“Financial Feasibility of Environment Friendly Brick Manufacturing in the Context of Bangladesh”

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May 30, 2016

Dr. Suman Paul Chowdhury

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Subject: Submission of Internship report

Dear Sir,

I am very glad to submit the report on **"Financial Feasibility of Environment Friendly Brick Manufacturing in the Context of Bangladesh**" this report is an outcome of the internship program, has undergone by me. It gives me immense pleasure to complete my Internship successfully and submit this report on the analysis I have conducted during this period. Working in Infrastructure Development Company Limited (IDCOL), was an inspiring experience for me. I feel the immense knowledge and experience will facilitate me a lot in my future career life. With my limited knowledge, I have tried my level best to prepare the report worthwhile.

Your acceptance and appreciation would surely inspire me. For any further explanation about the report, I will be gladly available to clarify the ins and out.

Sincerely Yours,

Md. Asif Iqbal

ID: 13364079

Acknowledgement

During Internship Program, I have been fortunate to get the support, assistance and encouragement from a number of individuals. Firstly, I would like to express my grateful appreciation to the almighty Allah for enabling me to complete this report successfully.

I would like to convey my heartfelt respect and cordial thanks to Dr. Suman Paul Chowdhury, my internship supervisor in BRAC University, for his encouragement, guidance, advice and valuable supervision. I am very lucky for getting the opportunity to prepare this report under his supervision and guidance. Without his instruction, it was impossible for me to complete this report successfully.

I also articulate my heartiest appreciation to Mr.Nazmul Haque, Director (Investment) and Head of Advisory and Mr.Md. Mehedi Hasan, CFA, Senior Investment Officer, Small and Medium Infrastructure, IDCOL to direct and guide me under a working schedule and enabling me doing my job in a favorable environment in my internship program period. I also admire all the personnel of Infrastructure Development Company Limited (IDCOL), for their co-operation and cordial assistance to me. I am grateful to the Small and Medium Infrastructure team of Investment Department of Infrastructure Development Company Limited (IDCOL) for granting me the opportunity to make my internship program in this organization.

I am grateful to all the employees for providing me with valuable information for my report. Though I was unknown to them, they have helped me by fulfilling my internship program. Their valuable information allows me to find out real information and complete my report successfully.

Executive Summary

Brick remains the major construction material in our country as we have limited source of construction rocks. Topsoil from agricultural lands, river floodplains are used for making the green bricks which is burnt later at the kilns mainly using the imported coal and domestic fire wood. Brick kiln owners mainly use imported Indian poor quality coal for burning bricks in the seasonal brick kilns operated during November to May every year. A recent UNDP study suggests that fire wood share approximately 33 per cent of the fuel used in the seasonal brick kilns in the country.

Bangladesh Brick Manufacturing Owners Association (BMOA) claims that there are approximately 8,000 brick fields that manufacture bricks of different grades in the country. About 60 per cent of the produced bricks in the country are consumed by different government departments, such as the Roads and Highways Department, Public Works Department and Local Government Engineering Department annually. The rest is consumed by private sector users. As reported by BMOA, brick making industry employs around 2 million workers during the peak-season and 0.8 million in the off-season. According to a UNDP source, the country produces over 8.66 billion bricks a year and the sector has grown at 5.3 per cent over the last decade. But there are reasons to believe that total brick production in the country is almost three times the above estimate per year.

Brick kilns are major sources of greenhouse gas in Bangladesh, emitting annually 6 to 9 million tons of CO_2. Such high levels of emissions are a result of the use of age-old technologies and substandard fuels such as high sulfur coal, tires and wood used in the kilns. This situation is being exacerbated by the growth of new brickfields every year.

It is not easy to replace the existing brick kilns with new technology very quickly, although there is availability of proven technology capable of producing quality bricks using one-third fuel (coal) compared to conventional FCK or BTK. Installation of a fixed chimney brick kiln involves approximately Tk 3 million, while a Zigzag kiln installation requires double the amount (excluding land price or rent). A Hybrid Hoffman kiln may require an investment of Tk 80-100 million (excluding land price) to be installed. Hoffman and Hybrid Hoffman brick kilns are generally installed in the highlands, and BTK, FCK and the Zigzag brick kilns can operate both at high and low lands as they are seasonal kilns.

UNDP started providing technical assistances in Bangladesh to improve the brick kiln technology with the support of the Global Environment Facilities (GEF) fund. Within this scope,

seven Hybrid Hoffman Kilns are set at different locations of the country which operate round the year to produce quality bricks using significantly less amount of coal. These projects are attracting new entrepreneurs to replicate the environment-friendly brick kiln technology. The Chinese Xian Design Institute of Wall and Roof Materials is helping the efforts to implement the HHK technology viably. HHK includes among others, using pulverized coal mixed with clay to form green bricks. This technology helps to improve reduced fuel use for brick burning and Green House Gas emission. As reported, almost 80 per cent of the total energy required for burning bricks in the HHKs is met by the coal mixed with the clay used in the green bricks. The remaining 20 per cent coal is fed externally into the firing chambers of the specially designed hybrid Hoffman Kiln. And because of proper air circulation inside the kiln, almost all the coal used for brick making and for firing is burnt efficiently. The system also includes the preheating arrangements for the green bricks in the stacks put inside the properly insulated dryer chambers with the help of exhausts directed in the dryer chambers from the previous firing in the kiln.

Due to the efficient drying and burning technology, HHK require only 13-14 tons of coal for making one hundred thousand quality bricks. A single unit HHK may produce 45,000-50,000 bricks every day. Thus a HHK can replace 5-7 conventional FCK or BTK or Zigzag kilns as the HHK can operate round the year. HHK requires an investment of Tk 100-110 million initially including the land price. As the HHK saves approximately 9-10 tons of coal for burning 100,000 bricks (compared to FCK or BTKs), entrepreneur may claim the carbon credit from the global carbon trading market. A rough estimate suggests that a HHK may claim approximately Tk 700,000 annually from carbon credit by producing 15 million bricks in HHK. And the carbon emission saving benefit is on top of the regular business returns from the brick production and selling.

To implement environment friendly brick manufacturing project, financial feasibility is a must. As this technology is capital intensive, this report aims to identify the parameters to achieve to implement a green brick technology.

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IDCOL TOGETHER FOR TOMORROW

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1 Introduction

At the end of MBA program, the students of BRAC Business School, BRAC University, are sent to different organizations to get real life experience as internees. Internship program acts an external dimension of career development. Moreover this program gives a student the opportunity to apply his/her knowledge of theory in the field of practical life. This internship report is based on my internship experience at Infrastructure Development Company Limited (IDCOL).

1.1 Origin of the Report

This report is submitted to the BRAC Business School, BRAC University, under the supervision of Dr. Suman Paul Chowdhury, Assistant Professor, BRAC Business School, BRAC University, as part of the internship program. This is a requirement for the Masters of Business Administration (MBA) Degree.

I was assigned in IDCOL starting from January to March, 2016 as an intern by the Office of Career Services & Alumni Relations (OCSAR), BRAC University. In IDCOL, I was assigned in Small & Medium Infrastructure Department. During the twelve week internship period in IDCOL, I gained practical knowledge about different projects of IDCOL. My organizational supervisor was Mr. Md. MehediHasan, CFA, Senior Investment Officer, Small and Medium Infrastructure, IDCOL. My project is "Financial Feasibility of Environment Friendly Brick Manufacturing in the Context of Bangladesh" which was assigned by my faculty advisor and my organizational supervisor also approved the project and authorized me to prepare this report.

1.2 Report Objectives

The main objectives of the report can be broadly categorized in two pre-defined categories. The categories are

- Broad Objectives
- Specific Objectives

1.2.1 Broad Objectives

Broad objective of the report is to evaluate the financial feasibility of starting up an environment friendly brick manufacturing project.

1.2.2 Specific Objectives

Specific objectives include the following:

- To assess the initial capital required to start up a brick manufacturing project depending on the capacity;
- To assess the available financing sources including green banking wing of Bangladesh Bank;
- To identify the required moratorium period for successful project implementation and smooth repayment of borrowed money;
- To assess the capacity and utilization required to make the project viable incorporating the cost and estimated payback period.

1.3 Scope of the Report

The study would focus on achieving financial indicators and required capacity utilization to make the project viable.

1.4 Methodology

Both primary and secondary information sources were used to complete this study.

The primary sources are:

- Survey of entrepreneurs who have or are being implementing automated brick project;
- In depth interview with Mr.NazmulHaque, Director (Investment) and Head of Advisory and Mr.Md. MehediHasan, CFA, Senior Investment Officer, Small and Medium Infrastructure, IDCOL
- Interview with some machinery suppliers from China;
- Practical deskwork.

The secondary sources are:

- Different manuals published on Efficient Brick Manufacturing.
- Publications obtained from internet.

1.5 Limitations

The major limitations faced during the preparation of this report are as follows -

- There are only two automatic brick manufacturing projects are running in the country and as a result, the sample size was few;
- Time constraint is a major issue.

2 Literature Review

Brick manufacturing industry is among the largest industrial polluters of Bangladesh. A large number of small capacity kilns operate with outdated and outmoded technologies, causing severe industrial pollution and poor labor standards throughout the sector. However, with the current rate of economic growth, the brick sector continues to expand at about 8% per annum while burning about 6.0 million tons of coal and emitting about 9.8 million tons of carbon dioxide (CO2) per year. Additional negative impacts include deforestation by burning firewood (as a cheaper replacement to coal), loss of farmlands and other natural habitats (for construction of brick kilns) and loss of vegetation from extracting fertile top-soils for brick making.

Demand for bricks is increasing in parallel to the rapid growth of real estate and public infrastructure sectors of Bangladesh. According to Bangladesh Brick Manufacturing Owners Association (BBMOA), there are approximately 6,000 brick fields that manufacture bricks of different grades in the country. About 60 per cent of the produced bricks in the country are consumed by different government departments, such as the Roads and Highways Department, Public Works Department and Local Government Engineering Department annually. The rest is consumed by private sector users specially the private housing development companies. Despite the high demand, brick manufacturing has been dominated so far mainly by the seasonal fixed chimney brick kilns or its closest counterparts in Bangladesh. These technologies are more than 150 years old and inefficient in terms of fuel usage. Also, such technologies are already proscribed in the other parts of the world.

Meanwhile, to improve environmental conditions, Ministry of Environment and Forests (MoEF) issued a directive on 20 September, 2010, requiring conversion of Fixed Chimney Kilns (120 m) to newer and efficient technologies i.e. improved ZigZag Kiln, Vertical Shaft Brick Kiln, Hybrid Hoffman Kiln, and Tunnel Kiln within two years of issuing the directive. Under this directive, Brick Manufacturers only using the improved ZigZag Kiln, Vertical Shaft Kiln, Hybrid Hoffman Kiln or Tunnel Kiln technologies will get the permission for operation.

Recognizing the need for producing bricks with smart technologies while minimizing environmental impact and contributing towards economic development, it is now a necessity to establish environmental brick manufacturing facilities in Bangladesh. These technologies are expected to produce high quality bricks using less energy and hence reduce environmental pollution.

