Source of data	On-site weighing by the kiln owner
Value(s) applied	3.5 – estimated value for ex-ante calculation. Actual value will be determined as described below.
Measurement methods	The average weight of bricks will be calculated as per the “Guidelines for

and procedures	sampling and surveys for CDM project activities and programme of activities, version 03.0, EB 75" using digital weighing scale. The daily average mean weight of bricks will be used along with daily brick production for calculation of daily mass of brick production. Details of brick sampling are provided in the section B.7.2 below.
Monitoring frequency	Daily
QA/QC procedures	The kilns may purchase a new weighing scale every year or calibrate the existing weighing scale in case the calibration services/facilities become more affordable, during that monitoring period. In case of any delay in procuring new weighing scales or calibration of existing equipment after one year, then the maximum permissible error as per the respective manufacturer specifications shall be applied on the measured readings for the period until next calibration or procurement of new equipment.
Purpose of data	To calculate the baseline and project emissions
Additional comment	The data will be archived for two years after the end of the crediting period.

Data / Parameter	**$SEC_{i,y}$**
Unit	TJ/kg -brick
Description	Specific Energy Consumption in brick field i
Source of data	Calculation result using equation (3)
Value(s) applied	9.54×10^{-7} (estimated value for ex-ante calculation)
Measurement methods and procedures	The specific fuel consumption per brick will be calculated once a year based on the data for coal consumed and bricks produced during the corresponding period.
Monitoring frequency	Recording frequency is annual
QA/QC procedures	The data can be cross checked by comparing it with the quantity of bricks sold and coal purchased based on the sale/purchase receipts.
Purpose of data	To calculate the project emissions
Additional comment	The data will be archived for up to two years at the end of the crediting period.

Data / Parameter	**N**
Unit	days
Description	Number of operational days of the kiln in a year
Source of data	Recorded by the kiln owner
Value(s) applied	300 – estimated number of days for ex-ante calculation
Measurement methods and procedures	The kiln owner will keep a record of the number of operational days of the kiln during the year.
Monitoring frequency	Daily
QA/QC procedures	The kiln owner will record the data.
Purpose of data	To calculate the baseline and project emissions
Additional comment	The data will be archived for up to two years after the end of crediting period.

Data / Parameter	**$FC_{Diesel, j, y}$**
Unit	kilolitre/yr
Description	Quantity of diesel (fuel type) combusted in process j during the year y
Source of data	Measured using standard measuring cans[40]
Value(s) applied	21 (for ex-ante estimate based on experience of the Universal Bricks Ltd and Diamond Auto Brick field Ltd)
Measurement methods and procedures	The diesel consumption at the kiln is measured generally using 1/2/5 litre standard measuring cans. The purchased diesel is also measured at the supplier end itself and is recorded in the purchase invoice. The records are maintained at the kiln office for consumption as obtained from above measurements. The invoiced consumption can be cross checked with actual consumption against the diesel purchases at the end of monitoring period by tallying out the total purchase with opening stock and closing stock of diesel in that period.
Monitoring frequency	Daily
QA/QC procedures	The diesel stock at the end of each verification period will be estimated and noted in the annual report and the diesel stock register. Since there is no proper institutional/laboratory set up available for easy processing of calibration of measuring cans, new measuring cans are purchased every year by the kilns to ensure the accuracy of measurements. This is also supported by the affordable cost of the new measuring cans. In case of any delay in procuring new measuring cans after one year, then suitable error shall be applied on the measured readings for the period until new equipment are procured. The error value shall be estimated based on actual conditions during the verification in discussion with the verifying DOE.
Purpose of data	To calculate project emissions

[40] Since there is no fixed diesel storage tank, installation of flow meters is not possible. The metal drums may get distorted in their shapes during transportation and handling. Hence, the use of ruler gauge will also give inaccurate measurement due to deformations in the drums. The measuring cans used at the kilns are of standard volumes (1, 2, 5 litres) and the measurements obtained can be considered equivalent to the use of ruler gauges as required by the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion".

Additional comment	The data will be archived for two years after the crediting period.

Data / Parameter	$EC_{i,y}$
Unit	MWh
Description	Electricity Consumption in plant i per year
Source of data	Electricity bill from the REB
Value(s) applied	270 (for ex-ante estimate based on experience of the Universal Bricks Ltd and Diamond Auto Brick field Ltd)
Measurement methods and procedures	Monthly Electricity bill paid to Rural Electricity Board (REB) will be used to calculate the total electricity consumption of the month and will be noted in the monthly report
Monitoring frequency	Monthly
QA/QC procedures	Electricity consumption from the individual monthly electricity bills shall be cross checked with the electricity consumption calculated from the first and last month of the monitoring period. In case of energy meters, there is no calibration method in practice in Bangladesh. A letter from Bangladesh DNA is provided as a proof of evidence for the same. In cases where a single electricity meter is used by two kilns and unless there is proper sub-meter is installed and consumption is monitored, the total power consumption of the meter will be considered for each of the kilns. This is a conservative measure.
Purpose of data	To calculate project emissions
Additional comment	The data will be archived for two years after the crediting period.

B.7.2. Sampling plan

The project proponent will use the multi-stage cluster sampling to determine the mean daily value of the HHK brick weight for each kiln. The representative sample will be chosen so as to achieve 90% confidence interval with +/- 10% error margin.

Both target population and sampling frame include the daily brick production of each of the kilns included in the monitoring plan. The desired precision is 10% with a confidence level of 90%. The sample size is calculated based on precision, confidence level and standard deviation. Since the standard deviation for the entire population is unknown, an estimate of standard deviation will be used.

Sample Size:

According to "Guidelines for sampling and surveys for CDM project activities and programme of activities, version 03.0, EB 75", the multi-stage sampling plan will be used to determine Daily Mean Weight of HHK bricks in Kiln i during the crediting period as per below procedure:

- Stage 1 (primary sampling) – no. of days to be selected per year : 24 (2 per month)
- Stage 2 (secondary sampling) – no. of bricks to be sampled in each sampling day : 20 (fixed)
- Total bricks to be sampled per year : 480
- 2 days shall be selected from every kiln operation month
- 20 bricks will be taken for every type of brick (solid, 3 holed, 6 holed, etc.) produced on a day

- Sample selection within a day shall also be random.

However, the total bricks to be sampled per year (480) is not fixed for all the kilns and the total number of brick samples may vary based on the number of operational months of an individual kiln. For example, if a kiln operates for only 6 months in a year, then it will have, 6 months x 2 days/month x 20 samples/day = 240 samples only while a kiln operating for 12 months will have 480 samples.

For complete details refer Appendix 5.

IIDFC will conduct required training for implementation of the monitoring plan at each kiln level. Quality control officers and CDM Monitoring and Compliance Officers of each plant site will be trained to measure brick weight as per sampling plan.

The measurements will be conducted at each kiln level by the personnel responsible for quality control as designated by the kiln management. One brick will be taken randomly at a time and weight of that brick will be measured using digital weighing scale. They will follow the sampling plan and take records in the data sheets.

The quality control department will present the data sheet to the CDM Monitoring and Compliance Officer appointed by the kiln owner on a daily basis. CDM Monitoring and Compliance Officer will check and ensure that the measurements were conducted according to the sampling plan. In case the sample plan is not followed he will investigate, make necessary records and take corrective actions required. The data will be recorded in a excel file after being checked and verified by him.

B.7.3. Other elements of monitoring plan

This section details the steps taken to monitor on a regular basis the GHG emissions reductions from this project.

The main components within the monitoring plan are:

1. Parameters to be monitored and data collection procedures.
2. Management and Operational System/procedures
3. Quality assurance measures and responsibilities including data base management

If necessary, this Monitoring Plan can be updated and adjusted to meet operational requirements, provided that such modifications are approved by a Designated Operational Entity during the process of verification. The Senior Project Associate, IIDFC, will be responsible for the activities related to implementation of the procedures.

1. Parameter to be monitored and data collection procedures

Parameters to be monitored, and how data will be collected are described in Section B.7.1.

Continuously all the data to be monitored will be registered in the plant register either in electronic form or on paper worksheets or both. Data collected will be entered in electronic worksheets and stored.

Emission reductions calculations will be carried out by a competent manager using a MS Excel spread sheets. Backup of the data electronically will be conducted on a weekly basis, and hard copy data will be printed monthly and a Performance Report will be prepared quarterly.

All data will be kept for the full crediting period, plus two years.

2. Management and Operational System

The data relevant to the project are proposed to be monitored and recorded manually by the plant operators.

The plant owners (entrepreneurs) will monitor the data for their respective plants based on, daily brick production and weight of the bricks. This data will be recorded daily in the plant registers and once a month this will be compiled and delivered to IIDFC.

The coal supply of each consignment will be evidenced by suppliers invoice. The daily coal consumption register will serve as the measurement for coal consumption. Sum of daily consumptions of each operating day is calculated at the end of each monitoring period and taken as the total coal consumption for that period. This value shall be cross checked using the invoices of coal purchase and stock of coal at the end of the monitoring period. A composite sample of 1 kg coal will be taken from each new consignment of coal. At the end of each quarter all the samples taken in that quarter will be crashed and mingled to produce a representative sample for that quarter and will be laboratory tested at the BRTC, Bangladesh University of Engineering & Technology (BUET) to determine the net calorific value of coal used for that particular quarter and the value will be reported in the quarterly report. The entire data will be monitored and will be archived on paper and electronically. Average of the Net calorific values of different quarters will be calculated at the end of each verification/crediting period and will be considered as the net calorific value of coal used by related brick company in that crediting period. The above data will be submitted to IIDFC for checking and for archiving purposes.

Each plant owner will employ a competent person in his plant as CDM Monitoring and Compliance Officer whose responsibility will be to collect the monitoring data as described in Section B.7.1 from different departments/sections of the plant and compile the data in the Excel format provided to them by IIDFC, the bundling agent. The CDM Monitoring and Compliance Officer will also be responsible for monthly delivery of both hard copies and electronic version of the Monitoring Data. Monitoring Officer of IIDFC will collect data from each subproject on a monthly basis and submit these reports to the Senior Project Associate / Senior Officer to produce quarterly performance reports and annual Emission Reports.

The monitoring operation will be conducted according to the following table:

Task and Area of Responsibility	***Method Used***	***Frequency***	***Responsible person***	***Responsible Entity***
Operation of the monitoring equipment	Manual entry, data recording Electronic Recording	Daily Continuously	Operator in-charge Operator in-charge	Respective plant owner
Quality control of information	On a monthly basis monitoring reports will be checked On monthly basis these reports will be forwarded to Senior Project Associate	Data review monthly	Monitoring Officer Senior Project Associate	IIDFC IIDFC
Data collection	Collection of Monitoring data from each Subproject in both hard copies and electronic workbook	Monthly	Monitoring Officer	IIDFC

	format provided to each subproject by IIDFC			
Calculation of the emission reductions and any deviations from projections	As per PDD/ monitoring plan with excel spreadsheets	Quarterly	Senior Project Associate / Senior Officer	IIDFC
Storage of the data (measured calculated, estimated data)	Data collection from subprojects and storage	Monthly Periodic Monitoring Reports	Monitoring Officer	IIDFC
QA/QC	As per the OMP Weighing equipment (depends on type of scale)	Yearly Yearly	Senior Project Associate / Senior Officer Operator in-Charge	IIDFC Respective Brick Company
Kiln owner's staff training (CDM monitoring)	Training program as and when required	As and when required	IIDFC or their Consultants	IIDFC
Approval of monitoring reports and achieved ERs		Yearly	Project in-Charge	IIDFC