As a result, the financial feasibility is a must to undertake such a capital intensive industry in our country. This report aims to identify key financial aspects needed to succeed in establishing automatic brick factories.

3 Infrastructure Development Company Limited (IDCOL)

Infrastructure Development Company Limited (IDCOL) was established on 14 May 1997 by the Government of Bangladesh (GoB). The Company was licensed by Bangladesh Bank as a non-bank financial institution (NBFI) on 5 January 1998. Since its inception, IDCOL is playing a major role in bridging the financing gap for developing medium and large-scale infrastructure and renewable energy projects in Bangladesh. The company now stands as the market leader in private sector energy and infrastructure financing in Bangladesh.

IDCOL is managed by an eight-member independent Board of Directors comprising four senior government officials, three prominent entrepreneurs from the private sector and a full time Executive Director and Chief Executive Officer. It has a small and multi-skilled work force comprising economists, financial and market analysts, engineers, lawyers, IT experts and accountants. IDCOL's stakeholders include the government, private sector, NGOs, multilateral institutions, academics and the people of Bangladesh at large.

IDCOL, has performed exceptionally well in the reporting year because of the hard work and dedication of the employees to maintain consistent quality and to cope up with the required standard.

3.1 History of IDCOL

Infrastructure Development Company Limited (IDCOL) was established on 14 May 1997 by the Government of Bangladesh (GOB). The Company was licensed by Bangladesh Bank as a non-bank financial institution (NBFI) on 5 January 1998.

IDCOL is registered as a public limited company under the Companies Act 1994 and licensed by the Bangladesh Bank as a non-bank financial institution. IDCOL’s share capital is fully subscribed by the GOB.

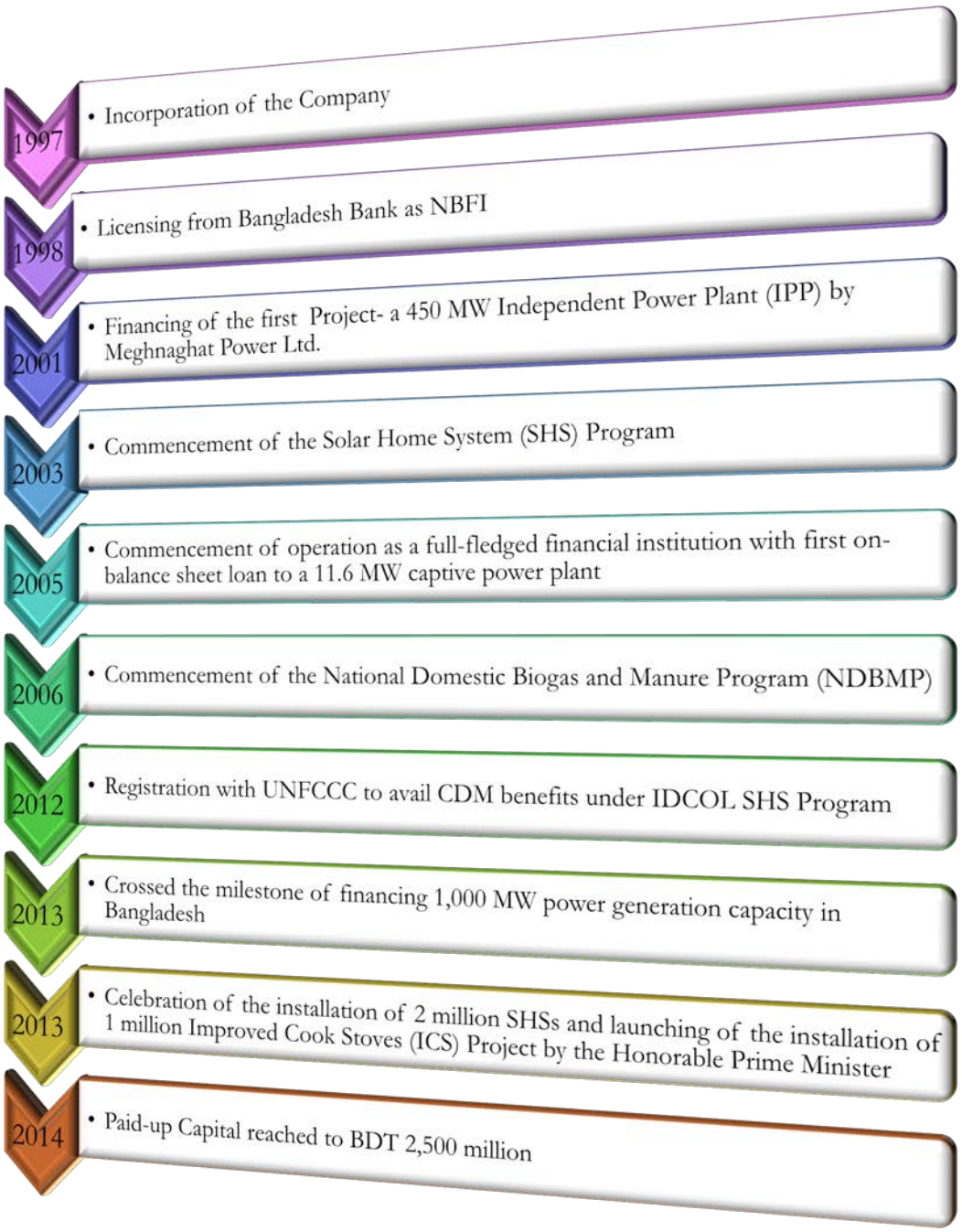

Figure 3-1: Milestones of IDCOL

3.2 Overview of IDCOL

3.2.1 Vision

IDCOL's vision is "To help ensure economic development of the country and improve standard of living of the people through sustainable and environment-friendly investments".

3.2.2 Mission

To catalyze and optimize private sector participation in promotion, development, and financing of infrastructure as well as renewable energy, and energy efficient projects in a sustainable manner through public-private-partnership initiatives.

3.2.3 Core Values

- **Global Standard and Competence:** IDCOL is committed to deliver financial services to the clients maintaining global standards and competence.
- **Transparency and Integrity:** IDCOL believes in maintaining transparency and integrity in all activities performed by the Company.
- **Social Responsibility:** IDCOL is dedicated to perform as a development financial institution that articulates social responsibility.

3.3 Corporate Governance

3.3.1 Board of Directors

IDCOL is managed by an eight-member independent Board of Directors comprising four senior government officials, three prominent entrepreneurs from the private sector and a full time Executive Director and Chief Executive Officer.

Table 3-1: Board of Directors of IDCOL

Name	Designation
Mr. Mohammad Mejbahuddin	Chairman, IDCOL and Secretary, Economic Relations Division (ERD)
Mr. FazleKabirndc	Director, IDCOL and Secretary, Finance Division, Ministry of Finance
Mr. Md. Nazrul Islam Khan	Director, IDCOL and Secretary, Ministry of Information & Communication Technology
Mr. Monowar Islam ndc	Director, IDCOL and Secretary, Power Division, Ministry of

	Power, Energy and Mineral Resources
Ms. NihadKabir, Barrister-at-Law	Director, IDCOL & Advocate, Bangladesh Supreme Court & Senior Partner, Syed Ishtiaq and Associates
Mr. Abdul Haque	Director, IDCOL and Managing Director, Haq's Bay Automobiles Ltd.
Mr. WaliurRahmanBhuiyan, OBE	Director, IDCOL
Mr. Mahmood Malik	Executive Director and CEO, IDCOL

3.3.2 Management Committee

The next highest governance committee after Board of Director is the Management Committee which is headed by ED & CEO, IDCOL and consists of all Unit Heads.

Table 3-2: IDCOL Management Committee

Employee Name	**Functional Designation**
Mahmood Malik	Executive Director & CEO
S. M. Monirul Islam	Chief Financial Officer and Head of Operations
NazmulHaque	Director (Investment) and Head of Advisory
Md. EnamulKarimPavel	Head of Renewable Energy
M. Maftun Ahmed	Company Secretary and Unit Head, Compliance
Tanvir A Siddiqui	Unit Head, Large Infrastructure
MohammedZahidulHaque	Vice president &Unit Head, Small and Medium Infrastructure
FarzanaRahman	Unit Head (Investment), Renewable Energy
MerinaKashem	Vice President & Unit Head, Credit Risk Management
Md. WahidurRahman	Unit Head (Technical), Renewable Energy
M. MizanurRahman	Unit Head, Finance and Accounts
Farhan Reza	Unit Head, Credit Administration
Md. SohelRana	VP, Internal Audit
Md. NazmulHaque Faisal	AVP, Corporate Affairs
RaihanUddin Ahmed	Environmental Specialist, Infrastructure
Dr. AhmedulHyeChowdhury	Environmental Specialist, Renewable Energy

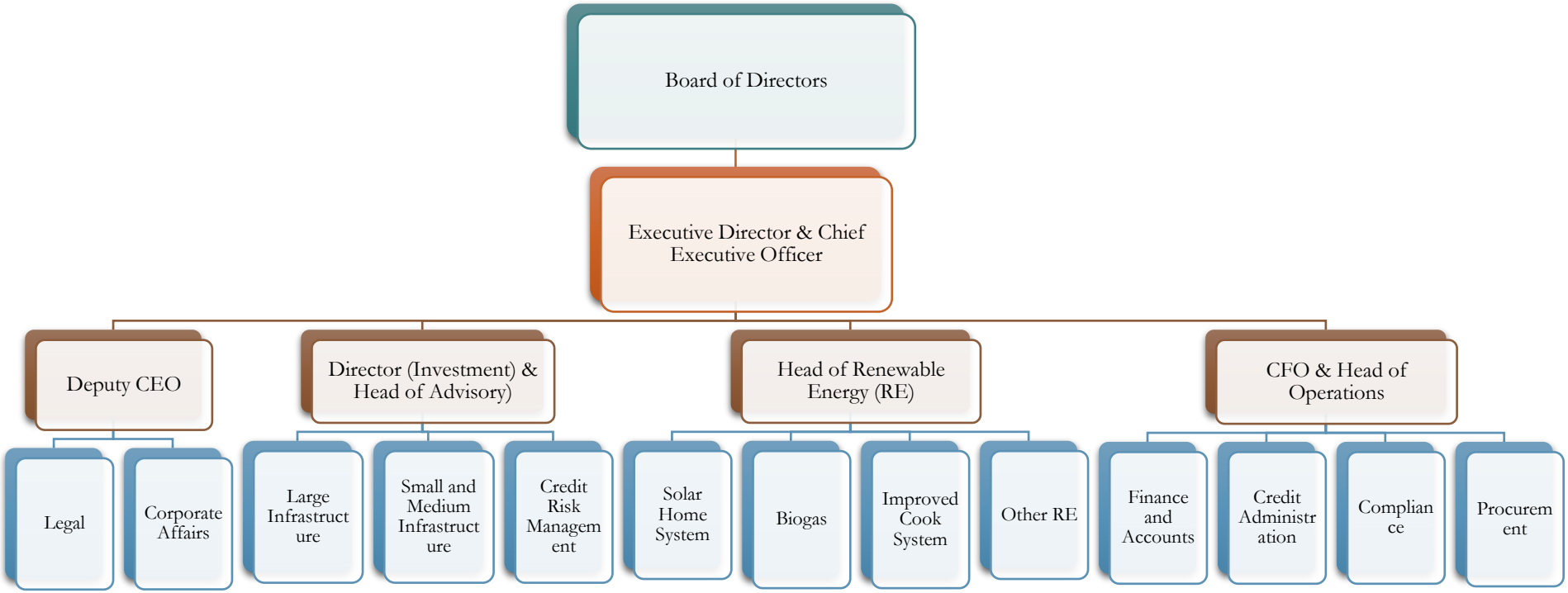

Figure 3-2: Organogram of IDCOL

3.4 Stakeholders of IDCOL

IDCOL's stakeholders include the government, private sector, NGOs, multilateral institutions, academics and the people of Bangladesh at large. Government through its policies, donor agencies through their financial support and global experience, NGOs through their access to grassroots levels, private companies through their dynamism and academicians through their professionalism have contributed towards IDCOL's success.