3. Quality assurance measures and responsibilities including data base management

Senior Project Associate/ Senior Officer, IIDFC will be in charge of, and accountable for, the generation of the ERs, including monitoring, record keeping, computation of ERs, audits and verification. The Project in Charge, IIDFC will ultimately be responsible for ensuring that the monitoring system is established and implemented to the satisfaction of a DOE and the IBRD acting as trustee of Carbon Funds.

IIDFC shall conduct onsite training and quality control programs as and when required to ensure that good management practices are ensured and implemented by all project operating personnel in terms of recordkeeping, equipment calibration, overall maintenance, and procedures for corrective action.

The following quality control measures will be adopted to increase the reliability of the data monitored:

- To improve the reliability of data recorded by the plant operators, IIDFC or their consultants will carry out an audit of the plants on an annual basis. The audit will be carried out at least for three consecutive days, and IIDFC nominated auditors (designated as Carbon Inspectors) will verify the data on brick production as well as fuel consumption; and

- The annual coal consumption data reported by the plant operators will be cross-checked against the data recorded in the coal purchase register of the plant, and the higher value after adjusting for the closing stock at the plant will be used to calculate annual coal consumption.

SECTION C. Duration and crediting period
C.1. Duration of project activity
C.1.1. Start date of project activity

20/11/2006. It is the project start date of first HHK (Universal) as evidenced by the issued Sub Contract.

C.1.2. Expected operational lifetime of project activity

10 Years[41]

C.2. Crediting period of project activity
C.2.1. Type of crediting period

Fixed

C.2.2. Start date of crediting period

01/09/2011 or not before project registration

C.2.3. Length of crediting period

10 years and 0 months

SECTION D. Environmental impacts
D.1. Analysis of environmental impacts

Three clearances for documenting and mitigating the environmental impacts of the project activity are required:

1. Bangladesh "Environmental Clearance" permits:

HHK entrepreneurs are required to submit a "Primary Environmental Study" containing information relevant to the HHK facility for which an environmental clearance is requested. This study enables the Bangladesh Department of Environment to assess the level of compliance of the new HHK industrial facility against the Environmental Conservation Act (1995) and Rules (1997). The study includes general information on the project, lists the industrial wastes generated, by-products from liquid wastes, drainage systems, solid dust and gaseous emissions, sound pollution control management, adopted measures for professional health protection, assessment of environmental impacts and mitigation and environmental management plan. With the receipt of a complete study, the Department issues an "Environmental Clearance" which lists the conditions under which the plant is authorised to proceed to construction or installation. These applications and permits are at various stages of submission and approval.

2. Compliance to the World Bank's safeguard policies[42]

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[41] Conservatively. Most facilities in Bangladesh and LDCs are maintained beyond their projected operational lifetime.

[42] World Bank safeguard policies explained:
http://web.worldbank.org/WBSITE/EXTERNAL/PROJECTS/EXTPOLICIES/EXTSAFEPOL/0,,menuPK:584441~pagePK:64168427~piPK:64168435~theSitePK:584435,00.html

The project triggered World Bank safeguard policy on Environmental Assessment Policy O.P./B.P.4.01. The project is rated as category B in terms O.P./B.P.4.01. A category B means that the project will have some impacts but that they can be mitigated.

Therefore, in compliance with O.P./B.P.4.01, IIDFC completed a report entitled "Environmental Management Framework for HHK Project (01/04/2009)[43]" (EMF Report). The report identifies the project risks to the environment, mitigation actions and responsibilities for the implementation of the mitigation actions/plan. The EMF addresses possible issues associated with land development, influx of workers, transport of equipment, construction and operation of the plant. The two main impacts which could potentially arise are air pollution and worker occupational health and safety impacts. The mitigation plan suggests a number of routine or standard measures for this type of activity to safeguard worker health. For reasons listed below the plants provide reduced risk to air pollution.

3. Air quality management

A report titled "Energy and Stack Emissions Monitoring in Hybrid Hoffman Kiln (HHK) Type – Universal Type" by Dr. Amir Khan, ST Consultant, December 2008, was produced for both Government and World Bank interests. The report was undertaken to assess the air quality impact of HHKs based on the operation of the Universal kiln. Its findings were that the HHK is significantly less polluting than FCKs. The main reasons for this are that the green brick making process traps coal particulates inside of the brick preventing them from becoming air borne. This also reduces the volume of fly ash. Secondly, the HHK uses less coal per brick which also reduced pollution levels. Therefore, whereas the FCK require a tall chimney to disperse coal particulates, this is not required for the HHK.

The most significant potential environmental issues in brick kilns are air pollution. The HHK Energy and Stack Emissions Monitoring Report, discussed above, noted that very low stack emissions were observed. The Report made three recommendations:

(i) Based on the very low emissions observed, the HHK technology should be included as a recommended technology in any future revision of National Brick Kiln Regulations;
(ii) The stack height requirement currently set for FCK should be relaxed for HHK based on observed particulate levels at the kiln gate; and
(iii) Stack emission measurements should be conducted in other HHK facilities before emission levels for such kilns are specified in official documents. This would include periodic measurements to observe if these low emissions can be sustained over a longer period of operation.

SECTION E. Local stakeholder consultation
E.1. Solicitation of comments from local stakeholders

Inputs from local stakeholders, informed the project design, from early on through two main processes:

Firstly, extensive consultations took place from May 2002 to March 2007 to prepare the Global Environment Facility Project titled "Improving Kiln Efficiency for the Brick Making Industry, Bangladesh" (IKEMBI)[44]. The objective of the consultations were to prepare a program for barrier removal activities to the market transformation of the brick industry towards cleaner technologies and to demonstrate a preferred kiln technology that would interest potential investors, entrepreneurs and policy makers. The project design at that stage included consideration of the CDM in order to support project implementation. Consultations were conducted through:

[43] http://projportal.worldbank.org/servlet/secmain?pagePK=219321&piPK=219326&theSitePK=213348&conceptattcode=BD-Bangladesh+-++Brick+Kiln+Efficiency+Project+--+P105226~930701|Environmental%20Assessment~540624&PSPID=P105226&menuPK=109012
[44] http://gefonline.org/projectDetailsSQL.cfm?projID=1901

- Informal and frequent consultations with members of the Bangladesh Brick Making and Owners Association (BBMOA) from May 2002 onwards;
- Formal consultations at the Logical Framework Analysis (LFA) workshops of July 2003 and July 2005;
- UNDP-GEF sponsored study tours with the BBMOA, financial institutions and regulators to Xian, China to view the HHK technology; and
- Numerous market surveys, interviews, and round table discussions.

Secondly, IIDFC initiated site specific HHK CDM stakeholder consultations in a public meeting and workshop format during the January-September 2009 period. These meetings were held to explain and receive questions about the CDM, technical, social, economic, financial and environmental aspects of the overall project and to each HHK site. The general public and other stakeholders were informed about the consultations through the use of a "village crier" [45] using a loudspeaker, the issuance of public leaflets within a 1 km radius of the site and by invitation, especially to officials. The meetings were conducted at locations close to the respective HHK facilities. Attendance at the consultations ranged from 21 persons at the Sunflower/Diamond HHK site to 74 persons at the SSL HHK site. Aside from local residents who attended the meetings, other stakeholders included the BBMOA, BUET, IIDFC, DoE and the Ministry of Power Energy and Mineral Resources (MoPEMR), Members of Parliament and in one instance the media, UNDP and the World Bank attended (Universal kiln).

Discussions were led by both IIDFC and Clean Energy Alternatives (CEA) who described the projects CDM and technical aspects in local language as well as in some cases through power point presentation. This was followed by a question and answers session. The comments from stakeholders were compiled into meeting minutes, and summarized into a document entitled "Stakeholder's Consultations Report for Improving Kiln Efficiency for the Brick Making Industry in Bangladesh" by IIDFC, in February 2009.

E.2. Summary of comments received

1. Comments received during the preparation of the GEF Project grant were as follows:

- On 21/7/2005, a national participatory workshop was conducted to solicit stakeholder comments and inputs on strategies for supporting cleaner brick making technologies in Bangladesh. The workshop included a wide range of participants and issues. Stakeholder's supported the concept of developing a program to demonstrate and operate Energy Efficient Kilns (EEKs), and to transform the industry in that direction. Suggestions were made on the type of technologies to be demonstrated, the need to build capacity, transfer knowledge, provide technical assistance for planning, financing, designing, constructing, operating and maintaining EEK facilities throughout Bangladesh. However, support for the HHK, was reserved pending a planned visit to Xian, China to observe an operational HHK;

- In November 2005, stakeholder undertook a visit to XIAN facilities in Xian, China, to observe operational HHKs. Stakeholders formed an overall positive impression about HHKs. Positive benefits which were noted included the overall efficiency of the kilns and lower stack emissions. The higher costs of HHKs were noted and the need to build and operate an HHK in Bangladesh to see if the same high performance standards could be replicated; and

- On 28/03/2007, a second national participatory workshop was conducted. Comments from BBMOA membership, prospective investors and government officials on the HHK program were received. A field trip was incorporated as a part of the workshop to showcase the completed demonstration HHK in Dhamrai, west of Dhaka City. Though the HHK was not yet operational at that time, several

[45] This is often the most appropriate way to call a meeting for illiterate members of the community.

BBMOA members and interested entrepreneurs were able to observe the energy conservation features of the HHK and were sufficiently impressed by the CDM project to inform project promoters of their plans to commence construction of HHKs as soon as they could observe the actual operations of a demonstration HHK in Bangladesh.[46]

2. Comments received during the CDM stakeholder consultation at each of the five HHK sites covered by this project were as follows (during the January-June 2009 period):

- At the Universal site, attendees were given the opportunity to observe an operational HHK, and commented on the lack of smoke from the small smokestacks;
- At all sites, the HHK projects were strongly supported by local residents as they viewed the HHK plants as significant job opportunities for the communities;
- At all sites, stakeholders supported the HHK projects since the project was presented as a clean industrial facility with few if any adverse environmental impacts;
- At all sites, there were significant concerns that the entrepreneurs might only import skilled workers from outside their communities;
- At all sites, the HHK facility was viewed as a means to facilitate development of other infrastructure projects in the area (namely road development) further creating more employment opportunities:
- At all sites the CDM was explained as a means to fund and transfer cleaner technologies such as the HHK to developing countries such as Bangladesh. The explanations were positively received by all attendees with journalists expressing their interest in disseminating the information through newspapers, journals and television;
- At all sites, local brick makers wanted technical assistance to assess their ability to convert their brick fields to the HHK technology.