Figure 3-3: Stakeholders of IDCOL

3.5 Financial Highlights of IDCOL

3.5.1 Key Operating & Financial Highlights

Table 3-3: Key Operating & Financial Highlights

Particulars	2009-10	2010-11	2011-12	2012-13	2013-14
Long-term Investment (in M BDT)	1,000	800	800	400	-
Short term Investment (in M BDT)	1,880	3,023	4,442	9,337	13,932
Loan Portfolio (in M BDT)	7,058	11,316	17,393	24,513	28,855
Power (in M BDT)	1,640	2,630	4,040	2,904	3,817
Ports (in M BDT)	82	132	203	82	82
Telecom (in M BDT)	757	1214	1866	968	431

IT (in M BDT)	245	392	603	299	224
RE (in M BDT)	4,290	6,878	10,572	20,074	24,080
Others (in M BDT)	43	70	110	186	221
Total assets (in M BDT)	10,861	15,744	24,427	37,198	48,843
Total Liabilities (in M BDT)	9,904	14,417	22,575	34,431	44,737
Total equity (in M BDT)	957	1,326	1,852	2,767	4,106

3.5.2 Operating Performance

Table 3-4: Operating Performance

Particulars	2009-10	2010-11	2011-12	2012-13	2013-14
Operating income (in M BDT)	718	1,001	1,399	2,123	2,826
Operating expenses (in M BDT)	44	65	70	156	135
Interest expenses (in M BDT)	99	247	411	727	1,044
Profit before tax & provision (in M BDT)	584	849	1,194	1,864	2,605
Net profit after tax (in M BDT)	296	449	626	1,035	1,453

3.5.3 Financial Ratios

Table 3-5: Financial Ratios

Particulars	2009-10	2010-11	2011-12	2012-13	2013-14
Debt equity ratio (Times)	9.63 x	10.33 x	11.24 x	11.33 x	10.17 x
Debt ratio (%)	84.89%	87.00%	85.20%	85.97%	85.45%
Return on assets (%)	2.72%	2.85%	2.56%	2.78%	2.97%
Return on Investment (%)	3.67%	3.71%	3.44%	4.16%	5.03%
Return on shareholders' equity (%)	30.90%	33.86%	33.80%	37.07%	35.38%
Profit Margin (%)	36.20%	35.99%	34.59%	36.31%	37.54%
Opex as % of Operating Income	6.08%	6.45%	5.00%	7.35%	4.78%
Earnings per share (BDT 100/share)	44.81	51.64	52.16	60.21	55.87
% of Classified Loans	1.16%	1.17%	2.32%	0.81%	0.80%

3.5.4 Equity Statistics

Table 3-6: Equity Statistics

Particulars	2009-10	2010-11	2011-12	2012-13	2013-14
Number of shares (No.)	6,600,000	8,700,000	12,000,000	17,200,000	26,000,000
Paid up Capital (BDT million)	660	870	1,200	1,720	2,600
Shareholders' equity (BDT million)	957	1,326	1,852	2,767	4,106

3.5.5 Resources

- BDT 2,500 million as paid-up capital.
- BDT 1,047 million as reserve.
- IDCOL is a multi-donor funded financing institution and currently manages:

➢ Reflows from USD 80 million loan extended to 450 MW Meghnaghat Power Ltd. project;

➢ USD 308 million from International Development Association (IDA) for implementing Rural Electrification and Renewable Energy Development Project (REREDP). IDCOL initially received USD 56 million and later on USD 80 million and USD 172 million under 15t and 2nd additional financing agreements, respectively;

➢ USD 165 million from Asian Development Bank (ADB) for financing infrastructure and renewable energy projects under Public-Private Infrastructure Development Facility (PPIDF);

➢ USD 18 million from Islamic Development Bank (IDB) for financing renewable energy projects under Participating in the Financing of Improving Rural Households Livelihood through Solar Energy Project in Bangladesh;

➢ Yen 11,335 million from JICA for renewable Energy project;

➢ EUR 16.5 million from KFW for renewable Energy project;

➢ EUR 9.2 million from KFW for renewable Energy project;

➢ USD 7 million from GEF for financing REREDP;

➢ EUR 13.1 million from SNV, KFW and other donor for NDBMP Project;

➢ USD 15.25 million from GPOBA arranged by world bank for financing REREDP;

➢ USD 3.3 million from Japan and ADB for financing of renewable energy project under PPIDF.

3.6 Awards

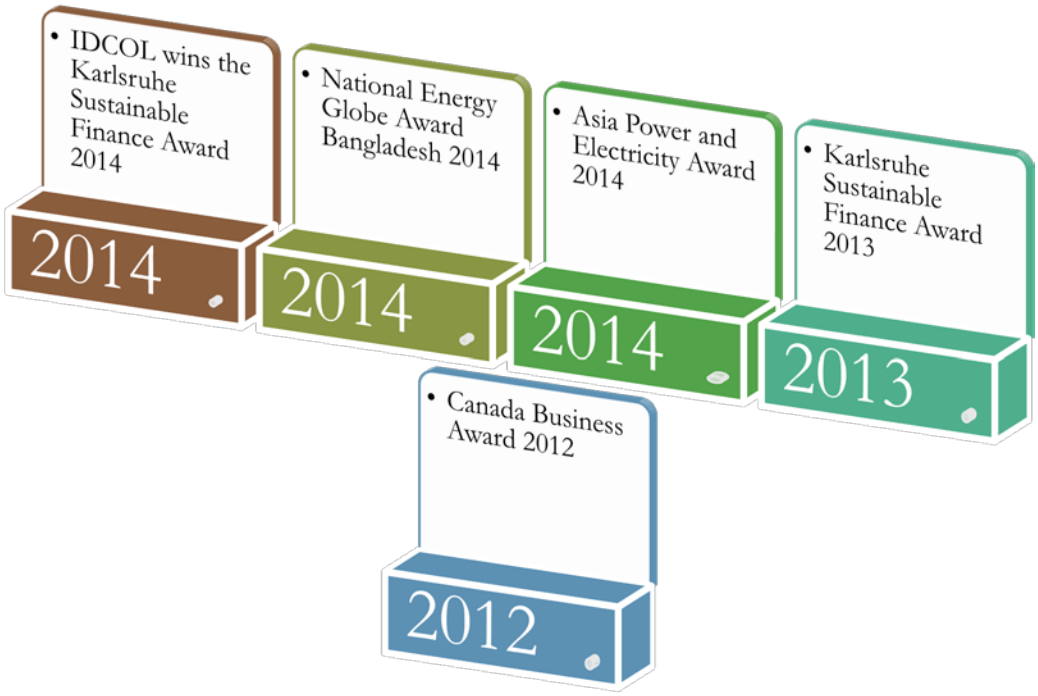

Figure 3-4: Awards won by IDCOL

3.7 Products & Services of IDCOL

IDCOL is Bangladesh's leading diversified financial institution providing a wide range of financing products and fee-based services with private-sector infrastructure, renewable energy, and energy efficient projects as its focus areas. IDCOL's key businesses include project finance, corporate finance, debt and equity arrangement, grant & technical assistance, training & capacity building and advisory services. IDCOL also works closely with government entities and regulators in Bangladesh to advise and assist in formulating policy and regulatory frameworks that support private investment and public-private partnerships in infrastructure development.

IDCOL's products and services are:

- Infrastructure
- Renewable Energy
- Energy Efficiency
- Advisory Services

3.7.1 Infrastructure

As the leader in Infrastructure and Project Finance area, IDCOL offers full range of financing solutions to viable private-sector owned infrastructure projects including long term local and

foreign currency loans, working capital loans, debt and equity arrangement, debt restructuring, takeover financing, financial advisory and agency services.

Recently, IDCOL has expanded its infrastructure financing window bringing in social and tourism infrastructure as well as infrastructure backward linkage industries under the broad definition of infrastructure. IDCOL also provides concessionary financing support to projects with significant positive contribution towards environmental conservation and pollution control.

IDCOL's dedicated Large Infrastructure, Small & Medium Infrastructure and Agency Units have in-depth expertise and knowledge in their relevant sectors and the ability to effectively position financings to the market. Working alongside Legal, Environment and Advisory teams, IDCOL provides seamless transaction execution from start to finish.

Eligible sectors under the Infrastructure window include but not limited to the following:

- Power
- Telecommunications
- ICT
- Ports
- Social Infrastructure
- Gas and Gas Related Infrastructure
- Water Supply
- Toll, Roads and Bridges
- Shipyards and Shipbuilding
- Hotel and Tourism
- Mass Transportation System
- Environmental Services
- Infrastructure Backward Linkage Industries

Under the Infrastructure window, IDCOL provides long-term BDT and USD loans to viable private-sector owned projects that fall within the Eligible Sectors. Key indicative lending terms are as follows:

Table 3-7: Lending terms for infrastructure projects

Particulars	USD Loan	BDT Loan
Single Borrower/Group Exposure	Maximum USD 60 million or equivalent BDT	
Tenure	Maximum 50% of the Total Project Cost.	
Single Project Exposure	Maximum of 15 (fifteen) years including Grace Period	Maximum of 15 (fifteen) years including Grace Period
Grace Period	Maximum of 3 (three) years	Maximum of 3 (three) years
Interest Rate	Market Rate	Market Rate

IDCOL, however, may consider concessionary financing support to projects with significant positive contribution towards environmental conservation and pollution control i.e. solid waste management, effluent treatment plants, battery recycling plants etc.

3.7.2 Renewable Energy

IDCOL is the pioneer in mass scale off-grid renewable energy dissemination in Bangladesh. Started with the Solar Home System program in 2003, IDCOL now has country-wide programs in solar home system, domestic biogas, solar irrigation, solar mini-grid, biomass and biogas based electricity generation plants. IDCOL offers a comprehensive range of subsidy and concessionary loans to these viable renewable energy programs/projects. In addition, IDCOL provides support for feasibility analysis, training and capacity building as well as for promotion and awareness campaign.