E.3. Report on consideration of comments received

The project has responded to stakeholder comments as follows:

Use of local labour

- All entrepreneurs are intending to employ personnel from local communities to the extent possible for the unskilled labour requirements; and
- All entrepreneurs will be hiring semi-skilled personnel from outside but expect to train local unskilled personnel on a continual basis and promote them to semi-skilled positions as required;

Promotion of the HHK technology

- The project promoters have made arrangements for the XIAN Institute of Wall Building Materials to be resident in Bangladesh during the 2009 to 2014 period to technically support and build the capacity of a new and cleaner brick industry through the construction and operation of new HHKs. The role of XIAN as well as other Chinese service providers will be to provide knowledge transfers,

[46] http://www.undp.org.bd/projects/prodocs/IKEBMI/Brick%20Terminal%20Report%20April%2007.pdf

capacity building and technical assistance to entrepreneurs, engineers, and vocational level personnel in the planning, financing, design, construction, operation and maintenance of HHKs in Bangladesh for this program; and

- Technical advice on optimizing energy efficiency in HHK operations and continuing to reduce project emissions still further, will be provided through the long-term involvement of XIAN and other service providers contracted by kiln owners.

Promote efficient use of coal and further reduce air pollution

- The project promoters said that the HHK projects will reduce use of coal. Moreover, they said all HHK projects will fully comply to the "Brick Burning (Control) Act 1989 (Act #8 of 1989) on February 12, 1989" that prohibits the use of wood fuel for brick making in Bangladesh;

Project financing due to cost of HHKs

IIDFC will be providing financing for some HHK owners as will other financial institutions. IIDFC also needs to reduce its financial exposure to the new technology as do other financial institutions Bangladesh. The availability of CDM resources is expected to help support financial closure for outstanding HHKs.

SECTION F. Approval and authorization

The letter of approval from the host country is submitted during the time of registration.

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Appendix 1: Contact information of project participants

Organization	Industrial and Infrastructure Development Finance Company Ltd (IIDFC)
Street/P.O. Box	
Building	122-124
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State/Region	Dhaka
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First name	Joëlle
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Personal e-mail	

Appendix 2: Affirmation regarding public funding

There is no public funding in this project and no diversion of ODA. The Danish Government has confirmed that there is no diversion of ODA in a letter dated 18/09/2009. IIDFC has also confirmed this in a letter dated 03/03/2010.

Appendix 3: Applicability of selected methodology

As explained in section B.

Appendix 4: Further background information on ex ante calculation of emission reductions

This section describes (i) the baseline technology and (ii) provides detailed calculations for the emission reductions

1. Baseline technology

<u>Bull's Trench Kiln (19.2% of total)</u>

Prior to 2004, most of the kilns in Bangladesh used the Bull's Trench kiln (BTK) technology, a primitive technology that is over 150 years old, and exceedingly inefficient in terms of fuel use because they are poorly constructed. Leaks through the kiln walls cause excessive air intake and heat loss from the system.

A BTK is essentially an elliptical shaped trench 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. 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/gravel. 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. Therefore, each year the BTKs need to be reconstructed. It is less efficient than FCK.

<u>Zigzag (4.8% of total)</u>

The 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. At the bottom of the chimney there is a blower, which draws the flue gas from the kiln and discharges it to 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. The Zigzag Kiln is expected to be 10% – 15% more fuel-efficient than the FCK. However, many Zigzag kilns operating in Bangladesh have not been constructed according to the design standard according to a BUET Study 2006. The report states that literature data on emissions and energy consumption have too much spread to be considered reliable.[47] Informal discussion with Zigzag kiln owners revealed that there are several designs available in the country as the dispersion of the technology is informal and the entrepreneurs rely on their own experts and interventions. Due to deviation of design the energy efficiency is similar to the FCK although some energy efficiency was expected. Therefore, there is no specific zigzag type kiln which could be considered as a model for comparative purposes with other types of kiln. It costs approximately the same as an FCK to construct.

<u>Hoffman Gas (0.6% of the total)</u>

A Hoffman Kiln is rectangular in shape and measures 300 - 400 ft by 60 ft. Its construction and operation is very similar to the FCK. The predominant difference between the Hoffman Kiln and the others described above is the fixed roof, which enables bricks to be fired throughout the year although during

[47] Small Study on Air Quality of Impacts of the North Dhaka Brick field Cluster by Modeling of Emissions and Suggestions, BUET Study, 2006 (Page 16. Technical findings 2)

the rainy season, which is called 'off-season', the production decreases significantly because of frequent rain, high humidity and greatly reduced availability of sunlight. Some manufacturers overproduce green bricks during the dry season and store them for the rainy season but to do that adequate storage facilities must be made available. Also, for off-season production, clay has to be stored, as harvesting of clay becomes impossible due to widespread floods during the rainy season.

The inside roof of the kiln is arched and has a firebrick lining on the inside surface. The thick walls of the kiln and good insulation minimize heat loss to the surroundings. The chimney is 76 ft high with a blower at the bottom. Green bricks are stacked in the kiln in more or less the same fashion as in the FCK. The bricks are fired from the top by introducing the fuel (natural gas) into the combustion zone through pipe-type burners. 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 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. The firing technique is learnt through several years of on-the-job training, starting as an apprentice and then graduating upwards.

Fixed Chimney Kiln (75.4% of total)

This is the baseline technology. The Fixed Chimney Kiln (FCK) has a fixed chimney which 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. The kiln has underground piping to divert the flue gas from anywhere in the kiln to the fixed chimney. Its length is same as that of the BTK, but its width is greater to accommodate the underground piping. In comparison to BTKs, The FCK also has better insulation in the sidewalls, which reduces heat loss to the surroundings.

Table 4. A comparative study of the cost of various types of kiln in Bangladesh taka[48]

Bull's Trench Kiln	Fixed Chimney Kiln	Zigzag Kiln	Hoffmann Kiln (gas)
2,500,000	4,000,000	4,000,000	32,000,000

2. Energy baseline

The energy baseline of the different types of kiln is shown in Table 5 below.

Table 5. Coal consumption for Bangladesh Kilns per 100,000 bricks[49]

Bull's Trench Kiln	Fixed Chimney Kiln	Zigzag Kiln	Hoffmann Kiln (gas)
26-30 tons	22-26 tons	22-26 tons	12,000-13,000 m3

[48] Source: Clean Development Mechanism Project Opportunities in Bangladesh, Pre Feasibility Report on a Brick Manufacturing Fuel Substitution CDM Project, Bangladesh University of Engineering, December 2002, Table 1, pg 3, which compares different kiln types: http://pubs.pembina.org/reports/cdm_bangladesh_brickkilns.pdf

[49] Source: Clean Development Mechanism Project Opportunities in Bangladesh, Pre Feasibility Report on a Brick Manufacturing Fuel Substitution CDM Project, Bangladesh University of Engineering, December 2002, Table 1, pg 3, which compares different kiln types: http://pubs.pembina.org/reports/cdm_bangladesh_brickkilns.pdf

Baseline energy calculations

The baseline emissions $\mathbf{BE_y}$ from the baseline activity, if equivalent amount of bricks that were produced in the i[th] plant were to be produced by using FCK technology in year y, are calculated as follows:

$$\mathbf{BE_y = \sum_{i=1}^{8} BE_{FCK\ i,y}}$$

$= 10{,}536\ t\ CO_2/year_{(y)} \times 6 + (10{,}536\ tCO_2/year_{(y)} \times 2) \times 2$

$= 105{,}360\ t\ CO_2/year_{(y)}$

$\mathbf{BE_{FCK\ i,y}}$ = Baseline emissions per year for the i[th] plant

$= 10{,}536\ t\ CO_2/year_{(y)}$

$\mathbf{BE_{FCK\ i,y} = TP_{Bricks,\ i,y} * SEC_{FCK,\ Bricks,\ y} * CEF_{coal} * CF}$

$= [52{,}500{,}000\ kg\text{-}bricks_{(y)} \times 2.125 \times 10^{-6}\ TJ/Kg\ \text{-brick} \times 25.8\ t\ C/TJ \times 3.66\ t\ CO_2/t\ C]$

$= 10{,}536\ t\ CO_2/year_{(y)}$

Where,

$TP_{Bricks,\ i,y}$ = Total Production of bricks per year in HHK plant i (kg-bricks/year)
$SEC_{FCK,\ Bricks,\ y}$ = Specific Energy Consumption in FCK technology (TJ/kg-brick)
CEF_{coal} = IPCC default Carbon Emission Factor for fuel used (t C/TJ)
CF = Carbon to CO_2 Conversion Factor

$\mathbf{SEC_{FCK,\ Bricks} = SFC_{FCK,\ Bricks} * CV_{Coal,\ FCK} / M_{bricks,FCK}}$

$= [0.24Kg\ \ coal / bricks\ x\ (6135 \times 4.186 \times 10^{-9}\ TJ/Kg)] /2.9\ kg /brick)$

$= 2.125 \times 10^{-6}\ TJ/kg\text{-}Bricks$

Where,

$\mathbf{SFC_{FCK,\ Bricks}}$ = Specific fuel (coal) consumption per unit brick production in the FCK technology (kg of Coal/100,000 bricks)

= 24 ton coal per 100,000 bricks

= 0.24 kg of coal / brick

$\mathbf{CV_{Coal,\ FCK}}$ = Calorific value in the baseline FCK technology (TJ/kg)

= 6,135 kCal/kg

$= 6{,}135 \times 4.186 \times 10^{-9}\ TJ/kg$

$\mathbf{M_{bricks,FCK}}$ = Weight of FCK Brick (kg /brick)

= 2.9 kg/brick

The calculations are shown in the following tables:

Table 6: Specific fuel consumption FCK (for conventional-sized bricks)		
Parameter	**Value**	**Unit**
Quantity of Coal	24	Ton
Quantity of Bricks	100,000	Nos
Specific Fuel(coal) consumption	0.000240	ton coal/brick
Specific Fuel(coal) consumption	0.240	kg coal/brick
Specific Fuel(coal) consumption	0.083	kg coal /kg brick

Table 7: Calorific value of Coal used in FCK (for conventional-sized bricks)		
Parameter	**Value**	**Unit**
kCal to kJ conversion factor	4.186	kJ/kCal
Calorific Value	6,135	kCal/kg
Calorific Value	25,681	kJ/kg
Calorific Value	$25,681\times10^{-9}$	TJ/kg

Table 8: Weight of FCK Bricks (for conventional-sized bricks)		
Parameter	**Value**	**Unit**
Weight	2.9	Kg /brick

Table 9 : Specific Energy consumption FCK (for conventional-sized bricks)			
Parameter		**Value**	**Unit**
Specific Fuel(coal) consumption	(A)	0.240	kg coal/brick
Calorific Value	(B)	$25,681\times10^{-9}$	TJ/kg coal
Specific Energy consumption	(C) = (A) × (B)	0.0000062	TJ/brick
Brick Weight	(D)	2.9	kg/brick
Specific Energy consumption	(E) = (C)/(D)	2.125E-06	TJ/kg-brick