IDCOL's dedicated Renewable Energy office has in-depth expertise and knowledge in various renewable energy technologies and the ability to provide potential sponsors a seamless transaction execution experience from start to finish. Eligible sectors under the Infrastructure window include but not limited to the following:

- Solar Home System Program
- Domestic Biogas Program
- Solar Mini-Grid Projects
- Solar Irrigation Program
- Biomass and Biogas Based Power Projects

- Solar Diesel Hybrid Solution For Telecom BTS
- Other Renewable Energy Projects (i.e. solar diesel hybrid solution for telecom BTSs, solar-powered transportation, rooftop solar system, solar cold storage and dryers, battery charging stations, community biogas projects etc.)

3.7.2.1 Solar Home System Program

IDCOL started the SHS program in 2003 to ensure access to clean electricity for the energy starved off-grid rural areas of Bangladesh. The program supplements the Government's vision of ensuring 'Access to Electricity for All' by 2021.

About 3 million SHSs have already been installed under the program in the off-grid rural areas of Bangladesh till April 2014. As a result, 13 million beneficiaries are getting solar electricity which is around 9% of the total population of Bangladesh. IDCOL has a target to finance 6 million SHS by 2017, with an estimated generation capacity of 220 MW of electricity.

IDCOL initially received credit and grant support from the World Bank and GEF to start the program. Later, GIZ, KfW, ADB, IDB, GPOBA, JICA, USAID and DFID came forward with additional financial support for expansion of the SHS Program.

At present 47 Partner Organizations (PO) are implementing the program. IDCOL provides refinancing and grant support as well as necessary technical assistance to the POs. POs install the SHSs, extend credit to the end users and provide after sale services.

More than 65,000 SHSs are now being installed every month under the program with average year to year installation growth of 58%. The program replaces 180,000 tons of kerosene having an estimated value of USD 225 million per year. Moreover, around 70,000 people are directly or indirectly involved with the program.

The program has been acclaimed as one of the largest and the fastest growing off-grid renewable energy program in the world.

Under IDCOL SHS Program, IDCOL does not provide any loan directly to the end users. All loans are being channeled through the Participating Organizations (POs) as per the following terms:

Table 3-8: Lending terms for SHS projects

Particulars	Term Details	
Loan Amount	Up to BDT 250 M > BDT 250 M	80% of POs loans to households 70% of the POs loans to households
Tenure including Grace	Up to BDT 250 M > BDT 250 M &<= BDT 500 M > BDT 500 M &<= BDT 100 M > BDT 1000 M	Up to 7 years Up to 6 years Up to 6 years Up to 5 years
Interest Rate	Up to BDT 250 M > BDT 250 M and<= BDT 500 M > BDT 500 M and<= BDT 100 M <= BDT 100 M > BDT 1000 M	6% p.a. 7% p.a. 8% p.a. 9% p.a.

3.7.2.2 Domestic Biogas Program

IDCOL has been implementing domestic biogas program in Bangladesh since 2006 with support from SNV Netherlands and KfW. Later, the World Bank also joined the program. Biogas plants not only provide gas for cooking purpose but also produce organic fertilizer for the crops and fish pond. The program helps reduce the use of biomass fuel for cooking. Till April 2014, IDCOL has financed construction of over 33,000 biogas plants all over the country through its 24 partner organizations.

The program saves 80 thousand tons of firewood ever year worth USD 2 million and also reduces the use of 28,000 tons of chemical fertilizer worth USD 20 million by producing 200,000 tons of organic fertilizer. The program also reduces the use of 1,000 tons of kerosene every year. IDCOL has a plan to install 100,000 biogas plants in Bangladesh by 2018.

Under the Domestic Biogas Program, IDCOL does not provide any loan directly to the end users. All loans will be channeled through the Participating Organizations (POs) as per the following terms:

Table 3-9: Lending terms for Domestic Biogas Program

Particulars	Term Details
Loan amount	80% of the POs loans to the households
Tenure and Grace	7 years including 1 year grace period
Interest Rate	6% p.a.

3.7.2.3 Solar Irrigation Projects

Solar based irrigation systems are innovative and environment friendly solution for the agro-based economy of Bangladesh. The program is intended to provide irrigation facility to off-grid areas and thereby reduce dependency on fossil fuel. IDCOL has approved 114 solar irrigation pumps of which 38 are already in operation. The remaining pumps are expected to come into operation shortly.

IDCOL has a target to finance 1,550 solar irrigation pumps by 2017. The World Bank, KfW, GPOBA, JICA, USAID, ADB and Bangladesh Climate Change Resilience Fund (BCCRF) are supporting this initiative. The lending terms for the solar irrigation projects will be as follows:

Table 3-10: Lending terms for Solar Irrigation projects

Particulars	Term Details
Loan amount	Up to 50% of the Project Cost
Tenure and Grace	8 years including up to 1 Year grace period
Interest Rate	6.00% p.a.

3.7.2.4 Solar Mini / Micro Grid Projects

Solar PV based mini-grid projects are installed in remote areas of the country where possibility of grid expansion is remote in near future. These projects provide grid quality electricity to households and small commercial users and thereby encourage commercial activities in the project areas.

So far, IDCOL has financed one 100 kWp solar micro-grid project in Sandwip Island. The mini-grid project is currently supplying electricity to adjacent 250 shops, 5 health centers and 5 schools. Another four projects of different capacity (100~159 kWp) have been approved by IDCOL which are in various stages of construction.

IDCOL has a target to finance 50 solar mini-grid projects by 2017. The World Bank, KfW, GPOBA, JICA, USAID, ADB and DFID are providing financing support in these projects. The lending terms for the solar mini and micro grid projects will be as follows:

Table 3-11: Lending terms for Solar Micro / Mini Grid projects

Particulars	Term Details
Loan amount	Up to 40% of the Project Cost
Tenure and Grace	10 years including up to 2 years grace period
Interest Rate	6% p.a.

3.7.2.5 Biogas-based Power Projects

Establishment of biogas based electricity plants in the poultry farms reduces dependency on fossil fuel used forerunning captive generators. This also ensures bio-security and proper litter management in these farms. Moreover, slurry produced in the digesters as byproduct is a good bio-fertilizer.

According to the Livestock Department, currently there are more than 150,000 poultry farms in Bangladesh with about 1,500 farms having more than 20,000 birds population. So, Bangladesh has good potential for biogas based electricity projects.

IDCOL has so far financed 5 biogas based power plants, the largest one having a capacity of 400kW. IDCOL has a target to finance 450 such projects with an average capacity of 50 kW. The World Bank, KfW, USAID and JICA are providing support to IDCOL for these projects. The lending terms for the biogas based power projects will be as follows:

Table 3-12: Lending terms for Biogas Based Power Projects

Particulars	Term Details
Loan amount	Up to 80% of the Project Cost
Tenure and Grace	Up to 8 years including up to 1 year grace period
Interest Rate	6% ~ 9% p.a.

3.7.2.6 Biomass-based Power Projects

Since Bangladesh is an agricultural country and rice is one of the main agricultural products, rice husk is abundant in the country. Bangladesh produces about 6 million tons of rice husks

a year from about 30 million tons of paddy. Approximately 4 million tons of rice husks are being used for rice parboiling, domestic cooking, poultry and fish feed etc.

Using gasification technology, rice husk can be used to generate producer gas, which can then be used to run gas generators for electricity production. Furthermore, the by-products of the gasification process can also be used to generate other valuable chemicals such as precipitated silica, calcium carbonate as well as activated carbon. IDCOL has already financed two rice husk based biomass gasification projects: a 250 kW in Gazipur, and another 400 kW one in Thakurgaon. The lending terms for the biomass based power projects will be as follows:

Table 3-13: Lending terms for Biomass Based Power Projects

Particulars	Term Details
Loan amount	60% of the Project Cost
Tenure and Grace	8 years including 1 year grace period
Interest Rate	6% p.a.

3.7.2.7 Other Renewable Energy Projects

Power supply is an ongoing challenge for the telecom operators as many of the remote areas are not connected to the national grid. In off-grid areas, diesel generators are used to source the required power which requires periodical refueling and frequent maintenance and are subject to fuel price hike. This in turn has forced operators to choose alternative energy solutions, especially solar power. To provide uninterrupted voice and data services, a number of operators have decided to run off-grid BTSs with solar-diesel hybrid power system. These systems use solar PV as primary power source and diesel generator as backup. So far IDCOL has financed 138 such solar-diesel hybrid power solutions in the telecom sector.

IDCOL has contributed significantly in the development of local manufacturing/assembling facilities for solar batteries, charge controllers, inverters, etc. However, the country was lacking a solar PV manufacturing/assembling plant and had been importing its entire demand mostly from India, Japan and China. To make the country self-sufficient in SHS technology and ensure reliable supply of solar modules at affordable cost, IDCOL published RFP on 6 October 2009 for setting up solar PV module assembling/manufacturing facilities in Bangladesh. In response IDCOL received 23 proposals and after extensive due diligence financed 2 PV assembling plants with a combined capacity of 10 MW.

IDCOL is also exploring to finance other renewable energy projects i.e. solar-powered transportation, rooftop solar system, solar cold storage and dryers, battery charging stations, community biogas projects, wind turbines etc.

The lending terms for other solar/wind/hydro/other renewable energy projects i.e. solar diesel hybrid solution for telecom BTSs, solar-powered transportation, rooftop solar system, solar cold storage and dryers, battery charging stations, community biogas projects etc. will be as follows:

Table 3-14: Lending terms for Other Renewable Energy Projects

Particulars	Term Details
Loan amount	Up to 80% of the Project Cost
Tenure and Grace	Up to 10 years including up to 2 years grace period
Interest Rate	6%~10%p.a.

3.7.3 Energy Efficiency

Financing energy efficient projects is a recent initiative of IDCOL. Under this, IDCOL has already undertaken nationwide Improved Cook Stove (ICS) and Energy Efficient Brick Kiln programs. In addition, energy efficient boilers & industrial machineries and manufacturing of energy efficient components and appliances are within the focus areas of IDCOL.

IDCOL has already developed significant in-house capacity on the technology and financing of energy efficient brick kilns within the Small and Medium Infrastructure Unit. IDCOL is also enlisted as a Participating Financial Institution (PFI) under the Green Banking Wing of the Green Banking and CSR Department of the Bangladesh Bank.

A full-fledged team under the Household Energy Unit of the Renewable Energy Department looks after country wide dissemination of the ICS Program. IDCOL launched the 'Improved Cook Stove Program' in 2013. With funding support from the World Bank, IDCOL plans to install 1 million ICSs throughout Bangladesh by 2016.

The program will reduce indoor air pollution in the rural kitchens and hence, reduce the number of deaths from chronic obstructive pulmonary diseases attributable to solid fuel

burning at homes. The program will also result in up to 50% less firewood consumption compared to traditional stoves.

To improve the environmental condition and to fulfill the Government of Bangladesh's plans to transform and modernize the brick sector, IDCOL has approved BDT750 million debt financing to the following energy efficient brick kilns projects:

- Automatic Brick Manufacturing Plant of Pretty Auto bricks
- Automatic Brick Manufacturing Plant of Baridhara Corporation Limited

IDCOL is exploring to finance energy efficient boilers and other machineries in various industries and also manufacturing energy efficient components and appliance.

IDCOL offers a range of subsidy, technical assistance and concessionary financing under its Energy Efficiency window.

3.7.4 Advisory Services

The newly established Advisory Department has two main focuses - training & capacity building and corporate advisory services on infrastructure and renewable energy financing. IDCOL helps its business partners to identify the conceptual approach to focus on the obstacles that inhibit from realizing their developmental goals while enhancing the abilities to achieve measurable and sustainable results.

Under training and capacity building, IDCOL organizes regular training programs on Project Finance, Financial Modeling, Renewable Energy Finance, and Public Private Partnership etc. IDCOL also offers tailored training programs to various organizations as per their specific needs.

The corporate advisory services include but not limited to project due diligence support to banks/financial institutions, advisory support on new product development, policy formulation support to government, project feasibility analysis, bid document preparation support to the private sector, program replication and policy structuring support to cross border agencies etc.

4 Overview of Bangladesh's Brick Sector

Brick making is indispensable for Bangladesh's economy. Though not formally recognized as an industry, brick-making is a significant economic activity in Bangladesh (Ministry of Industries 2010). The country's overwhelming dependence on bricks is due to its lack of stones in any sizable quantity or other alternative building materials at comparable cost. Table 4.1 summarizes the main characteristics of the brick sector in Bangladesh.

Table 4-1: Snapshot of Bangladesh's brick sector (2011)[1]

Parameter	**Value**
Estimated total number of **coal**-fired kilns	5,000
Number of natural **gas** fired kilns	20
Annual brick production	17.2 billion
Value of output	TK83 billion (US$1.2 billion)
Contribution to GDP	~1%
Coal consumption	3.5 million tons
Value of imported coal	TK22.6 billion (US$322 million)
Firewood consumption	1.9 million tons
Emissions CO_2	9.8 million tons
Clay consumption	45 million tons
Total employment (incl. supply of clay and coal, transport of bricks)	1 million people
Growth rate of the construction industry (1995-2005)	5.6%
Estimated future growth rate of the brick sector over the next ten years	2-3%

Brick kilns in Bangladesh are mostly informal and small-scale operations. More than 90 percent of brick kiln owners are small-scale operators. Most FCKs are individually owned, with each owner possessing one kiln only. Multiple ownership of one kiln and multiple kilns under the same ownership are rare. In a few cases, established business houses own brick kilns that are part of a portfolio of industrial establishments. The kiln owners are organized as the Bangladesh Brick Manufacturers Owners Association (BBMOA). This association is expected to support actions perceived as beneficial to the interest of its members; thus, it must be involved in any reform concerning the brick sector.

[1]BUET (2007), Gomes and Hossain (2003) and World Bank (2011b)

Regulating the brick sector has improved considerably; however, enforcement is still needed. The Government of Bangladesh (GOB) has demonstrated serious commitment to regulating the brick industry through a series of measures:

- 1989. The Brick Burning (Regulation) Act of 1989, Bangladesh‘s first brick-making law, banned the use of firewood for brick manufacturing and introduced licensing for brick kilns.
- 2001. The 1989 Act was amended to regulate the location of brick kilns. The new provision required that brick kilns not be set up within 3 km of the upazilla or district center, municipal areas, residential areas, gardens, and the government‘s reserve forests. Despite this amendment, the location requirements have not been enforced, and use of firewood still continues on a limited scale.
- October 2002. The GOB introduced a rule that made the use of 120-ft chimneys for brick kilns compulsory. This requirement was successfully enforced, especially in the vicinity of urban areas, and most Bull‘s Trench Kilns (BTKs) were upgraded to FCK technology.
- March 2007. The GOB issued notification that environmental clearance certificates would not be renewed if the owners did not shift to alternative fuel and improved technologies by 2010. However, this regulation has not been implemented since little on-the-ground activity occurred to facilitate the switch.
- July 2010. A new notification was issued banning FCK operation three years from this date.

Outdated brick-production technology and seasonality of kiln operations hinder brick-sector productivity. FCK technology is more than a century old. The brick sector has largely grown by replication of existing kilns, with little variation in kiln design or operation. Brick-making is a seasonal operation. Because kilns are often located in low-lying areas that are flooded during the monsoon, the operational period averages about 5 months out of the year. Employment in brick kilns is therefore also seasonal, involving migrant workers who receive low wages and perform hard physical labor under hazardous conditions. As a result, annual production averages about 3–4 million bricks per enterprise (BUET 2007), compared to 12 million standard Chinese bricks (equivalent to 9.2 million Bangladesh bricks) per enterprise in China (MoEP 2009).

Most brick kilns have low energy efficiency and are highly polluting. Most brick kilns in Bangladesh burn low-quality coal imported from India with a high content of sulfur (about 5 percent) and clinker content. Dependence on this type of coal is likely to continue in the foreseeable future. Owing to Bangladesh‘s current energy shortage, the GOB decided not

toprovide natural gas for new brick kilns. Moreover, the 20 existing gas-fired kilns are facing closure.

Table 4-2: Bangladesh's Energy Shortage

Bangladesh faces up to 1,800 MW of load shedding. According to the latest data from the Power Division of the Ministry of Power, Energy, and Mineral Resources, the country's generation capacity is about 3,800–4,300 MW, with a peak demand of about 5,500–5,800 MW.

At present, the electricity-access rate is still as low as 47 percent. In 2009, per-capita electricity consumption was only 220 kWh (50 percent of India's, 40 percent of Vietnam's, and 9 percent of China's).

In addition, more than 88 percent of electricity is generated from natural gas–based power plants. The reserve of natural gas is limited, and domestic production is expected to peak soon if new reserves are not found. Power plants and other industrial sectors, such as fertilizer and steel production, compete for the limited natural gas supply. Under these circumstances, the GOB has decided not to provide natural gas to brick kilns, and existing gas-fired ones face closure due to supply shortage. The country expects an enormous increase in electricity demand as economic growth continues (at a rate of 5–6 percent per year). As supply shortages of natural gas are likely to grow in the future, more coal might be demanded for power generation and industrial sectors.

Source: GOB (2010)

Most operating kilns consume about 18–22 tons of coal to produce 100,000 bricks (BUET 2007). Coal burning by kilns releases pollutants into the atmosphere, leading to harmful effects on health (e.g., from PM) and agricultural yields (e.g., from NOx) and contributing to global warming and climate change (e.g., from CO2). Adopting such modern kilns as the Improved Zigzag, VSBK or HHK would mitigate some of the above-mentioned impacts due to their lower coal consumption (12–15 tons per 100,000 bricks) (BUET 2007; World Bank 2011).

Brick kilns have a negative effect on agricultural productivity. Almost invariably, good-quality topsoil from agricultural fields with high clay content is used in Bangladesh's brick kilns. Depletion of topsoil with high organic content for brick-making is a major concern for agricultural production. In addition, acid deposits from the sulfur dioxide (SO_2) and NOx emitted from the brick kilns negatively affect agricultural productivity.

The weak financial situation of most kiln operators hinders the adoption of modern technologies. Most kiln operators have a weak financial base, with limited or no access to bank financing. Because brick-making is not formally recognized as an industry, kiln owners cannot avail themselves of the concessional loan windows of financial institutions for the

SMEs. In addition, most kilns are established on rented lowlands that cannot be used as collateral to access finance. As a result, only short-term working capital financing is available to kiln owners. Table4.2 summarizes the main barriers faced by the brick sector in Bangladesh.

Table 4-3: Barriers facing the brick sector in Bangladesh

The barriers that have contributed to the current state of the country's brick sector and its inability to bring about changes include:

- Lack of supporting regulations, fiscal incentives and standards to encourage more energy efficient practices and technologies. Except for some efforts to regulate the sector, the government has made little effort to establish effective boundary limit emission standards;
- Little and no governmental activity to assist the brick sector to undertake comprehensive programs so as it to make it cleaner and more profitable. Brick owners usually were left to bring in changes of their own which they have often failed to do, because of the vicious cycle of low efficiency – low income.
- Lack of knowledge and access to energy efficient technology, which can lower production costs at the same time. Comprehensive dissemination programs that demonstrate the potential economic benefits of energy efficient technologies have yet to be carried out.
- Lack of access to liquidity to finance modernization of brick making operations. As traditional brick kilns have seasonal employment, they have not been included in the list of recognized SMEs and thus, are not eligible for concessional SME loan windows.
- Lack of capacity in terms of technical and business skills at the enterprise level that could bring changes towards improved efficiency and reduced pollution.
- Limited experience of commercial lending institutions with SMEs and in particular, brick SMEs.

Source: UNDP (2010)

Lack of access to finance constrains the owners' capacity to adopt improved technologies that would reduce pollution and increase energy efficiency. Thus, for small operators, incremental, low-cost retrofit technology appears better suited for upgrading kilns. Lower-emission, higher-efficiency kilns (e.g., coal-based HHKs) cost 10 times or more than the FCKs (World Bank 2011a). Moreover, these kilns operate year-round on highlands above flood level; these are scarce and those near major cities are very expensive. Because of these constraints, current FCK owners are unlikely to adopt the HHK or other modern technologies unless flood-free land is made available to them at an affordable cost.

5 Existing Brick Technologies

Bangladesh uses four main types of kiln technologies, as presented in Table 3.1. The Fixed Chimney Kilns (FCKs) and the Bull's Trench Kilns (BTKs), which form more than 90 percent of kilns, are very polluting and relatively inefficient. The gas-based Hoffmann kilns and the coal-based Zigzag kilns are substantially cleaner, but represent just a few percent of the total. The following sections discuss the characteristics of all these technologies, except for the BTK, which is now banned.

Table 5-1: Existing brick kiln technologies in Bangladesh (2009)[2]

Kiln type	Number	Percent of total kilns (%)	Brick production (billion bricks)	Percent of total production (%)
FCK	4,500	92	15.8	91.4
BTK	n.a.	n.a.	n.a.	n.a.
Zigzag	150	3	0.6	0.0
Hoffmann (gas)	20	0.4	0.2	3.5
HHK	10	0.2	0.2	1.4
Others	200	4.0	0.5	0.9
Total	4,880	**100**	**17.2**	**100**

5.1 Fixed Chimney Kiln

FCK is the mainstay technology for the brick sector in Bangladesh. It is very polluting, energy intensive and requires relatively low-cost investment. FCK dominates the northern Dhaka kiln cluster, are located on lowlands and operate for 5-6 months a year.

The above figure illustrates an FCK under operation emitting black smoke because of incomplete combustion of coal. The FCK is based on the traditional BTK technology, which dates back to the 19th century. While the BTK uses two 30 feet (ft) high moveable chimneys, the FCK has a fixed chimney of about 120-130 ft height. The tall chimney provides a faster and better dispersion of the flue gas and its pollutants, compared to the BTK. The FCK has an elliptical shape and measures about 250 ft long and 60 ft wide. It is constructed mostly in open fields either over ground or partially underground. The bottom and the sidewalls are lined with bricks. The FCK uses green bricks that are manually produced from mud processed in pug mills. The wet green bricks are sun dried and loaded in the kiln in a standard way developed over time with provisions for airflow and coal stoking. Once the green bricks

[2] Source: DoE (2010)

have been loaded in the kiln, the top is covered with two layers of bricks and dirt for insulation.