Table 10: Specific Energy Consumption in FCK technology (for conventional-sized bricks)				
Parameter	**$SFC_{FCK, Bricks}$**	**$CV_{Coal, FCK}$**	**$M_{bricks, FCK}$**	**$SEC_{FCK, Bricks}$**
	(A)	(B)	(C)	(D) = (A)× (B)/ (C)
Unit	kg Coal/brick	TJ/kg	kg/brick	TJ/kg-brick
Value	0.24	$25,681\times10^{-9}$	2.9	2.125E-06

Table 11: Emission calculation per FCK (for equivalent production in Kg bricks)					
Parameter	**$TP_{Bricks, i, y}$**	**$SEC_{FCK, Bricks}$**	**$EF_{CO2,coal}$**	**CF**	**$BE_{FCK\ i, (2010)}$**
	A	**B**	**C**	**D**	**E = A×B×C×D**
Unit	(kg-bricks/year)	TJ/kg-brick	(tC/TJ)	(tCO_2/tC)	tCO_2/year
Value	52,500,000	2.125×10^{-6}	25.8	3.66	10,536

Appendix 5: Further background information on monitoring plan

The detailed monitoring information has been provided in section B.7. In the following section the Sampling plan and its implementation procedure for brick weight measurement is discussed.

According to "Guidelines for sampling and surveys for CDM project activities and programme of activities, version 03.0, EB 75", The following sampling plan will be used to determine the Daily Mean Weight of HHK bricks in Kiln i during the crediting period.

Multistage sampling is a complex form of cluster sampling. Measuring all the elements in the selected clusters may be prohibitively expensive, or not even necessary. In multi-stage sampling, the cluster units are often referred to as the primary sampling units (PSU) and the elements within the clusters, as the secondary sampling units (SSU). In contrast to the cluster sampling, where all of the secondary units are measured, in multi-stage sampling, data are collected for only a random sample of the secondary units.

Since the quantity of brick production is high and the brick production from each day shall be considered as a cluster, multi-stage sampling is chosen for this project.

1. Requirements of multi-stage sampling

For the sample size calculations, the following details on the population are required:

(a) Variations in brick weight within a day
(b) Variations in brick weight between days
(c) Average mean brick weight within a day
(d) Overall average mean brick weight

The expected mean and standard deviation are calculated from brick weight measurements carried out at Kapita Auto Bricks Ltd. (kiln capacity - 100,000 bricks/day). The measurements were taken for 100 brick samples randomly selected from fired bricks produced on those respective days. The mean and standard deviations arrived from the above measurements are used for the multi-stage sampling estimations.

2. Assumptions

Following assumptions have been made with respect to the HHK brick kiln operations at Kapita brick kiln, for estimating the sample size:

- Primary sampling unit (PSU) = Each brick production day
- Secondary sampling unit (SSU) = All fired bricks output on a production day
- No. of bricks sampled per day = 10 (for initial analysis)
- Max. brick output on day = 100,000 (for Kapita brick kiln)
- Max. no. of brick production days = 365
- 90% confidence level and 10% precision as per small scale CDM requirement is taken.

3. Estimation of number of days to be selected

The following table gives the mean and standard deviation calculated for the 100 brick weight measurements from each of the 11 production days (randomly selected) during first monitoring period at Kapita brick kiln, which is typical for the other kilns in the bundle.

The number of days to be selected for sampling can be calculated using the following formula:

Day	Bricks produced per day	Mean Weight per brick	Total weight of bricks per day	Standard deviation within a day
1	47,137	3.018	142,250	0.044
2	69,841	3.008	210,105	0.015
3	32,104	3.026	97,157	0.028
4	73,646	3.031	223,209	0.015
5	71,318	3.013	214,897	0.027
6	90,324	3.056	276,059	0.084
7	67,075	3.036	203,639	0.033
8	56,754	3.031	172,029	0.022
9	59,037	3.021	178,342	0.049
10	66,065	3.024	199,783	0.024
11	67,672	3.034	205,335	0.027
Total bricks	**700,973**	-	-	-
Overall mean weight (brickmean)		**3.028**	-	-
Overall mean total weight of each day (daymean)			**193,946**	-
SD of total weight of days (SD_b)			**46,175**	-
Standard deviation within a day (SD_w)				**0.041**

$$c \geq \frac{\left(\frac{SD_B}{day\,mean}\right)^2 x \left(\frac{M}{M-1}\right) + \left(\frac{1}{u}\right) x \left(\frac{SD_W}{brick\,mean}\right)^2 x \left(\frac{N-u}{N-1}\right)}{\left(\frac{0.1}{1.645}\right)^2 + \frac{1}{M-1}\left(\frac{SD_B}{day\,mean}\right)^2}$$

Where,

c	=	No. of days to be selected
M	=	Total number of days
N	=	Average number of bricks per day
u	=	Number of bricks to be sampled per day
1.645	=	Represents the 90% confidence required
0.1	=	Represents the required 10 % precision
SD_B	=	Standard deviation of weight of each day
SD_W	=	Standard deviation within a day
brickmean	=	Overall mean brick weight
daymean	=	Overall mean of total brick weight of each day

Number of samples is estimated as follows:

$$c \geq \frac{\left(\frac{46,175}{193,946}\right)^2 x\left(\frac{365}{365-1}\right)+\left(\frac{1}{10}\right)x\left(\frac{0.041}{3.028}\right)^2 x\left(\frac{100,000-10}{100,000-1}\right)}{\left(\frac{0.1}{1.646}\right)^2+\frac{1}{365-1}\left(\frac{46,175}{193,946}\right)^2}$$

Therefore, the number of days to be sampled,

c = 15.

Here, the required number of days to be selected per year is 15. The following table gives the calculation carried out for all the kilns and their sample size estimation.