5.2 Zigzag Kiln

The Zigzag kilns used in Bangladesh are replications of similar Indian kilns developed by the Central Building Research Institute (CBRI) in Roorkee, India during the 1970s. They are fairly similar to Habla kilns once widely used in Germany and Australia. In Bangladesh, the Zigzag kilns are concentrated in the Comilla region. If properly constructed and operated, zigzag kilns would result in better energy efficiency and lower emissions. The energy efficiency gains are due to better insulation and improved heat transfer to the green bricks. The emission reductions are due to lesser fuel use, better brick stacking, zigzag air flow over longer path and flue gas scrubbing in a water filled duct connecting to the outlet chimney.

A Zigzag kiln is rectangular and typically measures about 250 ft long and 80 ft wide. It has a 55 ft high fixed chimney located on one side of the kiln. An induced draft fan located at the bottom of the chimney draws the flue gas from the kiln and discharges it into the atmosphere. The induced draft fan ensures a well-controlled airflow through the kiln. The kiln is divided into 44 to 52 chambers, separated from each other by green bricks in a way that the hot gas moves in a zigzag path through small openings. The long travel path of bricks in a zigzag pattern and the contact of hot gas from the firing zone with bricks in the preheating zone contribute to the transfer of more heat in the preheating zone. Thus, the flue gas - rather than the fuel - heats up the bricks. In addition, the waste heat in the flue gas helps to better drying and reducing the moisture content in bricks. These effects promote reduced fuel consumption, greater efficiency and higher brick quality compared to the FCK‘s.

The flue gas’ repeated changes in direction and impinging on the walls and stacked bricks lead to the deposition of significant amounts of particulate matter mostly on the green brick surface. The deposition of particulates implies that the flue gas has much less particulate load. This could be the reason for reduced Zigzag emissions compared to FCKs emissions.

The Zigzag kiln also incorporates a simplified flue gas scrubber. The connecting duct between the center of the kiln and the inlet of the induced draft fan is half to two-third filled with water. The flue gas laden with dust particles impinges on the water thus losing some of its particulate load. The water is periodically cleaned to ensure continued scrubbing.

The Zigzag kilns in Bangladesh have been implemented with the help of artisans without expert supervision. Thus, it has not been possible to ensure proper construction according to certified design, which is important in reducing the level of particulate emissions. To achieve this goal, it is essential to: (1) try out the technology with expert professional input; (2) develop certified design specifications for construction and standard operating procedures; (3) establish good operational practices and management. In the absence of such a systematic approach, not only there may not be significant reductions in emission levels, but the local pollution may actually increase due to reduced chimney height.

5.3 Hoffman kiln (natural gas)

Hoffman Kiln (HK) was developed in Germany by Friedrich Hoffman in the mid-19th century and was once widely used in Europe for brick, ceramics and lime production. Natural gas-fired Hoffman kilns were introduced in Bangladesh during the 1980s. A Hoffman kiln is rectangular and measures 300-400 ft long and 60 ft wide. HK have excellent insulation provided by the thick kiln walls thus heat loss is greatly reduced. The emissions are also very low due to the use of natural gas as fuel.

Building this type of kiln requires special engineering expertise. The main difference between Hoffman and the traditional kilns is that HK is built on high land, which does not get flooded and hence can produce throughout the year. In addition, the HK has a roof which makes it possible for the plant to operate even during the rainy season. The inside roof of the kiln is arched and has a firebrick lining on the inside surface. The thick walls provide good insulation that minimizes heat loss.

The chimney is about 80-100 ft high with an induced draft fan at the bottom. The flue gas is conveyed towards the chimney through a network of channels just below the kiln. The fire is controlled by merely adjusting the gas flow rate and by opening and closing the dampers located at selected points in the flue gas network.

Green bricks are stacked in the kiln in the same way as in FCKs. The bricks are fired from the top by introducing the natural gas into the combustion zone through pipe-type burners. This firing practice is identical for all types of kilns in Bangladesh, except that in the other kilns, coal particles are manually charged every 20-30 minutes from stoking holes located at the top of the kiln. The gas burners operate in a steady state. When the bricks from the firing zone are sufficiently burnt, they are moved to the next section. During the firing process, the burnt bricks are unloaded at the back, while green bricks are stacked in front of the firing zone.

5.4 Hybrid Hoffmann Kiln (HHK)

Developed in China, the HHK represents a hybrid version of the Hoffmann kiln technology developed in Germany in the mid-19th century. Unlike the gas-based Hoffmann kiln, the HHK uses coal as fuel. The HHK combines fuel injection and external firing in highly insulated kilns, leading to lower energy use, high-quality bricks, and reduced pollution. It was introduced in Bangladesh in 2006 under a GEF supported project (UNDP–GEF, 2006). Eight HHKs are operating in Bangladesh, and another eight are in the pipeline.

The HHK design combines a highly efficient kiln technology, known as Forced Draft Tunnel Kiln (FDTK), with a unique technique of forming green bricks: Granulated coal is injected for internal combustion. Nearly 80 percent of the total energy required is injected into the bricks, while the remainder is fed externally into the firing chamber. Most of the fuel injected into the green bricks is completely burned during firing. This technology improves energy efficiency in two ways: (i) internal combustion of injected fuel in green bricks and (ii) application of heat optimization techniques in a minimum heat-loss chamber in the kiln‘s combustion zone to capture waste heat for recirculation in the drying tunnel. The HHK, like traditional technologies, does not require a tall chimney (IIDFC 2009).

The back process (i.e., coal crushing, coal-clay mixing, pugging, and brick forming by extrusion) is mechanized and rail-mounted trolleys carry the green bricks during most of the process. These mechanizations reduce physical labor and alleviate the problem of labor shortage.

Pilot demonstration near Dhaka. Universal Bricks Ltd established a pilot HHK at Amtali (Dhamrai, Savar) near Dhaka, with support from the GEF project. Xian Research and Design Institute of Wall & Roof Materials of China provided technical assistance for the plant design, supervision of construction, and trial operation. The plant went into trial production in 2009 and is now in commercial operation. It includes two operating kilns, each producing about 40,000 bricks per day. A single mechanized green-brick production line operates for both kilns. Khan (2008) reported measurements of stack emissions of 20.3 mg per m3. The calculated mass emission load of suspended particulate matter (SPM) per 1,000 brick production is nearly twice as much as that of the FCK (0.879 kg versus 1.71 kg). Measurements of PM concentrations near the gate of the kiln site reveal ambient concentrations of 251 μg per m^3 for PM10, 157 μg per m^3 for $PM_{2.5}$, and 1.30 ppm for CO. Despite the HHK’s significant emissions reduction compared to the FCK, HHK should not be located close to inhabited areas.

HHK bricks are stronger and their price more competitive than those of FCK. The World Bank has signed an Emission Reduction Purchase Agreement (ERPA) for buying Certified

Emissions Reductions (CERs) from the operating 8 kilns. The HHK initiative promises to be successful in the marketplace; however, there are barriers to adopting the technology. First, HHK implementation requires a substantially higher capital (about TK60 million per kiln) compared to FCK (TK5 million). Second, HHK needs higher land (above the monsoon flood level), which is scarce and expensive in the area surrounding the city of Dhaka and other major urban centers.

5.5 Tunnel Kiln

In a tunnel kiln, which is a horizontal moving ware kiln, bricks to be fired are passed on cars through a long horizontal tunnel. The firing zone remains stationary near the center of the tunnel, while the bricks and air move in counter-current paths. Cold air is drawn from the car exit end of the kiln, cooling the fired bricks. The combustion gases travel towards the car entrance, transferring part of their heat to the incoming green bricks. The cars can be pushed either continuously or intermittently at fixed time intervals. The tunnel kilns have provisions for air extraction and supply at several points along the length of the kiln.

Tunnel kilns are the preferred technology for firing bricks in developed countries. The advantages of tunnel kiln technology lie in its ability to fire a variety of products; good control over the firing process; ease of mechanization, thus reducing the labor requirement; and large production volume. Typically the capacity of a single tunnel kiln ranges from 60,000 to 200,000 bricks per day. While there are fewer than 10 tunnel kilns operating in South Asia for brick firing, the technology has become very popular in Vietnam, where roughly 700 tunnel kilns are in operation. Figure 5-1 shows a schematic of typical tunnel kiln.

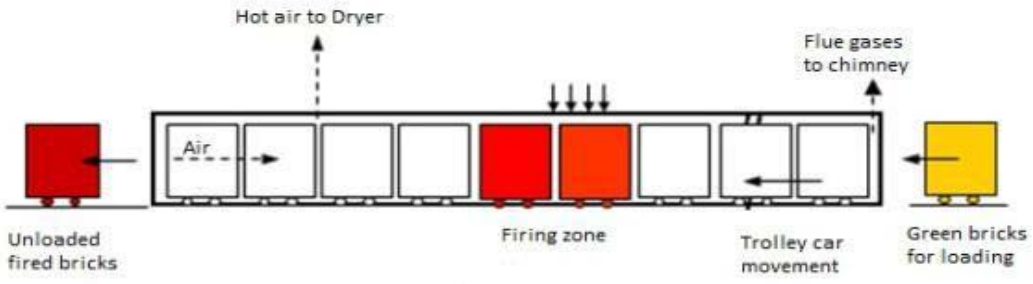

Figure 5-1: Schematic of Tunnel Kiln

5.6 Comparison of Different Technologies

Below table summarizes the different technologies for brick manufacturing and their impact on environment:

Table 5-2: Brick Manufacturing Technologies

Types of Kiln	FCK	Improved Zigzag	VSBK	HHK	TK
Pollution Level	High	Medium	Medium Low	Low	Lowest
Emissions (mg/m^3 per 1000 bricks)	>1000	500-800	78-187	20 - 40	<30
CO_2 emissions (tons/million bricks)	582	440	291	315	291
Coal Consumption (tons/million bricks)	240	180-220	100-120	120-130	100-120
Total Market Share	92.2%	3.1%	0.0%	0.2%	0.0%
Approx. Investment (USD)	70,000	80,000	250,000	2,000,000	3,500,000
O&M cost (USD/Year)	150,000	160,000	190,000	500,000	900,000
Required Labor per day	150	150	75	80	25 - 45
Brick Production (Yearly)	3,000,000	3,000,000	4,000,000	15,000,000	30,000,000
Brick quality (PSI)	<2500	<2500	4260	4500-6000	4500-6000
Brick price (BDT)	5.5-6.0	5.5-6.0	6.0	7.0-7.5	7.5-9.0

From the above table it can be inferred that, tunnel kiln technology is the most suitable when the environment is concerned.

6 Financial Feasibility of Energy Efficient Brick Manufacturing

As tunnel kiln is the long term sustainable technology for brick manufacturing, the financial feasibility is conducted for this technology in the context of Bangladesh.

6.1 Estimated Project Cost

Following is the estimated project cost for establishing a tunnel kiln brick manufacturing concern with a capacity of around 80,000-130,000 bricks per day.