No.	Kiln	Brick Mean	Std. deviation within a day (SD_w)	SD of total weight of days (SD_b)	Sample size per day	No. of days to be selected	Total samples required
1	Kapita	3.03	0.04	46,175	10	15	150
2	Diamond	3.60	0.11	17,289	10	3	30
3	Sunflower	3.59	0.10	13,218	10	2	20
4	Banolata	3.06	0.11	9,438	10	4	40
5	Haair	3.18	0.05	22,064	10	13	130
6	Universal	3.25	0.07	15,886	10	7	70

From the above table, it is inferred that the sample size depends very much upon the standard deviation within a day (SD_w) and standard deviation of total weight of days (SD_b). The maximum number of samples to be selected is 150 for Kapita brick kiln.

4. Selection of sample bricks from each gate

A list of number of sample bricks per day and the corresponding estimation of number of days per year has been generated based on above calculation.

No. of samples per day	No. of days to be selected
1	14.81
5	14.77
10	14.76
15	14.76
20	14.76
25	14.76
30	14.76

From the above table, it is observed that the required days per year does not vary much with the samples selected per day.

Required sampling as per cluster sampling

From the above estimations, the minimum required sample size for all kilns = 10 bricks per day x 15 days = 150 brick samples per year.

It is observed that the kilns operate in a wide range of periods from a minimum of 4 months to one year. Hence, the number of samples per day and selection of number of days must be estimated such that even at the minimum operating period of 4 months, the kilns are able to achieve the required sample size of 150 bricks. To achieve this:

- 40 samples (150 samples/4 months) must be selected from a month
- Taking 20 samples per day, 2 days shall be selected for a month

As per the above plan, a kiln operating for a minimum of 4 months will be able to achieve 160 (8 days x 20 samples) sample measurements which is above the minimum requirement of 150 samples.

Therefore, below are the sampling numbers required as per the multi-stage sampling procedure:

- Stage 1 (PSU) - no of days to be selected per year : 24 (2 per month)
- Stage 2 (SSU) - no of bricks to be sampled in each day : 20 (fixed)
- Total bricks to be sampled per year : 480
- 2 days shall be randomly selected from every operational month based on the production pattern
- 20 bricks will be taken for every type of brick (solid, 3 holed, 6 holed, etc.) produced on a day
- Sample selection within a day shall also be carried out by random.

However, the total Number of bricks to be sampled per year (480) is not fixed for all kilns and the total number of brick samples may vary based on the number of operational months of an individual kiln. For example, if a kiln operates for only 6 months of year, then it will have, 6 months x 2 days/month x 20 samples/day = 240 samples only while a kiln operating for 12 months will have 480 samples.

Appendix 6: Summary of post registration changes

No	Section	Description	Change
1	A.1	Description of project activity	Removal of SSL brick kilns (kilns 1 and 2) from the bundle.
2	A.2	Location of project activity	Removal of SSL brick kilns (kilns 1 and 2) from the bundle
3	B.6.1	Monitoring and metering the energy use of the equipment installed	Direct monitoring of coal, diesel and electricity consumption is updated.
4	B.6.3	Ex-ante calculation of emission reductions	Revision of emission reduction calculation after the removal of SSL brick kilns (kilns 1 and 2)
5	B.7.1	Total consumption of coal	• Direct monitoring of parameter is implemented with the daily coal consumption measurement using digital weighing scale • QA/QC procedures for ensuring the accuracy of digital weighing scales are added to the purchase new weighing scale every year.
6	B.7.1	Daily Mean Weight of bricks	• Brick sampling procedures is revised as per the latest “Guidelines for sampling and surveys for CDM project activities and programme of activities, version 03.0, EB 75” • QA/QC procedures for ensuring the accuracy of digital weighing scales are revised to purchase new weighing scale every year.
7	B.7.1	Quantity of diesel (fuel type) combusted in process	• Direct monitoring of parameter is implemented with daily diesel consumption measurement using standard measuring cans • QA/QC procedures for ensuring the accuracy of measuring cans are added to purchase new measuring cans every year.
8	B.7.1	Electricity Consumption in plant	There is no calibration procedure existing for the energy meters in Bangladesh. A letter from Bangladesh DNA is provided as a proof of evidence for the same.
9	B.7.2	Sampling plan	Brick sampling procedures is revised to multi-stage cluster sampling as per the latest “Guidelines for sampling and surveys for CDM project activities and programme of activities, version 03.0, EB 75”
10	B.7.3	Other elements of monitoring plan	Direct monitoring of parameter is implemented with the daily coal consumption measurement using digital weighing scale
11	Annex 5	Further background information on monitoring plan	Brick sampling procedures is revised to multi-stage cluster sampling as per the latest “Guidelines for sampling and surveys for CDM project activities and programme of activities, version 03.0, EB 75”

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History of the document

Version	Date	Nature of revision
04.1	11 April 2012	Editorial revision to change history box by adding EB meeting and annex numbers in the Date column.
04.0	EB 66 13 March 2012	Revision required to ensure consistency with the “Guidelines for completing the project design document form for small-scale CDM project activities” (EB 66, Annex 9).
03	EB 28, Annex 34 15 December 2006	• The Board agreed to revise the CDM project design document for small-scale activities (CDM-SSC-PDD), taking into account CDM-PDD and CDM-NM.
02	EB 20, Annex 14 08 July 2005	• The Board agreed to revise the CDM SSC PDD to reflect guidance and clarifications provided by the Board since version 01 of this document. • As a consequence, the guidelines for completing CDM SSC PDD have been revised accordingly to version 2. The latest version can be found at <http://cdm.unfccc.int/Reference/Documents>.
01	EB 07, Annex 05 21 January 2003	Initial adoption.
Decision Class: Regulatory **Document Type:** Form **Business Function:** Registration		