Table 6-1: Estimated Project Cost

Particulars	Cost in BDT	% of PC
Land & Land Development	56,704,812	14.69%
Building & Civil Works	70,530,906	18.27%
Imported Machinery & Equipment	51,363,000	13.30%
Generator and Substation	28,650,000	7.42%
Local Material & Overhead	50,168,646	12.99%
Foreign Engineers and Erection and Installation Charges	19,340,000	5.01%
Security Deposit	500,000	0.13%
Vehicle	58,316,000	15.10%
Office Equipment & Others	1,000,000	0.26%
Pre-operating Expenses	6,017,000	1.56%
IDCP	18,941,288	4.91%
Initial Working Capital	22,011,587	5.70%
Contingency	2,568,150	0.67%
TOTAL PROJECT COST	386,111,389	100.00%

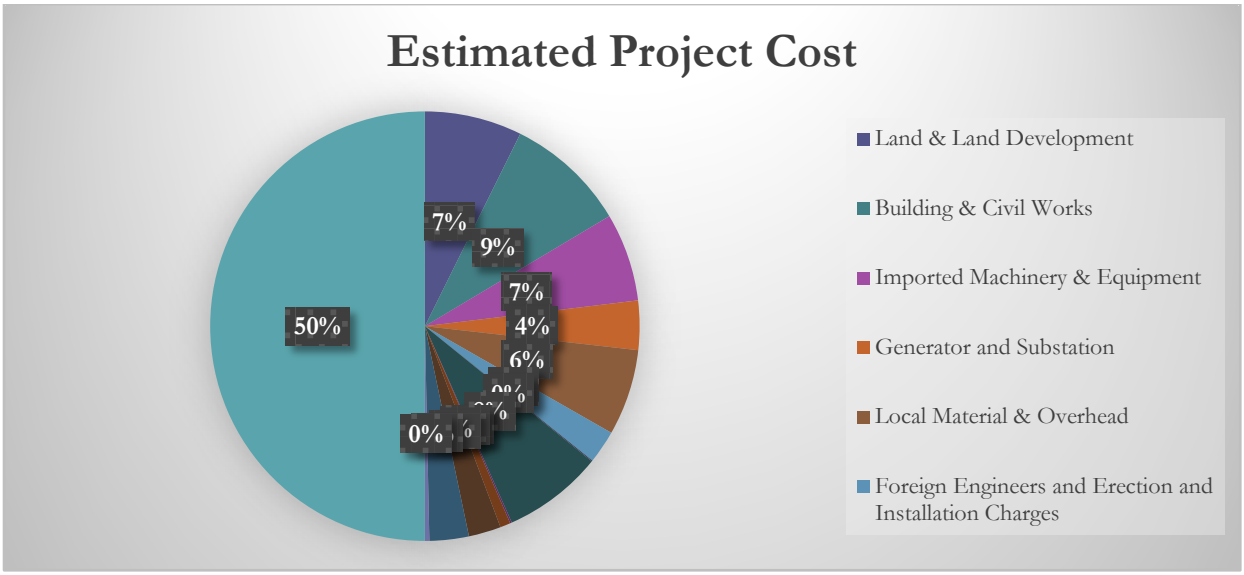

Figure 6-1: Project Cost

6.1.1 Land & Land Development

For a tunnel kiln project, around 500 decimal of undivided land is required. Price of land varies in different parts of the country. As a result, it is difficult to estimate the cost for land and land development.

6.1.2 Imported Capital Machinery

Following table summarizes the imported machinery and cost of those machinery:

Table 6-2: Imported Capital Machinery

	Items	Description	No. of Unit	Unit Price	USD	BDT
1	Box Feeder	GD65	1	4,200	4,200	327,600
2	Box Feeder	GD80	2	5,000	10,000	780,000
3	D-ironing Separator	0.6x0.4x0.2 m 26T	1	750	750	58,500
4	Double Roller Crusher	SGP800	1	4,800	4,800	374,400
5	Hydraulic Multi Bracket Excavator	14x3x2.5m 13T	2	24,600	49,200	3,837,600
6	Double Shaft Mixer	SJ-3.5	2	7,900	15,800	1,232,400
7	Two Stage Vacuum Brick Machine	JKY60-4.0	1	87,000	87,000	6,786,000
8	Full Atuo Strip Cutter and Adobe Cutting Machine	Strip Cutter: 3.6x1.3x1.5 Adobe	1	13,600	13,600	1,060,800

		Cutting machine 2.4x2.5x1.7 m				
9	Vacuum pump	2SK-12	1	1,800	1,800	140,400
10	Air compressor	1.5x0.6x1m 1T	1	1,200	1,200	93,600
11	Pawing Tractor	1.7x0.6x0.5 m 0.9T	9	1,400	12,600	982,800
12	Ferry Cart	4.6x3.8x1.5 m 3T	3	6,500	19,500	1,521,000
13	Hydraulic Pump Pusher	4.5x2x1m 2.5T	4	5,000	20,000	1,560,000
14	Fine Roller Crusher	GS800	1	11,000	11,000	858,000
15	Full Auto Brick Stacking Machine	9x5x4m 15T	1	95,000	95,000	7,410,000
16	Kiln Car Lower Part	0.35x0.32m 0.25T	240	370	88,800	6,926,400
17	Belt Conveyer	PM600	303	138	41,814	3,261,492
18	Reversible Belt Conveyor	172x0.81x1.2m 15.5 T	1	10,000	10,000	780,000
19	Coal Crusher	Size: 0.8m Dia.: 1m Wieght: 1.2T	1	3,100	3,100	241,800
20	Tunnel Kiln Accessories and Raw Materials	-	1	143,420	143,420	11,186,760
21	Electricity Cabinet	2x0.7x0.4m 0.07T	1	1,300	1,300	101,400
22	Star Cabinet	30 KW & 55 KW Cabinet	5	1,100	5,500	429,000
23	All Motors	-	1	21,420	21,420	1,670,760
24	Spare parts for 1 year	-	1	9,644	9,644	752,232
25	Kiln Technology Fee	-	1	15,000	15,000	1,170,000
	Total				686,448	53,542,944
	Discount offered	-	1	(27,948)	(27,948)	(2,179,944)

	Total after discount				**658,500**	**51,363,000**

6.1.3 Local Machinery

The list of local machinery for a typical tunnel kiln project and associated cost is provided below:

Table 6-3: List of Local Machinery

	Item	Descr.	Unit	Unit Price	Total (BDT)
1	Sand and Stone Aggregate	m3	900.00	2,200.00	1,980,000
2	Cement	MT	700.00	7,800.00	5,460,000
3	Gravel Sand	m3	600.00	900.00	540,000
4	Red Brick	PCS	1,600,000.00	8.00	12,800,000
5	Angle Steel Plate	M	2,700.00	140.40	379,080
6	Reber (Dia. 12)	M	18,000.00	50.70	912,600
7	Hooping	M	4,100.00	13.26	54,366
8	Rail	M	2,000.00	1,872.00	3,744,000
9	Standard Refractory Brick	T	150.00	8,580.00	1,287,000
10	Narrow Refractory Brick	T	50.00	17,940.00	897,000
11	Wide Refractory Brick	PCS	200.00	320.00	64,000
12	Kiln Car Upper Part Material	Set	240.00	91,260.00	21,902,400
13	Steel Wire	T	0.50	249,600.00	124,800
14	Steel Belt	Set	1.00	23,400.00	23,400
Total					**50,168,646**

6.2 Revenue Assumptions

6.2.1 Capacity Utilization

To estimate the revenue over the life of the project requires the projection of capacity utilization. It this case, though a typical tunnel kiln project can run for 30-40 years, we are considering only 10 years for hypothetical purpose.

Following are the estimated capacity utilization over the 10 years:

Table 6-4: Estimated Capacity Utilization

Estimated Capacity Utilization	Average	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capacity Utilization (% of yearly prodcution capacity)	75%	60%	65%	70%	75%	80%	80%	80%	80%	80%	80%

6.2.2 Estimated Revenue

Considering the price of brick as BDT 9.07 per brick in the base year and inflation rate of 6.8% per year and rated capacity of 100,000 brick per day, the estimated revenue from the project stands as follows:

Table 6-5: Estimated Yearly Revenue

Revenue	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Total Revenue (in BDT million)	161.32	186.58	214.52	245.38	279.43	298.32	318.49	340.02	363.00	387.54

6.3 Cost Assumptions

6.3.1 Raw Materials

The main raw material for a brick manufacturing project is clay and coal.

Table 6-6: Estimated Cost of Raw Materials

Raw Material Requirement	Unit	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Clay requirement	cft	1,800,000	1,950,000	2,100,000	2,250,000	2,400,000	2,400,000	2,400,000	2,400,000	2,400,000	2,400,000
Coal (kg)	kg	2,160,000	2,340,000	2,520,000	2,700,000	2,880,000	2,880,000	2,880,000	2,880,000	2,880,000	2,880,000
Price of Raw Materials	**Base Year**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Clay (BDT/cft)	8.4	9	10	10	11	12	12	13	14	15	16
Coal (BDT/kg)	14.00	15	16	17	18	19	21	22	24	25	27
Total Costs of	**Base**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year 8**	**Year 9**	**Year**

Raw Materials	Year	1	2	3	4	5	6	7			10
Clay		16,142,112	18,669,429	21,464,673	24,552,519	27,959,754	29,849,834	31,867,683	34,021,938	36,321,821	38,777,176
Coal		32,284,224	37,338,857	42,929,346	49,105,039	55,919,509	59,699,668	63,735,365	68,043,876	72,643,642	77,554,352
Total		**48,426,336**	**56,008,286**	**64,394,019**	**73,657,558**	**83,879,263**	**89,549,502**	**95,603,048**	**102,065,814**	**108,965,463**	**116,331,528**

6.3.2 Salary and Wages

There will be 55 workers in the project. Following table summarizes the estimated salary and wages for the 10 years:

Table 6-7: Salary and Wages

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
No. of labor	55	55	55	55	55	55	55	55	55	55
Monthly wage rate	8,845	9443	10082	10763	11491	12268	13097	13982	14928	15937
Total Wages & Salaries	5,838,000	6,232,649	6,653,976	7,103,785	7,584,000	8,096,679	8,644,014	9,228,350	9,852,186	10,518,194

6.3.3 Manufacturing Overhead

Table 6-8: Manufacturing Overhead

Particulars	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Fuel & Power	22,032,000	25,481,477	29,296,642	33,511,173	38,161,630	40,741,357	43,495,472	46,435,766	49,574,824	52,926,082
Repair and maintenance: Building	677,097	648,884	620,672	592,460	564,247	536,035	507,823	479,610	451,398	423,185
Repair and maintenance: Machinery	636,327	565,624	494,921	424,218	353,515	282,812	212,109	141,406	70,703	-
Store and Spares	-	565,624	742,382	636,327	530,273	424,218	318,164	212,109	106,055	-
Rent, tax and insurance (% of fixed costs of Project)	2,579,749	2,340,131	2,100,513	1,860,894	1,621,276	1,381,658	1,142,040	902,422	662,804	423,185
Total	**25,925,173**	**29,601,740**	**33,255,129**	**37,025,072**	**41,230,941**	**43,366,079**	**45,675,607**	**48,171,313**	**50,865,783**	**53,772,453**

6.3.4 Cost of Goods Sold

Following table summarizes the cost of goods sold:

Table 6-9: Cost of Goods Sold

Cost of goods sold	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Total Costs of Raw Materials	48,426,336	56,008,286	64,394,019	73,657,558	83,879,263	89,549,502	95,603,048	102,065,814	108,965,463	116,331,528
Wages	5,838,000	6,232,649	6,653,976	7,103,785	7,584,000	8,096,679	8,644,014	9,228,350	9,852,186	10,518,194
Manufacturing overhead	25,925,173	29,601,740	33,255,129	37,025,072	41,230,941	43,366,079	45,675,607	48,171,313	50,865,783	53,772,453
Total	**80,189,509**	**91,842,675**	**104,303,124**	**117,786,415**	**132,694,205**	**141,012,260**	**149,922,669**	**159,465,477**	**169,683,432**	**180,622,175**

6.3.5 Operating Expenses

Table 6-10: Operating Expenses

Items	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Salaries	8,162,000	8,713,751	9,302,801	9,931,670	10,603,051	11,319,817	12,085,037	12,901,985	13,774,160	14,705,293
General & Administrative Expenses	2,137,557	2,472,227	2,842,376	3,251,272	3,702,462	3,952,749	4,219,955	4,505,224	4,809,777	5,134,918
Postage & telephone	806,625	932,916	1,072,595	1,226,895	1,397,156	1,491,603	1,592,436	1,700,084	1,815,010	1,937,705
Printing & stationary	40,331	46,646	53,630	61,345	69,858	74,580	79,622	85,004	90,751	96,885
Travelling conveyance	161,325	186,583	214,519	245,379	279,431	298,321	318,487	340,017	363,002	387,541
Audit and legal fees	161,325	186,583	214,519	245,379	279,431	298,321	318,487	340,017	363,002	387,541
Advertisement	806,625	932,916	1,072,595	1,226,895	1,397,156	1,491,603	1,592,436	1,700,084	1,815,010	1,937,705
Miscellaneous	161,325	186,583	214,519	245,379	279,431	298,321	318,487	340,017	363,002	387,541
Total fixed O & M expenses	**10,299,557**	**11,185,978**	**12,145,177**	**13,182,943**	**14,305,513**	**15,272,566**	**16,304,991**	**17,407,209**	**18,583,936**	**19,840,210**

6.4 Feasibility

6.4.1 DSCR

The base case scenario is provided below:

Table 6-11: Base Case DSCR

CADS and DSCR:	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
EAIT	8,932,308	18,902,572	30,248,058	42,995,874	57,088,380	69,662,625	78,260,551	84,805,721	91,774,429	99,195,306
DepExp	29,053,474	29,053,474	29,053,474	29,053,474	29,053,474	23,961,816	23,961,816	23,961,816	23,961,816	23,961,816
IntExp	27,490,805	23,735,425	19,552,968	14,894,019	9,703,337	3,919,162	-	-	-	-
CADS	65,476,586	71,691,471	78,854,500	86,943,366	95,845,191	97,543,604	102,222,367	108,767,537	115,736,244	123,157,121
Debt Service	61,038,237	61,038,237	61,038,237	61,038,237	61,038,237	61,038,237	-	-	-	-
DSCR	1.07	1.17	1.29	1.42	1.57	1.60				

Minimum DSCR: 1.07

6.4.2 Capital Budgeting

Table 6-12: Projected Cash Flow

	INITIAL Outlay	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Project cash flow	(386,111,389)	15,974,195	44,231,101	55,402,704	67,753,114	81,396,286	91,042,469	99,464,351	105,821,576	112,589,634	119,796,297
(+/-)	(386,111,389)	(370,137,194)	(325,906,093)	(270,503,388)	(202,750,275)	(121,353,989)	(30,311,520)	69,152,831	174,974,407	287,564,040	407,360,337

IRR : 12.25%
NPV : 68,138,903
WACC : 8.98%
Payback : 6.3 years

If the capacity is reduced to 90,000 brick per day

CADS and DSCR:	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
EAIT	2,122,022	11,024,238	21,187,976	32,630,201	45,281,896	57,032,860	64,774,468	70,420,452	76,429,190	82,825,203
DepExp	29,031,715	29,031,715	29,031,715	29,031,715	29,031,715	23,961,816	23,961,816	23,961,816	23,961,816	23,961,816
IntExp	27,332,907	23,599,096	19,440,662	14,808,472	9,647,604	3,896,652	-	-	-	-
CADS	58,486,643	63,655,049	69,660,353	76,470,389	83,961,215	84,891,328	88,736,284	94,382,268	100,391,006	106,787,019
Debt Service	60,687,654	60,687,654	60,687,654	60,687,654	60,687,654	60,687,654	-	-	-	-
DSCR	0.96	1.05	1.15	1.26	1.38	1.40				

Minimum DSCR: 0.96

IRR : 9.40%
NPV : 8,346,562
WACC : 8.98%
Payback : 6.96 years

As a result, if the capacity is reduced to 90,000 bricks per day, the DSCR of the project comes down below 1 and the project will be unattractive to the lenders despite the fact that, the NPV is still positive. In this situation, it can be inferred that, for a tunnel kiln project needs to produce at least 100,000 bricks per day to remain feasible and attractive to the

lenders. Moreover, the average capacity utilization over the 1st 10 years of the project should be 75% of its stated capacity.

6.5 Sensitivity Analysis

Table 6-13: Sensitivity Analysis

Case	DSCR		IRR	PBP (in years)
	Average	Minimum		
1. Base case	1.36	1.07	12.26%	6.30
2. Selling price decreased by 10%	1.13	0.91	7.79%	7.37
3. Capacity utilization decreased by 10%	1.20	0.96	9.40%	6.96
4. Cost of raw material increased by 10%	1.30	1.04	11.22%	6.53

We can see that, the projected financials and feasibility is most sensitive to selling price of bricks and least sensitive to cost of raw materials.

7 Recommendations

Bangladesh's brick sector is characterized by outdated technologies with low energy efficiency and high emissions; low mechanization rate; dominance of small-scale brick kilns with limited financial capacity; and dominance of single raw material (clay) and product (solid clay brick). Adopting gas-based cleaner technologies is hampered by serious energy shortage and land scarcity.

How long can the country afford making bricks in this way? The current status is by no means sustainable. Bangladesh has every reason to upgrade its brick sector in order to save valuable natural resources, reduce air pollution, and increase energy efficiency. The government has already established regulations that ban the use of fuelwood and FCKs and has reconsidered the location and height of brick kiln chimneys. However, transformative development of the brick industry has yet to occur.

This report suggests that the development of the brick industry in Bangladesh over the next 20 years should aim at: (i) moving from traditional brick-making technologies (e.g. FCK) to cleaner ones (e.g. HHK, VSBK); (ii) diversifying products (e.g. hollow and perforated bricks) and locally available alternative raw materials; (iii) increasing the proportion of large-scale enterprises with higher capacity to adapt to cleaner technologies. To achieve these goals, a summary of concrete recommendations is provided below.

In the short-term:

a) Recognize brick kilns as a formal industry. This would enable easier access to financial resources (which in turn will enable investment in cleaner technologies and access flood free land) and improved working conditions.
b) Create a Brick Technology Center to raise awareness about the benefits of cleaner technologies. The center should: (a) disseminate information on the social benefits provided by cleaner technologies, new wall materials (e.g. perforated and hollow bricks) and alternative raw materials; (b) promote pilot projects of new technologies with improved provisions (e.g., mechanized, higher labor productivity and larger product lines); (c) improve use of existing dissemination channels (e.g., field visits to pilot plants, video demonstrations of the technologies, use of the Bangla language) and introduce new channels (e.g., newsletters, industry journals, conferences, and Internet blogs).
c) Support research and development aiming at: (a) exploring alternative raw materials that are locally available, brick diversification, and use of higher level of

mechanization; (b) conducting new studies such as energy consumption studies, land surveys, and brick technology surveys.

d) Facilitate the availability of subsidized credit lines to account for reduced health impacts from pollution and of other economic incentives supporting the production of new wall materials and use of alternative raw materials (e.g. via specific funds and preferential tax policies, as in China).
e) Provide access to carbon markets, on account of the carbon emission reductions provided by cleaner technologies.
f) Train several stakeholders with regard to the benefits of adopting cleaner technologies (e.g. brick owners, workers and the financial sector).

In the medium term:

g) Enforce the existing regulations and policies, such as the ban of traditional high polluting kilns (e.g. FCK, BTK), particularly those located close to large population centers, upstream of the wind (north) in the dry season (November to April).
h) Introduce regulations and policies that encourage adoption of cleaner technologies, such as: (a) revise emissions standards for brick kilns under ECR97 to make them technology independent and to encourage brick diversification (e.g., perforated or hollow bricks for partition walls); (b) establish proper emission monitoring for brick kilns; (c) impose an emission levy based on ―polluter-pay principle‖; (d) design rules and standards for the entire brick value chain: from raw materials to production processes and equipment and final products to building designs and construction processes.
i) Develop industrial parks to accommodate a large number of industries on flood-free land. These parks would mean less cost for kiln owners, due to the economy of scale achieved by providing the basic infrastructure for all kilns (e.g. roads, electricity, water) and other facilities (e.g. schools for the employees‘ children). They would also require less land for kilns establishment compared to the current situation.
j) Improve working conditions by introducing higher levels of mechanization, social programs to reduce child labor, occupational safety and health measures in kilns.

8 Conclusions

Because of seasonal productivity, outdated technology, low productivity of labor, non-existent capitalization and informal management system the brick making industry in Bangladesh is described as "footloose" industry. But the UNDP hosted new green brick concept can give Bangladesh a spirit of vow from the brick industries. Even though the traditional brick kilns pollute the environment heavily; most of the brick makers or entrepreneurs prefer it for its low capital requirement and high returns as well as easy installation. As a single unit traditional brick kiln needs only Tk. 10 million, investments while Tunnel Kiln costs at least Tk. 350 million people will not be easily motivated to develop such a new brick kiln. They are mostly unable to afford them and will result in an increase in price of brick.

Government need to push people by creating awareness against traditional kilns and make the technology simply available to the brick manufacturers. Electronic and print media should come forward to encourage people for using such kinds of bricks. More marketing is required to familiarize people with green bricks. To encourage entrepreneurs, banks need to provide long-term loan. But the problem is in receiving loan from banks, an entrepreneur has to complete a large number of formalities including verification of certificates and licenses. To avoid such unfairness policy makers should make process this easy and should modernize the policies and regulations with demand of time.

Bangladesh bank has also extended a refinance scheme of Tk. 200 crore in 2009 to establish and spread the technology. Different banks have already started providing loan for green brick kiln establishment with payback period of 5-6 years. So, the findings are:

- The capacity of a tunnel kiln technology should be minimum of 100,000 bricks per day;
- There has to have around 500 decimal of undivided land to implement an environment friendly tunnel kiln technology;
- Average capacity utilizations should be around 75% of the stated capacity over the first 10 years;
- Raw materials i.e. clay and coal need to be easily available to run the operation throughout the year continuously;
- The region where the technology will be implemented need to have adequate demand for bricks;
- Awareness among the customers is required regarding the green bricks.

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